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Assessing the Adequacy of the National Flood Insurance Program's 1 Percent Flood Standard

Gerald E. Galloway, Gregory B. Baecher, Douglas Plasencia, Kevin G. Coulton, Jerry Louthain, Mohamed Bagha and Antonio R. Levy

Water Policy Collaborative, University of Maryland

October 2006

Prepared under subcontract to the American Institutes for Research as part of the 2001–2006 Evaluation of the National Flood Insurance Program

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REPORTS IN THE EVALUATION OF THE NATIONAL FLOOD INSURANCE PROGRAM

This Evaluation consists of a series of reports assessing questions identified and prioritized by a steering committee about the National Flood Insurance Program. The reports of the Evaluation will be posted on the FEMA website as they are finalized. The website URL is http://www.fema.gov/business/nfip/nfipeval.shtm. The reports in the Evaluation are:

The Evaluation of the National Flood Insurance Program – Final Report
American Institutes for Research and NFIP Evaluation Working Group

Assessing the Adequacy of the National Flood Insurance Program's 1 Percent Flood Standard. Galloway, Baecher, Plasencia, Coulton, Louthain, Bagha, and Levy, Water Policy Collaborative, University of Maryland.

Costs and Consequences of Flooding and the Impact of the National Flood Insurance Program. Sarmiento and Miller, Pacific Institute of Research and Evaluation.

Developmental and Environmental Impacts of the National Flood Insurance Program: A Review of Literature. Rosenbaum, American Institutes for Research.

The Developmental and Environmental Impact of the National Flood Insurance Program: A Summary Research Report. Rosenbaum and Bouleware, American Institutes for Research.

An Evaluation of Compliance with the National Flood Insurance Program Part A: Achieving Community Compliance. Monday, Grill, Esformes, Eng, Kinney, and Shapiro, American Institutes for Research.

An Evaluation of Compliance with the National Flood Insurance Program Part B: Are Minimum Building Requirements Being Met? Mathis and Nicholson, Dewberry.

Evaluation of the National Flood Insurance Program's Building Standards. Jones, Coulbourne, Marshall, and Rogers, Christopher Jones and Associates.

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The National Flood Insurance Program's Mandatory Purchase Requirement: Policies, Processes and Stakeholders. Tobin and Calfee, American Institutes for Research.

The National Flood Insurance Program's Market Penetration Rate: Estimates and Policy Implications. Dixon, Clancy, Seabury, and Overton, RAND Corporation.

Performance Assessment and Evaluation Measures for Periodic Use by the National Flood Insurance Program. Miller, Langston, and Nelkin, Pacific Institute of Research and Evaluation.

The Role of the Actuarial Soundness in the National Flood Insurance Program. Bingham, Charron, Kirschner, Messick and Sabade, Deloitte Consulting.

State Roles and Responsibilities in the National Flood Insurance Program. Mittler, Morgan, Shapiro, and Grill, American Institutes for Research

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The Water Policy Collaborative is a gathering of scholars and practitioners brought together virtually to address national and international water resources policy challenges and to support other activities to improve the quality of decision making on critical water resource issues. Its membership includes a wide variety of disciplines and individuals located at organizations across the United States. It is hosted and sponsored by the A. James Clark School of Engineering, the School of Public Policy and the College of Behavioral and Social Sciences, University of Maryland. It may be contacted at 1173 Glenn L. Martin Hall, College Park, MD 20742 or at gegallo@umd.edu.

Established in 1946, with headquarters in Washington, D.C., the American Institutes for Research (AIR) is an independent, nonpartisan not-for-profit organization that conducts behavioral and social science research on important social issues and delivers technical assistance both domestically and internationally in the areas of health, education, and workforce productivity.

Water Policy Collaborative Team - Authors

Gregory B. Baecher is a professor in the civil engineering program at the University of Maryland. Prior to this, Dr. Baecher served on the faculty of civil engineering at the Massachusetts Institute of Technology from 1976 to 1988, and he served as the CEO and founder of Con-Solve Incorporated, Lexington, Massachusetts, from 1988 to 1995. His fields of expertise include risk analysis, water resources engineering, and statistical methods. Dr. Baecher is currently a member of the Water Science and Technology Board. Dr. Baecher received his B.S. degree in civil engineering from the University of California-Berkeley and his M.S. and his Ph.D. degrees in civil engineering from the Massachusetts Institute of Technology. He is a member of the National Academy of Engineering.

Mohamed Bagha is an Advanced Model Developer in the Water Resources Group at Michael Baker Jr., Inc. in Phoenix, AZ. His responsibilities include hydrologic and hydraulic modeling, floodplain mapping, watershed planning, and design. He has 6 years of experience in water resources engineering. He has been part of Federal Emergency Management Agency flood insurance mapping and disaster response/recovery teams at the national and regional levels and has experience with hazard mitigation applications and GIS applications in the water resources domain. He received his B.E. degree in Civil Engineering from the Regional Engineering College, Nagpur (now called National Institute of Technology), and his M.E. degree in Civil and Environmental Engineering from the State University of New York at Buffalo. He previously was with AMEC Earth and Environmental in Tempe, Arizona.

Kevin G. Coulton Kevin G. Coulton is the Portland, Oregon Office Manager for Watershed Concepts. He is a water resources engineer with project management and technical experience in coastal, river and watershed projects. He is experienced in the interpretation of FEMA regulations with consideration for provisions of the Endangered Species Act (ESA).. Mr. Coulton has extensive experience in performing flood studies in the Pacific Northwest for the Federal Emergency Management Agency (FEMA) and local governments. He is an active member of the Association of State Floodplain Managers (ASFPM) and has given numerous papers on floodplain management at professional conferences. He received B.S. degrees in civil engineering and landscape architecture from Penn State and a master's degree in civil engineering from Washington State University.

Gerald E. Galloway, Jr. is a Glenn L Martin Institute Professor of Engineering at the University of Maryland, College Park and Visiting Scholar at the US Army Engineer Institute for Water Resources. He is also a consultant to the Michael Baker Corporation for the FEMA flood map modernization program. Dr. Galloway has served as a consultant on a variety of water resources engineering and management issues to the Executive Office of the President, World Bank, the Organization of American States, the Tennessee Valley Authority, and the U.S. Army Corps of Engineers. In 1993-1994 he led the White House Study examining the causes of the 1993 Mississippi River Flood and recommending actions to be taken to prevent similar flood damages. Dr. Galloway holds master’s degrees from Princeton, Penn State, and the U.S. Army Command and General Staff College. Dr. Galloway received his Ph.D. degree in geography from the University of North Carolina. He is a member of the National Academy of Engineering.

Antonio R. Levy works in Project Risk Management in the Department of Financial Operations of the International Finance Corporation, World Bank Group. He is also a doctoral candidate in Project Management in the civil engineering program at the University of Maryland and received his B.S . degree in mechanical engineering from The George Washington University and his M.B.A. degree from University of Chile and Tulane University (combined degree program).

Jerry Louthain is a Senior Project Engineer for HDR Engineering in Olympia WA. He has more than 40 years experience in floodplain management, water resources management and stormwater management. Prior to HDR, he was with the Department of Ecology in Washington State, which included serving as the NFIP State Coordinator for several years, while serving as the Floodplain Management Supervisor. He has been active in ASFPM for 20 years, including serving as Chair of the Association and President of the Certification Board of Regents. He received his BS degree in civil engineering from the University of Wisconsin and is a licensed Professional Engineer in the State of Washington.

Doug Plasencia is an Assistant Vice President with Michael Baker Jr. Inc, and is responsible for Baker’s Western Water Resources practice. He previously was with AMEC Earth and Environmental in Tempe, Arizona. He has more than 21 years of experience in the field of floodplain management and stormwater management working for public agencies and most recently as a consulting engineer, and a professional engineer in Arizona, Nevada, and Virginia. He worked with the U.S. Army Corps of Engineers in Sacramento to develop the Nation’s first nonstructural emergency recovery program for a long-term reassessment of the Sacramento and San Joaquin River basins. Mr. Plasencia was also a hydrologist with the Flood Control District of Maricopa County, Phoenix, Arizona, and chief of flood protection for the Virginia Department of Conservation and Recreation. He received his B.S. degree in forest resource management from the University of Minnesota and his M.S. degree in watershed management from the University of Arizona.

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EXECUTIVE SUMMARY

Background

The passage, in 1968, of the National Flood Insurance Act (PL 90-448) established the National Flood Insurance Program (NFIP). It represented the Nation's first significant effort to reduce the fiscal impacts on those who might be flooded, control the use of lands in floodplains to reduce flood damages, and in both cases reduce the fiscal impacts of flooding on governments. In 1971, the Federal Insurance Administration (FIA), which at the time was part of the Department of Housing and Urban Development (HUD), issued a final rule that established the 100-year flood as the regulatory base flood elevation standard for implementation of the NFIP. The 100 year flood (or 1 percent annual chance flood as it is now called) has been the NFIP standard since that date.

Communities desiring to participate in the NFIP must agree to regulate use of the 1 percent floodplain by requiring all new construction to be at or above the 1 percent flood elevation. In addition, since 1973, owners of structures located within the 1 percent floodplain and whose mortgages are linked in any way to Federal government mortgage support must purchase flood insurance for the structures. The insurance provisions of the NFIP were designed to mitigate the losses of those owning property in floodplains and to reduce the necessity for Federal assistance to the same individuals. The land regulation provisions were established to reduce the number of properties that would be at risk in floodplains and thus the potential costs to government of post-flood assistance.[1] Although these objectives are related, one program does not depend on the other. While the NFIP is a Federal program, management of land use in floodplains is the responsibility of State and local governments. The success of the NFIP is dependent on close cooperation among all levels of government.

The Study

In 2001, the Federal Emergency Management Agency (FEMA) awarded the American Institutes for Research (AIR) a multiyear contract to evaluate the NFIP. This report represents the results of one substudy under the AIR program and addresses the adequacy of the 1 percent national standard. Does the 1 percent standard effectively contribute to achievement of the goals of the NFIP?

This study was conducted by members of the Water Policy Collaborative (WPC) at the University of Maryland in coordination with representatives of AMEC Earth and Environmental Services, HDR Inc., Michael Baker Corporation, and Watershed Concepts. The WPC team conducted an extensive review of and drew from pertinent floodplain management literature, papers prepared in support of the Gilbert White Forum, and interviews with over 50 professionals in the field of floodplain management, including senior officials at Federal, State and local levels and in the business and academic communities.[2] The team gathered data from

[1] Over the past two decades the Federal Emergency Management Agency (FEMA) has incorporated into the NFIP a goal of protection and enhancement of the natural and beneficial functions of the floodplain.
[2] The authors, with the approval of AIR, informed those interviewed that they would not be identified in the report.

reports of Federal agencies and FEMA claims and policy databases and worked cooperatively with the other sub-contractors of AIR to share appropriate information on relevant issues. It also took advantage of the extensive experience of the authors in dealing with floodplain management issues. This summary describes the critical findings of the study and reviews the study's conclusions and recommendations.

The 1 Percent Standard

The WPC team examined the standard to determine its history, structure, and implementation as an insurance norm and as a land use regulation tool. The team found that:

- The 1 percent flood is a statistical construct that is used to represent the probability that a flood of a certain discharge will occur on average once in a 100 years (or have a 1 percent chance of occurrence in any year) and will produce a specific flood elevation with that discharge. In reality, the 1 percent flood represents a range of discharge and elevation values that are dependent on the certainty of the information available for its computation and the use of probability distributions that portray the range of possibilities that can exist given uncertainties.

- Probalistically, there is a 26 percent chance occurrence of at least one (and possibly more than one) 1 percent flood during the lifetime of a 30-year mortgage. There is a 6 percent chance of at least one 0.2 percent flood during the same period.

- The 1 percent standard was never envisioned as an optimal standard by those who proposed and implemented it. At the time of its establishment, it represented a compromise that could be agreed upon by decision makers and the people who would be affected by its implementation. It would provide a point of departure for adjustments that could reflect the differences that might exist in floodplains across the country and in the objectives of the States and localities that would implement the standard.

- The myriad factors involved in flood frequency determination and topographic measurement make it difficult to ascribe to a flood map the accuracy that is frequently presumed by floodplain residents who see the 1 percent line as a commitment to a given elevation and to a sharp line on a flood map. Someone above that elevation or outside that line cannot be guaranteed to be safe from the 1 percent flood.

- Executive Order 11988 requires Federal agencies to construct critical facilities, to include access routes to and from the critical facilities, outside the 0.2 percent (500-year) floodplain. States vary in their treatment of critical facilities which generally include emergency operations centers, disaster shelters, schools, fire and emergency medical stations, hospitals, water and wastewater treatment plants, power facilities, and community buildings that are occupied by important public services.

- Flood standards in many developed countries far exceed the NFIP 1 percent standard. Japan and the Netherlands use 0.01 percent (10,000-year) protection for coastal works and 0.5 percent (200-year) to 0.05 percent (2,000-year) protection for riverine systems.

While territorially larger countries such as Germany, Canada and Australia decentralize development of standards to the State or provincial level, the standards typically are at the 1 percent or more restrictive level.

- The floodplain defined by the 1 percent standard has no scientific connection to the natural and beneficial functions of floodplains. However, the area contained within the 1 percent floodplain typically encompasses the land within which most of these functions occur and thus provides a useful delineation.

- The 1 percent standard and many supporting NFIP regulations were designed to strike a balance between promoting economic growth and preventing flood damages in the development of floodplains; however, this perceived balance might be significantly different if the economic value of the natural and beneficial functions of floodplains is considered.

Activity in the Floodplain

The team also examined occupancy of the floodplain and the influence that the standard and the NFIP have had on that occupancy. It found that:

- Delineation of the 1 percent floodplain and the resulting standards tied to the 1 percent flood has led to an apparent concentration of development in land areas protected by 1 percent flood control structures, new construction within the 1 percent floodplain that meets or marginally exceeds current 1 percent flood levels, and development outside the 1 percent floodplain intentionally positioned to avoid mandatory flood insurance purchase provisions and floodplain regulation. This results in significant damage exposure to floods that slightly exceed the current 1 percent level or to future floods where the recomputed 1 percent flood level may be even higher. The magnitude of property damage in the 0.2 percent floodplain may be two to three times larger than in the 1 percent floodplain.

    - Recent estimates for FEMA indicate that there are 3.5 million to 7 million structures within the area outside of the 1 percent but within the 0.2 percent (500-year) floodplain.

    - Analysis of data collected by the University Corporation for Atmospheric Research (UCAR) indicates that approximately 33 percent of flood damages occur as result of floods larger than the 1 percent event. While some of these damages can be attributed to losses in the 1 percent zone as a result of the increased flood height, the bulk likely occurs in the zone between the 1 and 0.2 percent flood lines.

    - Reports by the U.S. Army Corps of Engineers (USACE) indicate that the riverine 0.2 percent flood is expected to cause 2.24 times as much damage as the 1 percent flood and that the 0.5 percent flood is expected to cause 1.5 times as much damage as the 1 percent flood.

- FEMA claims data also suggests that there is considerable property at risk outside the 1 percent zone. About one-third of claims and losses accrue from properties other than those in the 1 percent zone.[3]

- HAZUS model runs indicate that the risk to property outside the 1 percent zone is substantial.[4] Damages in from the 0.2 percent flood are estimated to be 1½ times larger than those in the 1 percent event.

- NFIP claims data through 2004 suggests that in flood-prone areas the Nation is building to near a 1 percent standard. Since initiation of the NFIP and the issuance of flood maps, the rate of claims per policy on new construction (post-Flood Insurance Rate Map (FIRM)) and dollar loss per insured value are lower than 1 percent for those who are insured within the 1 percent flood zone indicating the relative effectiveness of some land use regulation and building codes in Special Flood Hazard Areas (SFHA).

- Flood threats differ by State and region, and NFIP claims and losses are concentrated in a few States. This represents a combination of the greater risk that exists in some States and the level of effectiveness of the floodplain management programs of the States. Over the full history of the NFIP, losses due to both riverine floods and hurricane events have been concentrated in Texas, Florida, and Louisiana, whereas non-hurricane losses have been concentrated in Texas and Louisiana. Repetitive losses are also concentrated in a few States.

- Physical conditions in floodplains differ from one location to another across the expanse of this Nation. Some floodplains are subject to flash floods or fast rising floodwaters. Others face floods that arrive slowly and can be forecast days or even weeks beforehand. In some areas, the difference between the 1 percent flood and the 0.2 percent flood is a matter of inches and the areal extent of the 0.2 percent floodplain is only slightly larger than the 1 percent floodplain. In other cases, the vertical difference may be a matter of feet and the areal difference very large.

- When a normally flood-prone area is protected by a levee that is designed to successfully pass the 1 percent or larger flood, under the NFIP the areas behind the levee may be removed from the Special Flood Hazard Area (SFHA) designation, land use regulation, and the requirement for mandatory purchase of insurance. As result it became fiscally advantageous, but not necessarily safe, for communities in the NFIP with large areas in floodplains to build levees with at least 1 percent protection. As far back as 1980, FEMA indicated that "the use of a 100 year standard was encouraging construction of levees to the 100 year design level for the sole purpose of removing an area from the special flood hazard designation."

- As illustrated by Hurricane Katrina's impact on New Orleans, the consequences of levee overtopping or levee failure can be catastrophic. The residual risk that exists for those

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[3] Some properties, previously mapped outside the 1 percent zone and insured as outside the zone, have been later remapped into the 1 percent zone but retain their non-1 percent insurance policy rating.
[4] HAZUS is FEMA's multi-hazard risk estimating software for earthquake, hurricane, and flood losses.

who are protected by levees and the binary nature of the protection that levees provide create a major challenge for the NFIP. If a levee is properly designed, constructed, and maintained, it should provide protection to the design height. When a flood exceeds the design height, the levee is overtopped by the flowing waters and may begin to erode and fail.

- Numerous studies and reviews conducted over the past 30 years have recommended that levees protecting urbanized areas be built to a protection level higher than the 1 percent standard and that those living behind such levees should be required to obtain flood insurance both to mitigate potential losses and to provide a reminder of the residual risk that exists.

- Although there are not extensive data to either support or reject the assertion, floodplain officials interviewed for this study indicated that having a regulated floodplain has slowed development and improved management of the 1 percent floodplain. They noted that in riverine as opposed to coastal areas, the development of post-FIRM structures in floodplains has been limited. The gradual reduction of the number of pre-FIRM structures gives some evidence of this change. This reduction represents a combination of changes in NFIP participation as well physical occupancy.

- The costs of affecting any change in the current standard would be significant and would cut across the public and private sectors but are likely far less than the potential costs of additional New Orleans disasters. These costs would stem from the need to elevate existing homes or build new structures at higher elevations. The impacts of change can be mitigated by phased implementation. Changes in the standard that tightens control over the floodplain and that concurrently heighten awareness of the residual risk to those in floodplains should result, *eventually*, in a reduction in individual flood losses, payouts from the NFIP, and disaster assistance expenses through gradual decrease in floodplain occupance and increased participation in the insurance program.

- Within the 1 percent floodplain, current regulations allow development in the outer flood fringe area and restrict but do not prohibit development in the regulatory floodway that encompasses the stream channel. The 1 percent standard, at best, results in a floodplain delineation that encompasses the watercourse and adjacent riparian zones and wetlands. These allowable activities in the flood fringe and floodway are governed by procedures and approaches that may have become outdated over time. This is resulting in continued disruption of natural terrain and vegetation, often affecting some of the highest-quality natural and beneficial functions of floodplains. Limited protection of these areas may result from floodways and floodplains. Significant damage of natural functions can result from processes designed to “remove” properties from the floodplain, such as channelization, levees, and the placement of fill.

- A derived goal of the NFIP is to support the conservation and management of natural and beneficial functions within the floodplain.

Communicating the Risk

Use of the 1 percent annual chance terminology to describe the national standard appears to be of marginal utility.

The 1 percent terminology is understood but not necessarily supported by the floodplain management community. It certainly is not in more common use by government officials, the media, or the public, and nearly two decades of work to enshrine the terminology has had little success. If the risk is going to be communicated more effectively, something needs to be done. FEMA should undertake a thorough analysis of the use of the percentage chance of occurrence as the basis for expressing the national standard for the NFIP to determine if a more effective approach can be developed.

Until such time that a risk communication strategy is developed and accepted, FEMA should consider returning to the 100-year flood terminology for public communications. FEMA also should ensure that there is a clear explanation of the meaning of the 100-year flood.

Conclusions and Recommendations

The 1 percent standard was developed to define an area in the floodplain where the Federal government believed it was necessary to control development. It also was to identify the zone in which a substantial number of individuals were at risk and should be required to purchase flood insurance. Both of these actions were focused on mitigating the impact of floods on floodplain residents, reducing the need for post-flood Federal assistance, and reducing future flood damages by limiting unwise development in floodplains. History has shown that implementation of the standard has varied considerably by location and local support and that this implementation is not as effective as it might be. The net result is that the risk to those in floodplains now extends beyond the 1 percent floodplain, and the exposure of individuals and the government to significant losses has grown as a result.

The WPC team concludes that the NFIP should meet its established goals in a manner that provides a balance between Federal administration of the program and State and local needs for some control over aspects of its implementation. It should provide standards and guidance to participants in the NFIP and to States and localities. The need for a Federal standard does not mean, however, that one standard should limit floodplain management *at the state and local level*. Given topographic, ecologic, meteorological, and land use differences across the country, state or local variations in the standard would seem logical. The team draws the following conclusions and offers accompanying recommendations:

The 1 percent standard, as currently applied, is inadequate and as a result is not contributing effectively to accomplishment of the goals of the NFIP. The standard is not being effectively implemented for land use regulation and, for insurance purposes, is too low to properly address the significant flood risk exposure faced by the Nation.

A properly implemented 1 percent standard would provide a reasonable baseline for NFIP-based regulation of land use in the SFHA across the Nation.

States and their communities have a responsibility to implement higher standards where local conditions threaten the health and safety of floodplain residents.

- ***Recommendation 1 (R1). If implementation of the standard can be improved, FEMA should retain the 1 percent annual chance flood as the Federal standard for regulation of activity in the SFHA.*** The Nation needs to have a common standard for Federally imposed land use restrictions.

- ***R2. FEMA should take action to improve the implementation of the 1 percent standard for regulation of land use*.** Such actions as enhancement of public understanding of hazards, use of future-conditions hydrology to account for urbanization and climate change, reduction in floodway infringements, and greater attention to enforcement of existing NFIP provisions would greatly improve the effectiveness of NFIP related land use decisions.

- ***R3. States and their communities should exercise their responsibility to impose higher standards, where the health and safety of the population merits a higher standard for land use regulation. Concurrently, FEMA should examine the use of incentives, possibly through use of the Community Rating System (CRS), to reward States that exercise these responsibilities.*** Imposition of higher standards is well within the purview of the States and the communities that lie within the States and receive their land use authority from the States.

Requiring insurance to the 1 percent standard does not provide for coverage of the significant amount of property at risk in the area outside the 1 percent but within the 0.2 percent (500-year) floodplain.

- ***R4. FEMA should seek legislative authority to require mandatory purchase of flood insurance by those living in the 0.2 percent floodplain*** if they hold a Federally insured mortgage or if they are to receive any disaster assistance from the Federal government in the case of a flood. The cost of this insurance should be determined actuarially, based on the reduced risk of living at a specific elevation within the 0.2 percent floodplain.

The 1 percent standard is too low for removal of NFIP land use and insurance requirements for population centers behind levees. A 1 percent standard does not adequately take into account the residual risk behind levees.

- ***R5. FEMA should not recognize levees under the NFIP unless they provide protection to the 0.2 percent (500-year flood) level.*** Levees in non urban areas should protect against the 1 percent or larger flood, depending on the economic costs and benefits of the levee.

- ***R6. FEMA should seek legislative authority to require mandatory purchase of flood insurance by those living behind accredited levees to address the residual***

risks they face and to ensure they are aware of this risk. Structures behind levees are subject to residual risks and should be insured against that risk.

The 1 percent standard is not an appropriate standard for siting of critical facilities.

- *R7.* ***FEMA should ensure that NFIP guidance and program activities clearly indicate that critical facilities should be located outside the 0.2 percent floodplain.***

Much of the baseline information, on which current determinations of the height of the 1 percent flood (and all other floods) are made, is out of date, and data collected about flood events are inadequate to support analysis of loss reduction strategies. Baseline hydrology technical reports have not been updated, and stream gaging data collection has been reduced. Levee designs and flood risk determinations may not reflect current conditions and as a result could increase the risk to those behind levees and in floodplains. Collection of flood data by the National Oceanic and Atmospheric Administration (NOAA) is not adequately supported, and information in the FEMA claims and policy databases is incomplete.

- ***R8. FEMA should improve the collection of policy and claims data, to assist in ongoing evaluation efforts, and should actively support Federal funding of efforts by NOAA to upgrade precipitation frequency estimates and flood data collection, and the U.S. Geological Survey (USGS) efforts to upgrade its stream gaging program. The accuracy of the Federal flood data is no better than the baseline information from which it is derived.***

The NFIP goal of supporting the protection of natural and beneficial functions of floodplains is closely tied to the 1 percent floodplains but is not being effectively pursued. The 1 percent floodplain identifies areas containing much of the Nation's important riverine habitat and the ecosystems that depend on that habitat. Influencing the wise us of that land through NFIP actions provides strong support to the NFIP goal of restoring and preserving the natural and beneficial values of floodplains

- ***R9. FEMA should ensure that consideration of natural and beneficial functions is fully integrated into all aspects of FEMA and NFIP actions influencing floodplain activity.***

1. ADEQUACY OF THE 1 PERCENT NATIONAL FLOOD STANDARD

The 100-year flood discharge, Q0.01, is an elegant abstract concept that presents complications when applied to real-world problems.

Hirsch, Cohn and Kirby (2005)

1.1 Beginnings of the Program and the Standard

Passage of the National Flood Insurance Act (PL 90-448) in 1968 established the NFIP and marked a milestone in United States efforts to deal with floods and their consequences on the human and natural environment. For over two centuries, those dealing with the threat of flooding had used a variety of techniques to move potential floodwaters away from property, speed the floodwaters past the same areas, or erect barriers such as levees or floodwalls to prevent the floodwaters from reaching properties. In some areas, floodwaters or rainfall that could become floodwaters were captured behind dams and held until they could be released without harm to the lands below. The NFIP marked the Nation's first significant effort to reduce the fiscal impacts on those who might be flooded through individual action on the part of those at risk and, of equal consequence, to support control of the use of lands in the floodplain. For 38 years, the NFIP has been an important component of a multifaceted effort to reduce flood damages and the costs to the Federal government from floods.

The NFIP offers flood insurance for flood-prone property located in communities that have agreed to participate in the NFIP. The 1968 Act prohibits the Federal Emergency Management Agency (FEMA) from providing flood insurance under the NFIP unless the community adopts and enforces floodplain management regulations that meet or exceed the floodplain management criteria established in the Act and that deal with the management of the land and its use. According to FEMA, "NFIP floodplain management requirements [are] directed toward reducing threats to lives and the potential for damages to property in flood-prone areas. Over 19,700 communities presently participate in the NFIP. These include nearly all communities with significant flood hazards. ... In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the Nation's floodplains. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance" (FEMA 2002b).[5]

[5] At the end of 2004 there were more than 20,000 participating communities (Dixon et al. 2006).

In implementing the NFIP, the key question quickly became the level or standard of protection that would be sought by the program. Initially focused on simply providing insurance to those at risk, it became obvious that for administrative and equality purposes there needed to be a uniform standard that would apply to land use regulation and that would define the floodplain of primary interest to the program.

In an early step toward defining a standard of protection, in August 1966 and prior to passage of the National Flood Insurance Act, President Lyndon Johnson issued Executive Order 11296, *Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities and Disposing of Federal Lands and Properties*. While it directed Federal agencies to take flooding into account when making decisions, it did not specify a level of protection. In 1971, the Federal Insurance Administration (FIA), the agency within the HUD responsible for the NFIP, issued a final rule that established the 100-year flood as the regulatory standard for implementation of the NFIP. This decision followed advice given to the FIA by a distinguished group of water resources practitioners in a seminar held in Chicago in 1968 and that was vetted in a series of administrative rule makings by the FIA between 1969 and 1971. The 100-year flood (or 1 percent annual chance flood as it is now designated) has been the NFIP standard since that year.

In May 1972, the Federal Water Resources Council issued guidelines recommending that agencies use the 100-year flood as the baseline flood in their deliberations involving use of the floodplain but permitted the use other floods as a standard where appropriate (Robinson 2004).

For 38 years the NFIP has operated as the foundation of the Nation's flood mitigation efforts, and for 35 of those years it has used the 1 percent chance flood as its standard. In turn, the existence of this standard has influenced development and land use actions by Federal, State, tribal, and local governments, businesses, and the public at large.

1.2 Evaluation of the NFIP and the Standard

The National Flood Insurance Act of 1968 has as one of its purposes to "study flood hazards…in order to provide for a constant reappraisal of the flood insurance program and its effect on land-use requirements." This clear call for evaluation and the fact that the NFIP has never been the subject of a comprehensive evaluation led FEMA to assemble a panel of experts to analyze a series of key issues about the program's operations and effectiveness. In 2001, FEMA (the successor agency to HUD for management of the NFIP), awarded the American Institutes for Research (AIR) a multiyear contract to evaluate the NFIP. AIR is charged with "assessing the effectiveness and efficiency of the NFIP and identifying promising alternatives and practical recommendations, using research questions identified by a committee of FEMA staff, retired government executives, and private sector and academic experts." Natural hazards experts; environmental and insurance industry practitioners; mapping, floodplain management, and engineering professionals, current and former FEMA officials; and local community officials helped shape the nature of the evaluation and to identify needed evaluation products. AIR and selected subcontractors have worked on studies that examined a wide spectrum of activities that make up the NFIP, such as the program's actuarial soundness, its developmental and environmental impacts, and compliance with the NFIP's requirements among participating communities. While each substudy addresses a discrete research questions, AIR works to coordinate information sharing among subcontractors for each sub study as well as for the final report.

This report represents the results of one sub study under the AIR program and addresses the adequacy of the 1 percent national standard. More specifically the report addresses five questions posed by AIR, the answers to which, taken together, provide for an assessment of the adequacy of the current standard:

- What are the implications of making the 1 percent annual chance flood standard a threshold for mandatory insurance purchase and flood management ordinances?
- Is the standard adequate in reducing risks from flood losses?
- What probability levels capture 50 percent, 75 percent, and 90 percent of disaster costs in a sample of coastal and riverine floodplains?
- If the standard is changed, how will it affect flood losses avoided, property values, NFIP loss experience, map modernization efforts, map revision and amendment costs, insurance sales, insurance rates, and Federal flood disaster expenses in areas that face flood hazards below the 1 percent annual probability threshold? The analysis should assume that rates will be grandfathered for existing structures in areas outside the 1 percent flood hazard boundaries as well as those properties that have been grandfathered administratively.
- If the 1 percent annual chance standard is deemed to be the most suitable standard, are there ways that its use or the restrictions associated with its use can be improved?

Any assessment of the adequacy of the 1 percent standard as an instrument of the NFIP must take into account the purposes and goals of the program and its origins in the National Flood Insurance Act of 1968. These purposes and goals explain what the Act and the program set about to accomplish.

In 1966, in House Document 465, "A Unified National Program for Managing Flood Losses," the Bureau of the Budget Task Force on Federal Flood Control advocated a broad perspective on flood control within the context of floodplain development. House Document 465 included five major goals for a national program:

- Improve basic knowledge about flood hazards,
- Coordinate and plan new developments in floodplains,
- Provide technical services,
- Move toward a practical national program of flood insurance, and
- Adjust Federal flood control policy to sound criteria and changing needs.

House Document 465 and the feasibility study issued the same year provided the basis for the National Flood Insurance Act of 1968. The primary purposes of the 1968 Act creating the NFIP were to:

- Through insurance, better indemnify individuals for flood losses that created personal hardships and economic distress,

- Reduce future flood damages through State and community floodplain management regulations, and
- Reduce Federal expenditures for disaster assistance and flood control.

(FEMA 2002b, 42 USC 4001)

In 2006 FEMA indicated on its web site that the goals of the NFIP are to:

- Reduce future flood damage through floodplain management, and
- Provide people with flood insurance.

While not listed specifically as a goal for the NFIP, protection and enhancement of the natural and beneficial functions of floodplains are inherent parts of the program. In addition, under the provisions of Executive Order 11988, *Floodplain Management*, each Federal agency "shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities. Under the 1994 Flood Insurance Reform Act, FEMA was directed to establish an interagency task force to examine the natural and beneficial functions of floodplains. To provide an incentive for local participation in environmental enhancement, the same Act provides that credit should be given to communities participating in FEMA's Community Rating System (CRS) when they take steps to enhance natural and beneficial functions. (CRS is discussed further in Chapters 10, 11 and 12. Jo Ann Howard, while serving as Federal Insurance Administrator, noted that "we are now looking beyond the focus on loss prevention to a new focus - the beneficial uses of the floodplain. We are looking to a more holistic view of floodplain management—focusing not just on the reduction of loss, but the renewal of land and the stewardship of resources." (Howard 2000). The evolution of this implicit goal is discussed in more detail in Chapter 11.

To provide standardization across all components of the *Evaluation of the National Flood Insurance Program*, FEMA directed that the following four goals be used as the basis for evaluation of the NFIP:

- Decrease the risk of flood losses.
- Reduce the costs and adverse consequences of flooding.
- Reduce demands and expectations for Federal disaster assistance after floods
- Restore and preserve the natural and beneficial values of floodplains.

In this report, the adequacy of the 1 percent standard will be judged on the basis of how well it meets these goals of the NFIP.

1.3 The 1 Percent Study

1.3.1 The Contract and the WPC

The Water Policy Collaborative (WPC) at the University of Maryland is an interdisciplinary group of individuals at Maryland and other universities and in other organizations who work in the water policy arena. The WPC organized a team for this study that represents an amalgam of academic and practitioner expertise in flood damage reduction activities. Principal members of the WPC involved with the study are:

Gerald Galloway, University of Maryland
Gregory Baecher, University of Maryland
Doug Plasencia, Michael Baker Corporation (formerly with AMEC)
Mohamed Bagha, Michael Baker Corporation (formerly with AMEC)
Jerry Louthain, HDR Inc.
Kevin Coulton, Watershed Concepts (HDR)
Antonio Levy, World Bank (formerly with University of Maryland)
Scott Otto, University of Maryland (Research Assistant)

1.3.2 The ASFPM Foundation Gilbert F. White Forum

In September 2004 in Washington, DC, the Association of State Floodplain Managers (ASFPM) Foundation, a nonprofit group focused on the furtherance of research and education in support of efforts to reduce flood losses and improve the management of the floodplains, held its first Assembly of the newly instituted Gilbert F. White National Flood Policy Forum. (For the remainder of this report, the ASFPM Foundation Gilbert F. White Forum will be referred to as the "Forum.") The Forum Assemblies are designed to bring together experts in floodplain management "to explore pressing issues in the field and to set out ideas for resolving them." The inaugural Assembly addressed the question of the usefulness of the 1 percent annual chance flood standard and gathered 75 professionals to discuss this topic for two days. The results of the Forum were released in 2005 as a Foundation report, *Reducing Flood Losses: Is the 1% Chance Flood Standard Sufficient* (ASFPM Foundation 2005). The report indicates that

> …the 1% chance flood standard, although in hindsight perhaps not a perfect choice, has nevertheless stood the test of many decades of use in a varied and changing nation…. There are areas in which specific scientific and technical knowledge are still lacking, and filling those gaps could help improve implementation…The Forum noted positive results from use of the 1 percent chance standard; some apparent shortcomings in the standard and its use; and some broad approaches and specific actions that could be taken to help address deficiencies in floodplain management.

The Executive Summary of the report is at Appendix 1 of this document and relevant results from the Forum have been included and will be referenced in this report. Two members of the WPC team, Gerald Galloway and Douglas Plasencia, were members of the Forum's six-person organizing committee and participated in the preparation of the report. Two other members, Kevin Coulton and Gregory Baecher, prepared papers for and participated in the Forum.

1.4 Conduct of the Study

The WPC team conducted an extensive review of and drew from pertinent floodplain management literature to include recent and past studies of floodplain activities, including the

National Floodplain Assessment, seminal documents on the formation of the standard, work of the National Research Council, and papers prepared in support of the Gilbert White Forum. WPC team members had access to the extensive collections in the University of Maryland System, the libraries of the four engineering firms, and the files of the Federal agencies involved in floodplain management.

WPC team members interviewed over 50 professionals in the field of floodplain management, including senior officials at Federal, State, and local levels and in the business and academic communities. (Interviews were conducted with the understanding that there would be no attribution of remarks.) The team gathered data from reports of Federal agencies and the FEMA claims and policy databases. It also worked cooperatively with the other subcontractors of AIR to share appropriate information on relevant issues.

1.5 What Is in the Report

Chapters 2 and 3 introduce the national challenge with floods and the flood standard. Chapter 2 provides a brief summary of the history of flood damage reduction activities in the United States and the development of the 1 percent standard. Chapter 3 describes the challenges in accurately determining a 1 percent flood and in delineating the 1 percent floodplain. It also discusses the difficulties in communicating the risk implied by a 1 percent flood.

Chapter 4 provides the Team's analysis of flood damage data from the FEMA claims and policy databases, HAZUS runs, and analysis of flood damage information gleaned from study of USACE reports. Chapter 4 identifies where in floodplains damages are occurring and the relative magnitude, by zone, of projected losses.

Chapter 5 forecasts possible deterioration of the level of protection under the standard from climate change and the loss of wetlands. Chapter 6 examines non-NFIP flood losses across the country, while Chapter 7 examines standards in use in other countries and other approaches that could be considered for setting benchmarks in the NFIP. These new options result from discussions during the Forum.

Chapter 8 identifies the social, economic, and environmental implications of making changes to the standard**.** Chapter 9 reviews the challenges connected to excluding areas protected by levees from the mandatory purchase requirements of the NFIP. It also raises and discusses the issue of the residual risk that exists for those who are protected by levees or other structures. Chapter 10 examines the treatment of critical facilities under the standard and the necessity to provide a higher than 1 percent level of protection for such structures as hospitals, nursing homes, fire stations, etc. Chapter 11 examines the relationship between the 1 percent standard and protection and enhancement of the natural and beneficial functions of the floodplain and what steps could be taken to improve this relationship. Chapter 12 identifies actions that could be taken to improve use of the 1 percent standard. The final chapter reviews the observations drawn in earlier chapters, addresses the conclusions and recommendations of the study, and identifies options for modification of the 1 percent standard. The reporting chapters are followed by lists of references cited, acronyms used, and appendices that provide more detailed information on topics covered in the basic report.

2. BACKGROUND

The Flood

Then God, our Lord, hindered the work with a mighty flood of the great river, which at that time – about the eighth or tenth of March [of 1543] – began to come down with an enormous increase of water: Which in the beginning overflowed the wide level ground between the river and cliffs; then little by little it rose to the top of the cliffs. Soon it began to flow over the fields in an immense flood, and as the land was level without any hills there was nothing to stop the inundation. …The flood was 40 days in reaching its greatest height, which was the 20th of April, and it was a beautiful thing to look upon the sea where there had been fields, for on each side of the river the water extended over twenty leagues of land, and all this area was navigated by canoes, and nothing was seen but the top of the tallest trees….By the end of May the river had returned within its banks.

Garciliaso de la Vega describing the De Soto Expedition
On the banks of the Mississippi River near Tunica, Mississippi
History of Hernando De Soto, Lisbon, 1605

FIGURE 2-1: Flooding in Richmond, Virginia, 1968

SOURCE: NOAA Photo Gallery (*http://www.photolib.noaa.gov/historic/nws/wea00714.htm*)

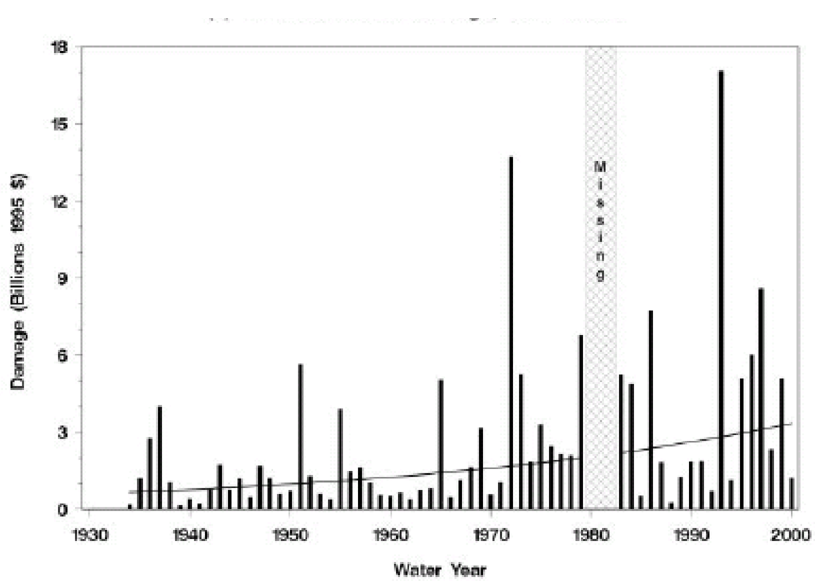
2.1 The Flood Hazard in the United States

As noted in the quotation above, floods have been an ever-present part of U.S. history. Long before Europeans visited North America, Native Americans were coping with periodic high waters on the rivers that they used for sustenance and transportation. When high waters came, they moved out of the way of the rising waters.

The first European settlers followed the path of the Native Americans in avoiding floods and flooded areas. Those coming to the new world located on the higher river banks, which provided them access to boats that brought in supplies and carried away the goods and commodities they produced. Homes, offices, warehouses, and factories soon appeared near the rivers. Unlike the natives, these early inhabitants did not move as the seasons changed. They soon discovered that large floods disrupted their activities and destroyed what they had built. Flooding also inhibited planting of crops in the fertile valleys that periodically were covered by flood overflows. As early as 1718, residents of New Orleans began to band together to build earth embankments to hold back the periodic rises of the river. Soon these embankments, levees, stretched along rivers and surrounded villages and low-lying areas in cities. By the end of the 19th century, protective levees followed the banks of the Mississippi River and other rivers across the country.

But as the levees grew, so did the damages. With little real knowledge of the hydrologic history of the rivers in the United States, levees never seemed to be high enough to restrain the next big flood. As upstream settlement grew, fields were cleared and the flow in rivers downstream increased. So did the height and width of levees in a seemingly endless cycle that continues to this day. Today, as noted, all or parts of more than 20,000 U.S. communities lie in floodplains and are subject to flooding. Damages have grown in every decade and more and more structures continue to be built in areas that are at risk to flooding (Figure 2-2).

FIGURE 2-2: Total U.S. Flood Damage, 1934-2000



SOURCE: Pielke et al. (2002)

2.2 Flood Damage Reduction Efforts

The Federal government's *lead* role in management of the floodplain and in developing protection systems for floodplain residents is less than a century old. The levee approach initiated efforts to control the floods; another approach, raising homes, was a form of living with nature or a “soft” method of damage reduction. Between the early part of the 18th century when plantation owners along the Mississippi began to build levees and then connect them with those of their neighbors and the 20th century, levees continued to be the first line of defense. Defenses were improved by making levees higher (and, as a result, wider) and more closely linking them with other levee system in order to provide protection for large areas. The Federal government became an early participant in use of the floodplain when, in 1849 and 1850, the Swamp Lands Acts ceded marshy lands to the States for reclamation and ostensibly reduction of the flood hazard. The government also assumed responsibility for learning more about the hydrology and hydraulics of the Mississippi system when it commissioned USACE to conduct the now famous Humphreys and Abbot Survey of the 1860s. This survey identified the flood threat in the Mississippi Valley and recommended the use of levees to reduce damages. Major floods on the Mississippi following the Civil War caused Congress to establish the Mississippi River Commission to oversee navigation and to a lesser degree flood control on the Lower Mississippi. While the Commission constructed works to aid navigation, its relationship with the many entities involved in flood control was more for oversight and coordination.

Following disastrous floods on the Mississippi in 1912 and 1916, Congress passed the Flood Control Act of 1917, which shifted some local flood control responsibilities on the Mississippi and on the Sacramento River in California to USACE. Eleven years later, following a major Mississippi River flood in 1927 that took hundreds of lives and left tens of thousands homeless, the Federal government assumed full responsibly for flood control activities in the Lower Mississippi Valley. In the Flood Control Act of 1928 Congress excused local governments from responsibility for sharing construction costs, noting

> … the extent of national concern in the control of these floods in the interests of national prosperity, the flow of interstate commerce, and the movement of the United States mails; and, in view of the gigantic scale of the project, involving floodwaters of a volume and flowing from a drainage area largely outside the States most affected, and far exceeding those of any other river in the United States….

Eight years later, the Nation was rocked by major floods across the country, and Congress declared in the Flood Control Act of 1936 that

> It is hereby recognized that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property, including the erosion of lands and impairing and obstructing navigation, highways, railroads, and other channels of commerce between the States, constitute a menace to national welfare; that it is the sense of Congress that flood control on navigational waters or their tributaries is a proper activity of the Federal Government in cooperation with States, their political sub-divisions and localities thereof; that investigations and improvements of rivers and other waterways, including watersheds thereof, for flood-control purposes are in the interest of the general welfare; that the Federal Government should improve or participate in the improvement of navigable waters or their tributaries including watersheds thereof, for flood-control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if

> the lives and social security of people are otherwise adversely affected (49 Stat. 1570).

This marked the Federal government's assumption of primary responsibility for dealing with flood control across the Nation and remains the foundation for today's flood damage reduction activities.[6] In reaction to the 1936 Act, Federal agencies developed methodologies to support the design of flood control structures. In essence, they attempted to define the largest storms that might occur across the relevant river basins and took the precipitation from those storms to define the flood discharge they had to control. These became within different agencies "project floods,"[7] "standard project floods," and "regional project floods" and generally represented flood events with a recurrence interval in excess of 500 or more years (the 0.2 percent flood). Dams and levees were designed so as to provide the desired level of protection.

Over the last 40 years, Federal and local governments set the protection level provided by many new Federal structural projects at or near the 1 percent level rather than at the level of the standard project flood (Jimenez 1980). In the view of many professionals (Emmer 2005, Galloway 2005), this lowering of the standard has resulted from a combination of

- A focus on economic benefit-cost ratios to the exclusion of non-economic factors.[8]
- A public belief that the 100-year standard of the NFIP represented a safe level of protection.
- The institution of cost sharing. Early coastal work was deemed beach erosion control and required local cost sharing. Beginning in 1986, all flood damage reduction projects required cost sharing, leading local sponsors to seek a minimum level of protection so as to reduce the fiscal impacts on the sponsoring entity.

During the 1950s and 1960s there was a growing interest in looking beyond structural approaches for reducing flood damages. Spurred by the dissertation and later report of Gilbert F. White, and an effort within the Tennessee Valley Authority (TVA) by staffer Jim Goddard, the

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[6] Post-1936 flood control legislation required local project sponsors to provide lands, easements, and rights of way for flood control projects constructed by the Federal government and to assume responsibility for maintenance and operation of the projects when completed. It did not change the responsibilities on the Lower Mississippi Valley established by the 1928 Act.

[7] The Standard Project Flood is derived from "the most severe flood producing rain fall depth-area duration relationship and isohyetal pattern of any storm that is considered reasonably characteristic of the region in which the drainage basin is located, giving consideration to the runoff characteristics and existence of water regulation structures in the basin….The Standard Project Flood is intended as a practicable expression of the degree of protection that should be sought as a general rule in the design of flood control works for cities where protection of life and unusually high-valued property is involved." (USACE 1965)

[8] "The "design flood" for a particular protect may be either greater or less than the standard project flood, depending to an important extent upon economic factors and other practical considerations governing the selection of design capacity in a specific case. However, selections should not be governed by estimates of average annual benefits of a tangible nature alone, nor should construction difficulties that may prove troublesome but not insurmountable be allowed to dictate the design flood selection, particularly when protection of high class urban or agricultural areas is involved. Intangible benefits, resulting from a high degree of security against flooding of a disastrous magnitude, including the protection of life, must be considered in addition to tangible benefits that may be estimated in monetary terms" (USACE 1965).

use of nonstructural floodplain management techniques that included wise land planning (including avoidance of flood hazard area, insurance, education, and floodproofing) became alternative approaches to the construction of levees and dams. Disastrous floods in the Missouri Basin in 1951 led to a call for Federal support of a flood insurance program, but it was not until 1956 that legislation was enacted initiating a limited insurance effort. However, "in the absence of technical studies to determine the costs of starting a Federal program…" Congress declined to fund the agency that was to administer the program, and the focus on insurance faded (AIR, PIRE, and Bingham et al. 2006). Following Hurricane Betsy in 1965, there was a push from within Congress for the Federal government to ensure the availability of flood insurance for those already at risk in floodplains. Flood insurance would compensate those hit by floods and, because they had already contributed to the insurance pool, reduce the government's costs to providing disaster relief. In 1968, the NFIP was established to offer insurance to homes and businesses in communities at risk if those communities would agree to manage their floodplains, and thereby reducing the long-term exposure of the government to flood losses.

Initially the NFIP did not specify a standard for protection. As indicated earlier, in 1971 HUD established the 1 percent flood as the base flood for land use regulation, requiring that all new structures in an NFIP community have their first flood elevation at or above this base flood elevation. Over time this standard of the NFIP has become the de facto standard for many programs beyond the NFIP. According to FEMA, the 1 percent flood was chosen on the basis that "it provided a higher level of protection while not imposing overly stringent requirements or the burden of excessive costs on property owners" (FEMA 2002b).

The 1 percent flood was recommended as the national standard because it represented a flood level that was not too high or not to low and "sounded about right." A higher standard would have brought enormous opposition from developers. Lower than 1 percent was estimated to be too low to make a difference in the level of losses, as it was hypothesized that the majority of damages would occur at the 1 percent level and lower. In 1983, Congress and the Office of Management and Budget (OMB), under pressure from developers to lower the standard, reviewed the standard and determined that it remained the appropriate level for the program. (Robinson 2004). For a more detailed discussion of the history of the standard, see Robinson paper in Appendix 2.

2.3 Execution of the 1 Percent Standard

Today, the NFIP is present across the country (Figure 2-2). Under NFIP regulations, participating communities are required to regulate all development in Special Flood Hazard Areas (SFHAs). "Development" is defined by FEMA as "any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials" (FEMA 2002b).

The SFHA is that "land within the floodplain of a community subject to a 1 percent or greater chance of flooding in any given year" (FEMA 2002b).

The NFIP requires communities to ensure that "new construction or substantially improved or substantially damaged existing buildings" in areas within the 1 percent floodplain have their lowest floor (including basement) elevated to or above the elevation of the 1 percent flood. Nonresidential structures can be either elevated or floodproofed. In coastal areas designated as being subject to wave action, buildings "must be elevated on piles and columns and the bottom of the lowest horizontal structural member of the lowest floor of all new construction or substantially improved existing buildings must be elevated" to the 1 percent flood level (FEMA 2002b).

A Statistical Portrait of the NFIP

Slightly more than 20,000 communities in the 50 States, American Samoa, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands participated in the National Flood Insurance Program as of September 30, 2004. A community can be a State, any of its political subdivisions, and Indian tribe, or an Alaska Native village that has the authority to adopt and enforce floodplain management regulations within its jurisdiction. Given the variety of governmental structures among the States, the distribution of communities is not evenly spread among the States or even dependent on the population of these States. Three States - Pennsylvania (with over 2,450 communities), New York (1,464 communities), and Texas (1,110 communities) - account for about 25 percent of all participating communities.

In contrast, California, the State with the largest population, has 518 participating communities. The lower number of participating communities in California reflects decisions about which jurisdictions should be responsible for floodplain management as well as the relative area and population of these jurisdictions. Among the States, Hawaii (4), Alaska (30), and Nevada (31) have the fewest participating communities.

Most flood-prone communities participate in the NFIP, and their residents had about 4.5 million policies in force as of September 30, 2004, with total coverage exceeding $722.7 billion. The total premium to obtain this coverage was $ 1.95 billion.

Nearly all property owners in these communities can purchase Federal flood insurance, but those most prone to floods seem to do so. Five coastal States, Florida, Texas, Louisiana, California, and New Jersey, account for nearly 70 percent of all policies. These five States plus five other coastal States account for 81 percent of all policies. Floridians have about 41 percent of all policies—but more than half of these policies are in 20 of the State's 437 participating communities. Outside of Florida, the median policy count per community is eight, but this number disguises the fact that many communities have no policies. Among participating communities, for example, 3,452 had no policies in August 2004. In each of an additional 7,500 communities, the policy count ranged from one to 10 while in another 2,277 communities, the number of policies ranged from 11 to 20. In other words, almost two-thirds of the 20,000 communities in the NFIP have 20 or fewer policyholders.

At the opposite extreme, the unincorporated areas of Miami-Dade County, Florida have the most policies, more than 209,200, followed by Houston, Texas (99,200 policies), Jefferson Parish (88,000 policies) and, New Orleans, Louisiana (85,200 policies), Lee County, Florida (81,000 policies), and Harris County, Texas (72,100 policies). The 25 communities with the most policies (or 0.12 percent of all participating communities) have just over 30 percent of all policies. One percent of participating communities have almost 65 percent of all policies. Miami-Dade County alone has more policies than the combined total of policies in more than 16,760 other participating communities.

SOURCE: Tobin 2004

FIGURE 2-3: Communities participating in the NFIP. The large number in the Northeast reflects the township and town structure of local governments in that region.

SOURCE: FEMA Mitigation Division; Michael Baker Corporation.

In riverine areas, communities are also required to identify and adopt a regulatory floodway that is designed to carry the waters of the 1 percent flood “without increasing the water surface elevation of that flood more than one foot at any point.” Once the community has designated the floodway, it must “prohibit development within that floodway which would cause any increase in flood heights.” According to FEMA, this latter requirement has the effect of limiting development in the most hazardous part of the floodplain and protecting an environmentally sensitive part of the floodplain (FEMA 2002b). A more detailed description of NFIP requirements is given in Appendix 3.

On a FIRM, delineated areas are divided into zones that identify the hazard within the area (Table 2-1). In riverine areas, Zone A identifies the 1 percent (100-year) floodplain. Within coastal areas the 1 percent standard is applied to identify both zones of high velocity (V zones) and coastal A zones. Coastal standards differ from riverine standards in that the concept of conveyance (floodway) is not directly present. Rather construction standards are such as to preclude construction in the most hazardous areas and in most areas to encourage elevation of the structure on piers leaving an area that is primarily open below the lowest floor. Many coastal

TABLE 2-1: FIRM Map Zone Designations

Zone A. Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no Base Flood Elevations or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-A30. Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. In most instances, Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone AH. Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding with a constant water-surface elevation (usually areas of ponding) where average depths are between 1 and 3 feet. The BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone AO. Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. The depth should be averaged along the cross section and then along the direction of flow to determine the extent of the zone. Average flood depths derived from the detailed hydraulic analyses are shown within this zone. In addition, alluvial fan flood hazards are shown as Zone AO on the FIRM. Mandatory flood insurance purchase requirements apply.

Zone AR. Zone AR is the flood insurance rate zone used to depict areas protected from flood hazards by flood control structures, such as a levee, that are being restored. FEMA will consider using the Zone AR designation for a community if the flood protection system has been deemed restorable by a Federal agency in consultation with a local project sponsor; a minimum level of flood protection is still provided to the community by the system; and restoration of the flood protection system is scheduled to begin within a designated time period and in accordance with a progress plan negotiated between the community and FEMA. Mandatory purchase requirements for flood insurance will apply in Zone AR, but the rate will not exceed the rate for unnumbered A zones if the structure is built in compliance with Zone AR floodplain management regulations.

For floodplain management in Zone AR areas, elevation is not required for improvements to existing structures. However, for new construction, the structure must be elevated (or floodproofed for non-residential structures) such that the lowest floor, including basement, is a maximum of 3 feet above the highest adjacent existing grade if the depth of the base flood elevation (BFE) does not exceed 5 feet at the proposed development site. For infill sites, rehabilitation of existing structures, or redevelopment of previously developed areas, there is a 3 foot elevation requirement regardless of the depth of the BFE at the project site.

The Zone AR designation will be removed and the restored flood control system shown as providing protection from the 1 percent annual chance flood on the NFIP map upon completion of the restoration project and submittal of all the necessary data to FEMA.

Zone A99. Zone A99 is the flood insurance rate zone that corresponds to areas of the 100-year floodplains that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No BFEs or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone D. The Zone D designation on NFIP maps is used for areas where there are possible but undetermined flood hazards. In areas designated as Zone D, no analysis of flood hazards has been conducted. Mandatory flood insurance purchase requirements do not apply, but coverage is available. The flood insurance rates for properties in Zone D are commensurate with the uncertainty of the flood risk.

Zone V. Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no BFEs are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone VE. Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zones B, C, and X. Zones B, C, and X are the flood insurance rate zones that correspond to areas outside the 100-year floodplains, areas of 100-year sheet flow flooding where average depths are less than 1 foot, areas of 100-year stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 100-year flood by levees. No BFEs or depths are shown within this zone. Mandatory flood insurance purchase requirements do not apply.

SOURCE: FEMA

.

States include standards designed to control disturbance of the primary dunes and regulate coastal hardening.

Prior to Hurricane Katrina, FEMA found that the presence of the program resulted in $1 billion in flood damages being avoided each year as a result of the NFIP floodplain management regulations and that structures built to NFIP criteria experienced 80 percent less damage because of reduced frequency and severity of losses. The post-Katrina statistics may cause a modification in this belief (FEMA 2002b).

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3. WHAT IS A 1 PERCENT FLOOD?

The 1 percent flood is a statistical construct that is used to represent the probability that a flood of a certain discharge will occur on the average of once in every 100 years (or have a 1 percent chance of occurrence in any year) and will produce a specific flood elevation with that discharge. In reality, the 1 percent flood represents a range of discharge and elevation values that are dependent on the certainty of the information available for its computation and the use of probability distributions that portray the range of possibilities that can exist given uncertainties.

In turn the computed elevation of the 1 percent discharge is used to delineate the areal extent of the 1 percent floodplain for portrayal on Flood Insurance Rate Maps (FIRMs) or other land use tools. The accuracy of the map produced is dependent on the accuracy of the computation of the 1 percent flood and the accuracy of the topographic information available for the area being mapped.

The myriad factors involved in the above make it difficult to ascribe to a flood map the accuracy that is frequently given to it by floodplain residents who see the 1 percent line as a commitment to a given elevation and to a line on the map. Someone above that elevation or outside that line cannot be guaranteed to be safe from a 1 percent flood.

The purpose of this chapter is to discuss the factors that influence the computation and delineation of the 1 percent flood.

3.1 Computation of the 1 Percent Flood Flows

Several factors must be taken into account in the computation of the flows that define a 1 percent flood or any other return interval. The level of certainty that can be attributed to each of these factors also influences the accuracy of the computations. These factors include (National Research Council (NRC) 2000):

- Hydrologic factors. These include flood frequency, volume, and intensity (time distribution). These in turn are functions of the weather events that produce storms with rainfall or snow and snow melt. Their impact on a given basin is a function of the stream network and attendant water-related physical characteristics (wetlands, lakes, soil moisture, slopes, and land cover) present in the basin. These factors are in constant change. The quality of the computations is a function of the amount of data collected, the methods by which data are gathered, and the quality of the models used in the computations.
- Hydraulic factors. The height of a flood produced by a given rainfall amount is a function of the stream and river dimensions, the shape of the river and its floodplain, its sediment load and the surface roughness in and out of its channel. Hydraulics may also be affected by dams and weirs and other structures in the river.
- Other factors. The presence of ice or debris in a river changes its characteristics and when ice flow or debris develops an ice dam or debris structure, the computation of return intervals for that particular flow becomes difficult if not impossible.

Some of these factors can be (but may not always be) accurately measured. Others must be developed by use of probability distributions that represent statistical portrayals of the frequency of given flows. As was pointed out in the Forum, “a gray area surrounds” many of these calculations (ASFPM 2005):

- The United States records of rainfall and stream flow are relatively short, with many under 100 or 50 years.
- The number of stream gages used to record critical data is decreasing every year, forcing those doing the calculations to extrapolate data from one area to cover the shortfall in ungaged areas.
- The NOAA atlases used to define rainfall in a basin are as much as 40 years old, and funding to support their updating is not on the horizon.
- Regional regression equations developed by USGS to assist in the calculation of a flow in a given watershed are 20 to 30 years old and may not reflect the current conditions.
- As a result of upstream development, there are continuous and unmonitored changes in the size and shape of stream channels. Until recently, the cost and time needed to obtain highly accurate topographic and bathymetric information made it very difficult to maintain data currency.
- The possibility of nonstationarity, discontinuities in the record of rainfall, river flows, and ocean events must be continuously appraised (ASFPM 2005).

3.1.1 Confidence Limits

The flow producing a 1 percent flood will lie somewhere between two flow values. If the confidence limits are low, the spread can be low; if the confidence limits are high the spread will be large. For example, it might be possible to compute that, with a 5 percent confidence interval (little confidence), the 1 percent flow of a given river would fall between 150,000 cfs and 170,000 cfs. If the mean (160,000) is used as the measure of the 1 percent flood, the elevation of the 1 percent flood would be at 30 feet but could be as low as 28 or as high as 32 feet, but there would be little confidence in the computations. With a high level of confidence (95 percent) the flow values spread to 100,000 to 220,000 cfs and the height above and below the mean of 160,000 could be 6 feet. Typically, in identifying the 1 percent flood, the mean is used, yet this leaves the possibility that the protection is 6 feet too low or 6 feet too high.

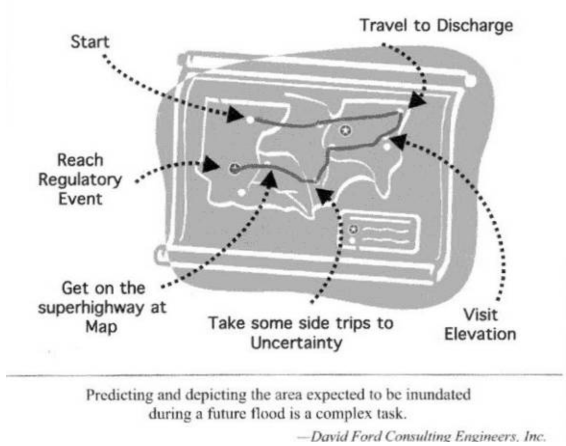
Computation of the 1 percent flood for a coastal zone is more complex than for riverine environments since coastal flooding is a function of tides, storm surge heights, and waves, with the latter two being the most critical during storm periods. These computations are based on available data from tide gages and other coastal monitoring and use of available data on storms that have affected the area under study, such as maximum winds, barometric pressure, forward storm speed, shoreline crossing point, and crossing angle. The computations are subject to the same challenges in data collection and modeling that face riverine computations. Examination of coastal flood levels following Hurricane Katrina indicated that the two principal methodologies used in the computation of the coastal 1 percent flood (empirical simulation and joint probabilities) may produce considerably different results. Efforts are currently underway to develop an all-agency approach to conduct of such analyses (Link 2006).

There have been significant advances in technology and in model development over the past three decades. The power of modern computers to carry out sophisticated calculations and to model real-world situations as well as the capability of remote sensors to rapidly gather highly accurate data offer opportunities for more accurate determination of flows. While there are opportunities to gather high-quality data, the data are not being collected.

3.1.2 Complexity

Hydrologist David Ford, pointed out at the Forum that computation of flood information follows the tortuous path illustrated in the "Road Map," Figure 3-1. At the start, the driver (the flood plain mapper who is gathering information) is driving on poorly marked paths and dirt roads with many forks and is uncertain if the roads are solid or even where they might be leading. As the driver progresses, he or she reaches paved roads that are more reliable and then moves on to the technology-supported interstate highway system, all the time having to deal with the challenge of some uncertainty as to the reliability of the information that is displayed on the highway. Since arriving at the right location depends in part on the choices made early in the trip, having to deal with marginal conditions in the beginning brings into question the certainty of knowing that when the driver arrives at the final location, the location is correct (ASFPM 2005).

FIGURE 3-1: Road Map of Computational Complexity



SOURCE: ASFPM Foundation (2005)

3.2 Delineation of the 1 Percent Floodplain

Once the elevation of the 1 percent flow has been determined, this flow must be applied to the topography of the floodplain under consideration to delineate the areal extent of the floodplain. Until the last decade of the 20th century, those mapping the floodplain relied on topographic information taken from maps with contours at a 10-foot or greater interval. Under these conditions it was not uncommon to have major inaccuracies in floodplain boundaries, placing some people outside the actual floodplain who should have been inside the boundary and vice versa.

New technologies have greatly improved the quality of map development and the move to highly accurate digital elevation data has dramatically changed the availability of high-resolution data. Now, it is possible, at a reasonable cost, to obtain 2- or even 1-foot (or less) topographic data.

With a recent initiative, FEMA, in support of the NFIP, has launched a five-year flood map modernization program to:

- Better reflect recent development and/or natural changes in the environment.
- Take advantage of revised data and improved technologies for identifying flood hazards.
- Support a flood insurance program that is more closely aligned with actual risk.
- Provide local communities and various stakeholders with more timely updates of floodplain maps and easier access to the data (FEMA 2006a).

Under the program, digital FIRMs will be developed using the most recent and best-available data and will replace the existing, earlier paper FIRMs. This will permit updates to be made rapidly in the face of changing conditions and for communities and other governmental organizations to tie flood maps into their local digital geographic information systems.

However, the accuracy of floodplain delineation will still rest on the resolution of the mapping data, the availability of stream and meteorological data, and the accuracy of the flow computations. When any or all are based on marginal data, the resulting product, while a best and reasonable estimate, still may not accurately reflect the "true" 1 percent flood level.

3.3 Terminology and Risk Perception

In a paper prepared for the Forum, Robert Ogle of the National Flood Determination Association (NFDA) pointed out that in 2003 his industry answered over 1.3 million customer service calls on behalf of its clients, noting that the "overwhelming majority of these calls reflect a true lack of understanding on the part of the general public as well as, local flood plain officials, surveyors, and insurance agents. Although more and more consumers have been made aware of the potential risk of loss due to flooding, as a result of the cooperative efforts of the NFIP, the NFDA, and the ASFPM, a great amount of confusion still exists." (Ogle 2004)

When the NFIP was initiated in 1968, most professionals used the term "100-year flood" to convey the standard. The description of the recurrence interval in these terms had been common for over 50 years. However, over time it became apparent that the public misunderstood the term, many believing that there was a 100-year interval between floods as opposed to a probability that over the long run, on average, there would be one such flood every 100 years. To better convey the probability component of the recurrence interval, in the late 1980s FEMA and much of the floodplain management community began stressing use of the "1 percent" terminology as better reflecting the actual hazard. As Jim Murphy pointed out in his paper for the Forum, FEMA, in FEMA 258, *Guide to Flood Maps*, "has attempted to further clarify the probability of such a flood occurring, saying that it has approximately a 26 percent chance of occurring during a 30-year period, which is the length of most home mortgages. In addition, numerous respondents to the FEMA Call for Issues in 1997-98 recommended that

FEMA stop using "100-year flood" and "500-year flood" on any NFIP-related products" (Murphy 2004).

While FEMA and State and local floodplain managers have started moving to the 1 percent terminology, much of the public has not and it is more likely today to see in the media the use of the 100-year flood, as opposed to the 1 percent flood when describing the NFIP standard. In the considerable press given to Hurricane Katrina-related flooding and the levels of protection required to bring New Orleans back to "safety," seldom, if ever, was there any reference to a percentage standard. The Administration, Congress, and even Federal agencies spoke in terms of 100-year, 250 year, and 500-year floods. To add to confusion, the computations of the recurrence interval for a hurricane-produced flood are different than those used in determining the recurrence intervals of riverine floods. Following Katrina, agencies frequently discussed the Katrina flood in both hurricane terms, Category 1, 2, 3, 4, or 5, and recurrence interval terms, even though there is no direct correlation.

As part of research related to the overall NFIP evaluation, AIR conducted a telephone survey of persons from 100 NFIP communities across the country, including flood insurance home and condominium policyholders and nonpolicyholders who lived in SFHAs or nearby. The purpose of the survey was to learn about perceptions of risk in flood insurance. Respondents were selected by using stratified random sampling to generalize to the population of NFIP policyholders and nonpolicyholders across all NFIP communities. The survey resulted in 870 respondents.

In one question, survey respondents were told that the risk of a flood occurring can be expressed in different ways – "in terms of how many floods, on average, are expected to occur in a specific span of time, or as the likelihood that a flood will occur in any given year." They were then asked, "Which do you think has a higher risk of flooding – a home in an area subject to a "100-year flood" or a home in an area subject to a "1 percent annual chance flood"? They were offered three responses: 100-year flood, 1 percent annual chance flood; and equal chance. Twenty-six percent said the 100-year had the higher risk of flooding, 48 percent indicated the 1 percent chance flood, 16 percent did not know, and only 9 percent provided the correct answer, equal chance (Shapiro and Evensen 2006). At the base level, less than 10 percent reflected sufficient understanding of the risk definitions to indicate that the 100-year and 1 percent terms represented the same risk. Almost twice as many selected the 1 percent designation, possibly reflecting the fact that this term may be in greater use by insurance personnel with whom the respondents have come into contact.

Hurricanes have introduced other risk communication issues. The ability of the National Weather Service to closely track hurricanes coupled with the availability of this information on news networks has made the public very aware of hurricanes and their characteristics. The public has become accustomed to hearing about "Category 5" and "Category 3" hurricanes. Since there is no apparent statistical relationship between the 1 percent flood and a specific hurricane category, it is difficult for the public to understand what flood impact a specific hurricane may have in an affected area, raising the question of how best to communicate risk in coastal zones.

Members of the WPC team conducted nonrandom surveys of four groups with some familiarity with floodplain management during professional meetings at which they were participants to determine their reaction to different terminology that might be used in communicating levels of risk. Group 1 was composed of senior civil engineers with a general knowledge of engineering practice; Group 2, professors in a civil engineering department with only three of the respondents familiar with floodplain management. Groups 3 and 4 were composed of professionals from multiple disciplines who are involved on a daily or frequent basis with floodplain management activities. Participants were asked to indicate which terms would best convey to the public the flood risk faced in their area. The question was posed to the group and each person submitted an answer in writing. Respondents were given five choices and the opportunity with the fifth choice to provide specific suggestions:

A. 1%, 0.5%, 0.2%, etc.
B. 100-year, 200-year, 500-year, etc.
C. Category 1, 2, 3, 4, 5.
D. Low risk, moderate, severe, etc.
E. Other.

The results of the survey are shown in Table 3-1.

TABLE 3-1: Responses of Groups to Risk Terms

Group Answer	Senior Civil Engineers	Engineering Academics	Floodplain Professionals	International Floodplain Professionals	Total	Percent
A - Percent	0	0	0	2	2	**4%**
B- Year	1	3	6	2	12	**23%**
C- Category	4	5	1	1	11	**21%**
D- Descriptive	6	8	4	2.5**	20.5	**39%**
E- Other	1	4	1	1.5**	7.5	**14%**
Total	**12**	**20**	**12**	**9**	**53**	

* Sum does not equal 100 because of rounding.
** One person split answers.

What is most obvious in the survey is the lack of support for use of the 1 percent standard as a means of conveying flood risk and the strong support for some form of more easily communicated descriptions of the flood threat.

Clearly the floodplain management community faces a difficult challenge in effectively conveying flood risk to the public and in defining the national standard. Nearly two decades of effort to push the 100-year terminology out of existence has not been successful. Any use of less-than-integer percentages to convey higher standards (0.2 percent) likely will face even more severe problems.

3.4 Observations

As noted in the quote in the frontispiece, the 100-year flood discharge is an elegant concept that has been transformed into a belief by the public that there is one 1 percent flood for a given river and that we can know all there is to know about that event. The problems in determining a 1 percent flood that can be used over time as an NFIP standard are very complex. Simplicity is not part of the equation.

In addition, public understanding of the 1 percent flood is limited and use of the 1 percent terminology instead of the 100-yea flood or some other description to describe the threat appears to be ineffective.

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4. ANALYZING THE RISK INSIDE AND OUTSIDE OF THE 1 PERCENT FLOOD ZONE

This chapter explores the impact of the 1 percent flood standard on National Flood Insurance Program (NFIP) loss experience in the NFIP claims data and by comparison to data and studies of other Federal programs. The primary questions addressed are:

- Do claims data suggest that the Nation is building to a 1 percent standard?
- What fraction of flood claims and losses accrue to properties at lower risk than the 1 percent standard?
- How would losses change by changing the standard that is what is the distribution of loss as a function of flood frequency?

The analyses were conducted based on data for the period 1978 to 2004 as data prior to 1978 are incomplete. All dollar values are adjusted for inflation and reported in 2005 values.[9] The chapter begins with a description of the NFIP claims database, and an analysis of overall trends in policies, claims, and losses. These trends confirm conclusions of other parts of the study (e.g., Bingham et al. 2005).

4.1 Flood Insurance Rate Maps (FIRMs)

The NFIP categorizes insured properties by the flood zone in which the property lies, as specified on the FIRM for the local community and as described in Chapter 2 of this report. For purposes of the present analysis, FIRM zones were grouped as indicated in Table 4-1. Zone A and all its variants are described simply as "Zone A," and similarly Zones V and VE are described as "Zone V."

TABLE 4-1: FIRM Flood Zone Designations

Zone	Denoted Here	Floodplain	Mandatory Insurance?
A, AEs, A#'s, AO, AR, A99	A	1 percent riverine	Yes
V, VE	V	1 percent coastal	Yes
D	D	Possible but undetermined	No
B	B/C/X	0.2 to 1 percent riverine	No
C	B/C/X	Less than 0.2 percent riverine	No
X	B/C/X	Outside identified high risk areas	No

Properties existing prior to the original mapping of the FIRM or December 31, 1974 are said to be "pre-FIRM" properties and are grandfathered into the NFIP at subsidized premium rates. Properties built after the mapping are said to be "post-FIRM" properties and pay actuarially determined premiums. Pre-FIRM properties hurt the actuarial soundness of the NFIP

[9] Inflation rates were based on the consumer price index as reported on *inflationdata.com* (2005). For reference, overall inflation from 1978 to date has been approximately 300 percent (*i.e.*, one dollar in 1978 is worth $2.99 in 2005).

because they enjoy premiums below fair actuarial rates. In theory, as more new properties have entered the program and many older properties become compliant or are replaced, the fraction of pre-FIRM properties in the program should decline, progressively increasing the actuarial soundness of the program. However, there are various factors in play that may limit the NFIP from moving away from being subsidized during extreme catastrophic years, including problems with worsening future conditions flooding or, from a fiscal perspective, whether Congress would allow the NFIP to actually build sufficient reserves to respond to the catastrophic year.

4.2 NFIP Policies and Claims Database

By the end of 2004, nearly 4.6 million NFIP policies were in place, and, since 1978 approximately 933,000 paid claims had been recorded, totaling $13.3 billion in actual payments, or $17.9 billion in 2005 adjusted payments.[10] It is, however, not uncommon for policyholders to carry the minimal coverage required to pay off a mortgage and not to elect optional contents coverage. Thus, flood losses for such insureds can be greater than the payments from the NFIP. Since inception of the program in 1968, the number of policies has grown on average 3.4 percent a year. The number approximately doubled from 1983 to 2003, reflecting implementation of the Flood Disaster Protection Act of 1973 and the Flood Insurance Reform Act of 1994. The number of claims per policy showed large variation in the first few years of the program, but stabilized quickly to somewhat above 1 percent. The ratio of claims per policy averaged 1.2 percent over the 26-year period, but in the most recent five years (1999-2004) it has averaged about 0.7 percent. Both the dollar loss per policy and the number of claims per policy vary considerably from one year to another.

NFIP coverage is provided both in *policies* (policies in force, PIF) and in *contracts* (contracts in force, CIF). Policies can either be on individual properties or for units in multiple ownership such as condominiums and cooperatives. Contracts generally represent individual buildings (i.e. all of the units in condominium building insured may be insured under a single contract). Thus, there is room for misunderstanding when policy numbers are used in calculations. In the present discussion, the terms *claims* and *losses* are used. In this context, *claims* means the number of policy payouts, while *losses* means the dollar value of the paid-out claims. The current analysis includes only NFIP data. Losses outside the NFIP, for example agricultural or infrastructure losses, are not considered, nor are losses to buildings not covered by the NFIP, for example uninsured buildings without Federally guaranteed mortgages. Such damages are important when attempting to understand total flood losses, but not for the present purposes of this chapter. Inclusion of losses outside the NFIP, especially those associated with agriculture, significantly increases the total loss associated with floods.

Individual losses under the NFIP are associated with a Flood Insurance Claims Office (FICO) number. The FICO is a claims processing office set up in a catastrophe area when a large number of claims result from a single event and is characterized by storm type (flood vs. hurricane) and by State. A single storm may have multiple FICOs if significant damages are

[10] Aggregate policy and claims data are available at *www.fema.gov/nfip* and are summarized in Bingham et al. (2006), Table 1, p.6.

claimed in multiple States.[11] A total of 498 FICOs have been established from 1978 to 2004, 359 associated with flood events and 102 with hurricane events. Not all claims, however, are associated with a FICO. Approximately 78 percent of all claims records ($11.1 billion in losses) are associated with an identifiable FICO. The remaining 22 percent ($3.2 billion in losses) are not. Thus, for the latter 22 percent the storm type is generally unknown.

4.3 Difficulties in Analyzing Policy and Claims Data

A number of difficulties face the analysis of policy and claims data from the NFIP database. Bingham et al., (2006) conclude that a primary focus of the NFIP should be refining data collection processes in order to ensure that all necessary information is captured to properly evaluate the program's actuarial soundness.

Policy data are originated at the time a policy is established and reside in a database of all policy information. Claims data are originated by the local claims adjustor and reside in a separate database of claims information. To obtain complete information on a policy and claims made under it, the two databases must be cross-referenced. Unfortunately, the claims records are often incomplete because the claims data are collected in the field by the local adjustor. For example, many claim records do not indicate base flood elevation or depth of flooding, and differentiation between wind and water losses is prone to error. Thus, individual policy or claims records are often missing critical fields, even when cross-referenced between the policy and claims databases. Also, in cases where the amount of flood insurance carried is less than the amount of damages, losses above the limit are not determined. The adjuster records the losses needed to reach the limit and then stops. Full damages are typically recorded only found when the policyholder has full replacement coverage.

The analysis of trends in NFIP policies and claims should be viewed as approximate. Claims data are highly variable from year to year, which makes the fitting of mathematical trends difficult and not as accurate. Scatter about such trends tends to be large and confidence in the corresponding parameter estimates somewhat low. Regressions and observations are sometimes inconsistent. Some data sources do not include all years or all data. Irregularities in data recording occur due to changes in nomenclature or human error. Loss events originating from the same storm may even be recorded in different years.

4.4 Aggregate Trends in NFIP Claims and Losses

Broad analyses of the policy and claims data were made to establish a background for the three questions addressed in this chapter. This included trends in policies, claims, and losses over time and claims and losses by type of storm, cause of loss, and State. Exponential regressions were fit to estimate rates of change, and R-squared values were used to test the goodness of the regressions for these trends.[12] The exponential function was chosen to approximate a constant

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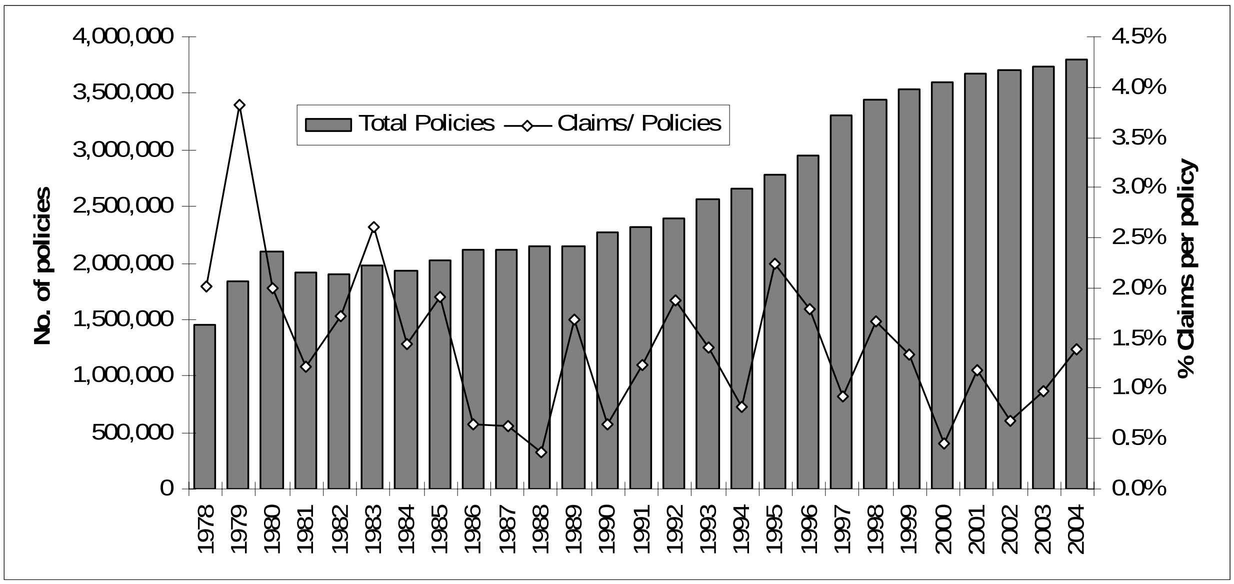
[11] Hurricane Floyd, for example, is recorded as five different FICO numbers, one for each State in which a significant number of claims was filed.

[12] The R-square statistic is the proportion of the variance of data explained by the regression, that is, R-square is the complement of the ratio of the variance of the data about a regression curve to the variance of the data absent the regression curve. An R-square approaching unity suggests a narrow fit of the data to the regression curve; an R-

rate of increase of decrease with time. In most cases, R-squared values are low, because year-to-year variations in claims and losses are highly erratic. Trends with time are weak and may be skewed by peaks or valleys in the data.

The number of policies and of claims per policy is shown in Figure 4-1. Claims per policy has decreased on average about 2½ percent a year, usually ascribed to a declining ratio of pre-FIRM to post-FIRM policies. However, this distinction does not account for administratively grandfathered policies. Some of this decline may be a function of the 1994 mandatory purchase requirements that broadened the policy base and likely pulled in more structures that experienced fewer floods.

FIGURE 4-1: Number of Policies and Percent of Policies on Which Claims Are Filed by Year.



SOURCE: National Flood Insurance Program, FEMA,

Distribution of the number of claims by year in 2005 dollars is shown in Figure 4-2. While the number of claims per policy has been declining, the absolute number of losses increased by approximately 1.6 percent a year (R^2=0.039) due to increasing numbers of policies. The total dollar value of losses shown in Figure 4-2 has been increasing on average 3½ percent a year (R^2=0.114).

The data in Figure 4-3 show trends in the numbers of claims and losses for only those claims with an associated FICO number, approximately 78 percent of the records. FICOs are categorized into “floods” and “other events” including hurricanes. Both the number of claims and the dollar value of losses from flood events (as opposed to hurricanes) show a decreasing trend. Claims related to flood events are decreasing at 9 percent a year; dollar value losses are decreasing at 7 percent a year. Dollar value per loss shows an increase of approximately two percent a year. The increase in dollar amount per loss is possibly explained by demographic growth in damage-prone areas, by an increase in the market penetration of flood insurance, or

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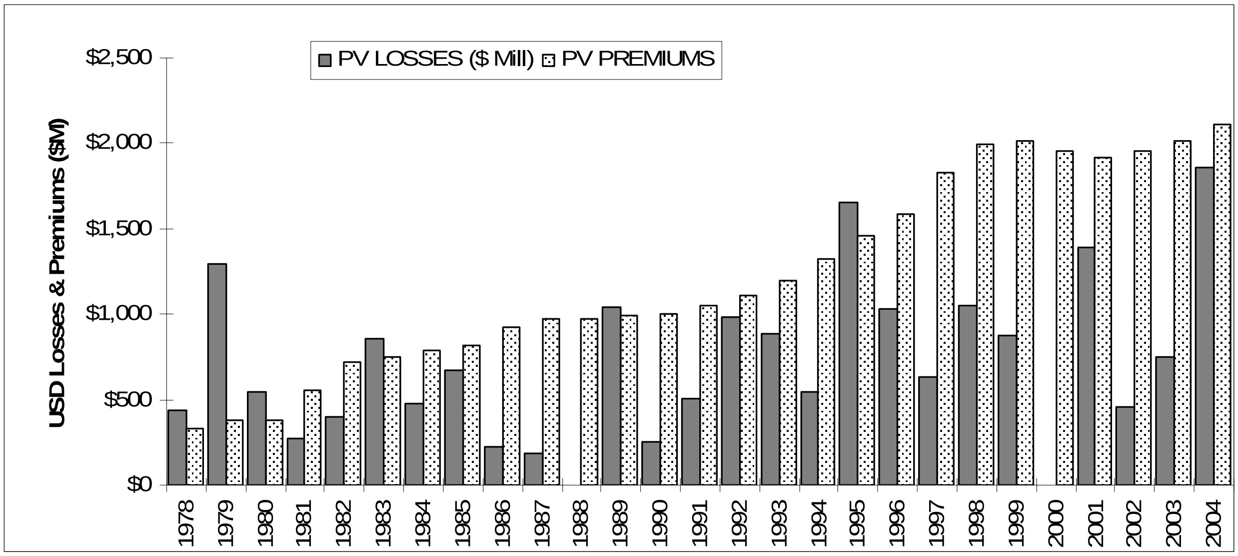
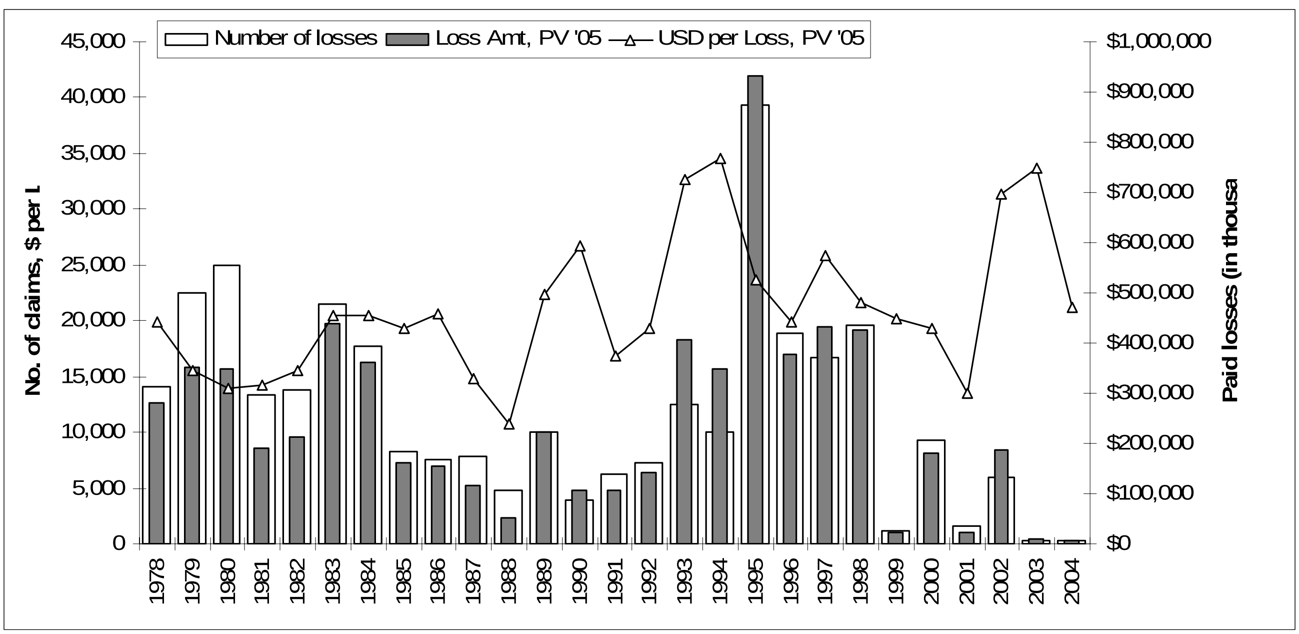
square approaching zero suggests that the data are nearly as variable about the corresponding regression curve as they are without the curve.

FIGURE 4-2: All NFIP Losses and Premiums, 1978-2004.



SOURCE: National Flood Insurance Program, FEMA; (loss amounts in 2005 dollars).

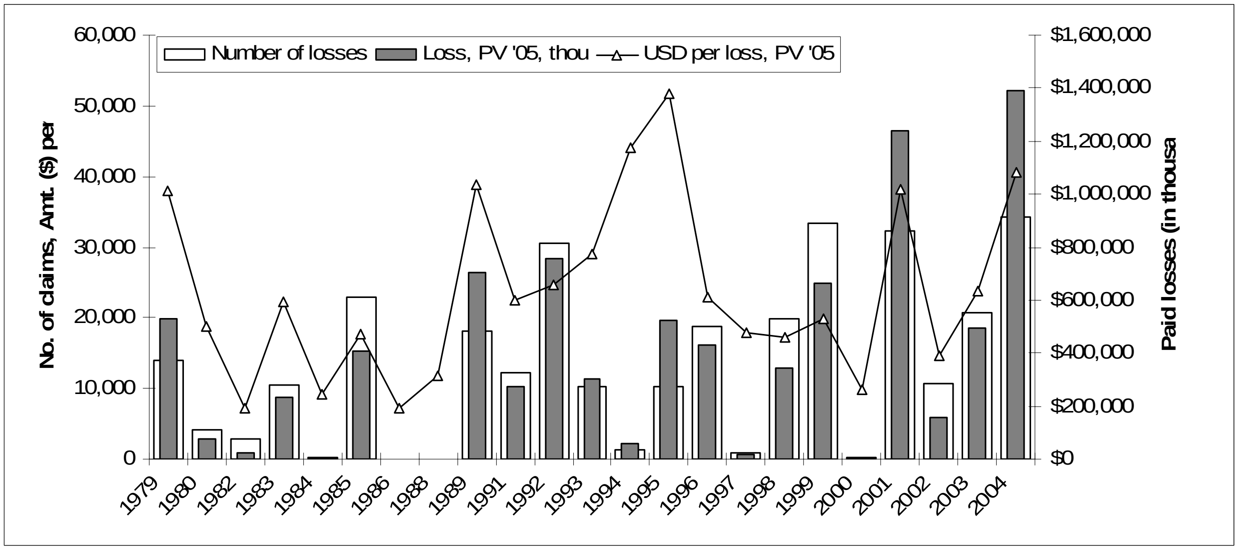
FIGURE 4-3. All Claims And Losses 1978-2004 For Fico Events Associated With Floods.



SOURCE: National Flood Insurance Program, FEMA both. It is also true that during the past decade real estate values in many areas subject to flooding, especially coastal areas, have risen substantially faster than inflation.[13]

In contrast to flood events, "all other" (i.e., hurricane) events show an increasing trend both in the number of claims and the dollar value of losses (Figure 4-4). The number of claims due to hurricane events is increasing 9.5 percent a year, and the dollar value of losses is increasing 12 percent a year. The dollar value per claim suggests of 2 percent increase per year for both floods and hurricanes.[14]

FIGURE 4-4: All Claims and Losses 1978-2004 for FICO Events Associated with Hurricanes.



SOURCE: National Flood Insurance Program, FEMA

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The geographical location of claims and losses is concentrated in a few States. Over the full history of the NFIP, losses due to both riverine floods and hurricane events have been concentrated in Texas, Florida, and Louisiana (Figure 4-5), whereas nonhurricane losses have been concentrated in Texas and Louisiana.

The following general conclusions can be drawn for aggregate trends in NFIP losses for the period 1978 to 2004: (1) overall losses per contract in place have increased at a rate of about 3¼ percent above inflation. The dollar amount per loss has increased at about 2 percent above inflation; (2) the increase in losses is principally due to events classified as hurricanes; and (3) losses are concentrated in relatively few States. Losses from flooding not associated with

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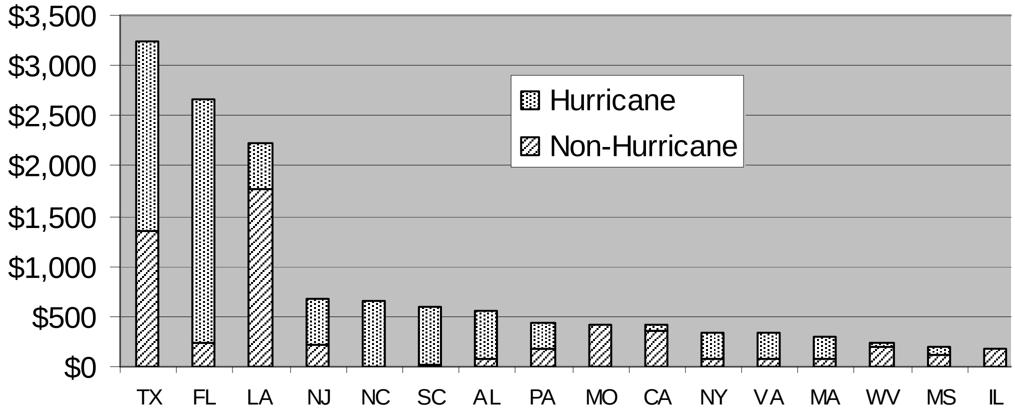
[13] NFIP claims are indexed by "cause of loss" in 12 categories. Few meaningful conclusions could be drawn from these cause-of-loss data. The codes and corresponding cause-of-loss descriptions are: (0) other causes; (1) tidal water overflow; (2) stream, river, or lake overflow; (3) alluvial fan overflow; (4) accumulation of rainfall or snowmelt (5) n/a (6) n/a (7) erosion – demolition (8) erosion – removal (9) earth movement, landslide, land subsidence, sinkholes, etc.; (A) closed basin lake. The majority of NFIP claims records are categorized as code 4, accumulation of rainfall or snowmelt, so there is little differentiation among the records.

[14] This may be due to coastal property values appreciating at a greater rate than inflation during the past decade, but no formal test of that hypothesis was made. Coastal properties, especially in Florida, have been appreciating faster than interior riverine properties in most parts of the country (Source: Office of Federal Housing Enterprise Oversight, HUD).

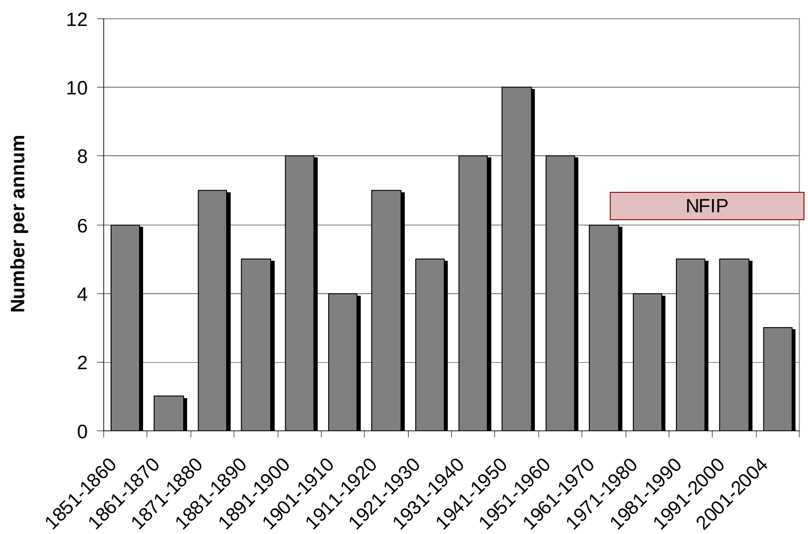
hurricanes are decreasing. Whether this remains true into the future has been deeply affected by the 2005 storm-year experience (i.e., Katrina) and by the observation that the period 1968-2004 experienced many fewer significant tropical storms than did earlier decades (Figure 4-6), although this trend is not reflected in the national flood loss statistics compiled by NOAA.

FIGURE 4-5: Losses by State, Sum of All Payments 1978-2004. FICO Event Only, Separated by Event Type. Note that Hurricane Losses in WV Are Due to Hurricanes Ivan And Fran.



SOURCE: National Flood Insurance Program, FEMA

FIGURE 4-6: Number of Severe Hurricanes (Category 3 or Above) in the Gulf of Mexico and Atlantic Ocean by Decade, 1968-Present



SOURCE: NOAA

4.5 Do Claims Data Suggest that the Nation Is Building to a 1 Percent Standard?

Whether the NFIP is inducing people to build to the 1 percent standard should, in principle, be reflected in the frequency of claims and size of losses reported to the program. That is, is the experience reflected in NFIP claims data consistent with a nominal 1 percent risk? This is mitigated by the extent to which individuals are building correctly to a standard that is out of date due to outdated maps, for example, if communities are not managing to future conditions and keeping maps updated. "Risk" for the present purpose is taken to be that faced by insured properties within A and V zones. If this is actually 1 percent or less, then the frequency of occurrence of claims, or the proportional dollar losses per insured value, should both be no more than 1 percent.

Two measures were chosen to assess the risk faced by NFIP-insured properties: (1) the ratio of the number of claims to the number of contracts in force and (2) the ratio of claim losses to insured valuation. As noted earlier, however, if claim losses arise from a policy base within which a high percentage of policy limits are below building value, then claim losses will underestimate actual losses. Each of these provides an estimate of risk as an historical frequency. Insured properties within A and V zones should exhibit numbers of claims per CIP and losses per insured valuation at rates below 1 percent. From the view of actuarial soundness (Bingham et al. 2006), the rates of claims and of losses must be sufficiently lower than 1 percent to account for the cost of managing the flood insurance program. To the extent that the nominal risk of flooding in zones other than A and V is less than 1 percent, one would expect the rates of both claims and of losses to be much less than 1 percent for properties insured in zones B, C, D, and X.

Pre-FIRM properties did not benefit from the beneficial influence of the NFIP on standards, and so the claims and losses reported on pre-FIRM properties should reflect land use and building practices prior to the standard, but post-FIRM properties should be reporting claims and losses that are consistent with the 1 percent standard. If people are building to the 1 percent standard, then flood events with greater frequency (e.g., 50-year floods) should not generate significant damages in post-FIRM properties, and the frequency of all claims per policy, presumably caused mostly by floods of lower than 1 percent frequency (e.g., 500-year floods), should be less than 1 percent. This is, in fact, the case, at least for riverine floods. It is not the case for coastal special hazard (V) zones.

Table 4-2 shows the number of claims per contracts in force (CIF) as a function of pre-FIRM versus post-FIRM designation. In keeping with standard practice at FEMA, CIF rather than policies in force (PIF) is used to normalize claims numbers. CIF differs from PIF in that it aggregates the possibly multiple policies within a condominium or cooperative into a single contract. The overall rate of claims per CIF for the period 1978-2004 is 1.36 percent for all policies, 1.67 percent for pre-FIRM, and 0.64 percent for post-FIRM contracts. That is, pre-FIRM contracts have generated claims at about a 60-year return period and post-FIRM contracts at about a 156-year return period, averaged across all zones. Both rates were somewhat higher in the most recent year of record, 2004, especially the post-FIRM rate, and especially for coastal (V) zones.

Within riverine special hazard (A) zones, the number of claims per CIF has averaged 1.66 percent for pre-FIRM and 0.60 percent for post-FIRM properties. This suggests that within the FIRM 1 percent flood zone the NFIP has reduced the frequency of damages for insured properties to substantially under the nominal 1 percent risk of flooding. The trend with time for the claims ratio averaged over all zones and properties has been declining by about 4 percent a year, which might be explained by the growth in the ratio of post-FIRM to pre-FIRM policies.

TABLE 4-2: Policy Risk by Hazard Zone in Percent for Pre- and Post-FIRM Policies.

Claims/CIF	A	V	B/C	X	Blank[15]	Average
post-FIRM	0.60	2.04	0.74	0.63	0.11	0.64
pre-FIRM	1.66	2.48	1.00	1.26	3.00	1.67
All policies	1.32	2.36	0.92	1.06	3.00	1.36

As of 2005, only about 25 percent of policies are pre-FIRM and subsidized. Why a similar reduction should occur for the B/C and X zones is less obvious. However, since flood insurance within these zones is voluntary, the fraction of properties insured is lower than in A zones and selective on the part of the insured. Thus, the statistics likely reflect a biased sampling of properties (i.e., adverse selection). The population as a whole should be expected to have a lower claims rate.

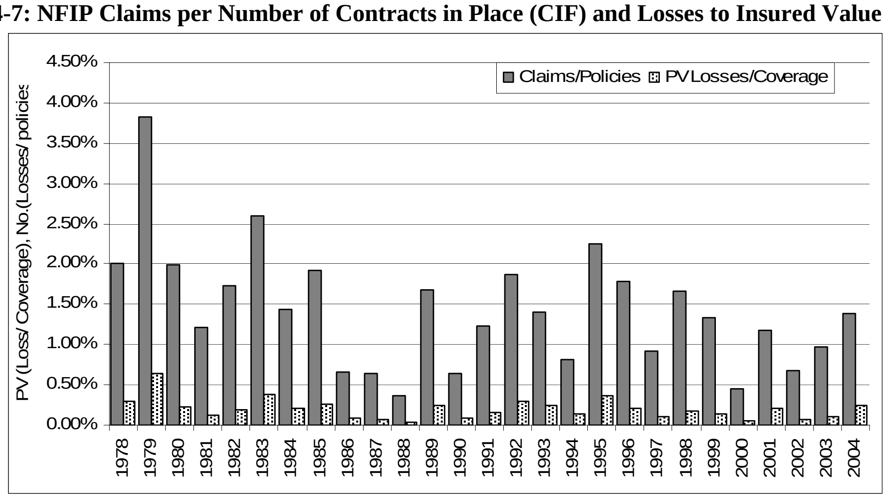
Analysis of policy histories for properties in zones B/C/X, as discussed below, indicates higher than expected rates of claims and losses. One supposition is that some of these properties – and disproportionately those whose owners seek to insure under the NFIP – are in fact at higher risk than indicated on the FIRMs, and this fact is known to or suspected by the owners, which is why they seek to insure the properties even though not required by statue to do so. In the language of the insurance industry, this is called *adverse selection*. The policies bought for properties in zones B/C/X are most likely not a random sampling, but biased toward the higher risk properties. Adverse selection is, of course, a drain on the NFIP fund since the B/C/X owners are paying for a lower risk than they actually experience. Within special hazard coastal (V) zones, the number of claims per CIF is reduced slightly for post-FIRM compared to pre-FIRM properties but remains at least twice the nominal 1 percent value. This is unrelated to the steeply appreciated values of properties within coastal zones since, in principle, the statistic deals only with the frequency of damages and not the corresponding monetary loss. Land use planning and construction standards inspired by the NFIP may not be as effective in coastal zones as in riverine zones, the FIRMs for coastal zones are less accurate than for riverine zones, or there are more compliance problems in coastal zones. This also may reflect, in part, that V zone buildings can have claims in floods of greater than 1 percent frequency, (which is reflected in the higher rates that they pay). Any time a storm surge is under the building, a claim is possible and even likely.

[15] "Blank" zone are those properties, mostly from early in the history of the NFIP, for which no zone is designated. The rate of claims for post-FIRM blank zones is small possibly because the absolute number of such properties is small.

In addition to the number of claims per CIF, the ratio of monetary losses to insured value should reflect the 1 percent standard since one would expect that the occurrence of the 1 percent flood would generate significant losses in the 1 percent zone and fewer outside that zone. Unlike the claims data, however, the loss ratio should be sufficiently less than 1 percent to account for operating costs of the program and will also be affected by the inflation-adjusted appreciation of building costs. The loss ratio statistics also appear to confirm the contention that the Nation is building to a 1 percent standard: the loss ratio since 2000 is approximately 0.2 percent. Since neither the ratio of claims to policies nor of losses to insured value reflects the premium paid by the insured, these 1 percent targets should hold true regardless of whether policies are fairly priced for actuarial risk. Absolute losses in both A zones and B/C/X zones are increasing, but total insured value is increasing at a faster rate. The absolute value of losses in V zones, while large compared to insured value, is small compared to riverine flood losses.

Whether premiums are priced at a fair actuarial rate has been addressed by Bingham et al. (2006). From 1978 to 1999, flood insurance losses grew erratically, especially pre-FIRM losses, at a yearly rate of 2.6 percent above inflation. Premiums rose steadily at 6.8 percent above inflation until 1999, but have settled since then. Yearly premium dollar amounts and the number of active policies, have remained relatively flat at $1.7 billion and 4.5 million policies since 1999, suggesting that market penetration has tapered off at those numbers. However, while in certain high-loss years (e.g., 1989, 1995, 2004) losses have approached premiums, on average losses have remained lower than premiums, especially for post-FIRM properties. Whether this remains true into the future has been deeply affected by the 2005 storm year experience (i.e., Katrina) and by the observation that the period 1968 to 2004 experienced many fewer significant tropical storms than did prior decades (Figure 4-7).

FIGURE 4-7: NFIP Claims per Number of Contracts in Place (CIF) and Losses to Insured Value (coverage).



SOURCE: National Flood Insurance Program, FEMA

4.6 What Fraction of Flood Claims and Losses Accrue to Properties at Lower Risk Than the 1 Percent Standard?

Properties insured within A and V zones, in principle, should be exposed to a 1 percent per annum risk. Properties insured within B, C, and D zones should, in principle, be exposed to less than 1 percent per annum risk. Potentially, these latter properties should be exposed to much less risk. Do the NFIP claims data bear out this relationship, and what fraction of claims and losses are associated with properties that should be at lower risk than the 1 percent standard?

The claims and loss experience of the NFIP by hazard zone is shown in Table 4-3. The top table shows data for all policies, the middle table shows data for pre-FIRM policies, and the bottom table shows data for post-FIRM policies. The last four rows in each of the three tables show the percentages of contracts in force, claim numbers, dollar losses, and dollar premiums.

Focusing on just the post-FIRM data, since these are intended to be actuarially fair, A zone policies account for 67 percent of the contracts in force (CIF), 63 percent of the number of claims, and 58 percent of present value losses. That is, they account for somewhat fewer claims and somewhat less loss than their pro rata share based on numbers of contracts. The opposite is true for V zone policies, which account for 2.0 percent of the contracts in force but 6.35 percent of the number of claims and 8.01 percent of the present value losses. Thus, the number of claims per contract in place for V zone policies is more than three times higher than for A zone policies. This is in part balanced by the fact that the average ratio of premiums to coverage for V zone properties is twice that for A zone properties.

Policies in B, C, and D zones (all listed under “D” in the tables) have lower numbers of claims per CIF and present value losses per CIF than do A zone policies. These are the properties that are nominally at lower risk than the 1 percent standard. However, the absolute proportion of policies in those zones is almost negligible. Thus, the fraction of flood claims and losses accrued to properties at lower risk than the 1 percent standard in these zones is itself almost negligible due to the low number of contracts in force.

Policies in X zones account for about one-third of the post-FIRM contracts in force and also for a pro rata share of the total number of claims and present value losses, even though the average premium to coverage ratio is the least of all for X zone properties. Those properties insured in these unmapped zones appear to have as high a risk as do insured properties in A zones, suggesting that property owners electing to insure within X zones may be aware of the flood risks they face, even if the zone in not mapped.

4.7 How Would Losses Change by Changing the Standard?

How would losses change if instead of requiring flood insurance on all structures within the 1 percent floodplain the mandate was changed to, for example, require insurance within the 0.5 percent (200-year) or 0.2 percent (500-year) floodplain? The question resolves to the distribution of loss as a function of flood frequency. Specifically, a great number of structures are located outside the 1 percent floodplain but within the 0.5 percent or 0.2 percent floodplains. The requirement of the NFIP that properties within A and V zones be insured but not properties within B/C/X zones presumably contributes to development just outside the 1 percent floodplain.

TABLE 4-3: Claims and Loss Experience by Hazard

All FIRM's

		ZONE					
	Data[1]	A	D	V	X	(blank)	Grand Total
Absolute Figures	Sum of Claims	589,261	2,961	36,097	215,592	112,610	956,521
	Sum of CIF (cumulative)	44,553,113	165,657	1,530,992	20,419,727	3,749,640	70,419,129
	Sum of PV LOSS PAYMENTS	$12,446	$65	$973	$4,681	$1,485	$19,650
	Sum of PV COVERAGE	$6,887,537	$17,516	$283,769	$3,548,061	$257,909	$10,994,793
	Sum of PV PREMIUMS	$22,720	$81	$1,597	$7,574	$1,120	$33,092
Ratios	No. claims/policies (CIF)	1.32%	1.79%	2.36%	1.06%	3.00%	1.36%
	Ave. Loss/ Claim (Loss $/ No. claims)	$21,121	$22,117	$26,944	$21,713	$13,188	$20,543
	Premium/ coverage	0.33%	0.46%	0.56%	0.21%	0.43%	0.30%
	Loss/ coverage ($/$)	0.18%	0.37%	0.34%	0.13%	0.58%	0.18%
% of Total	Claims	61.60%	0.31%	3.77%	22.54%	11.77%	100.00%
	No. of policies, CIF	63.27%	0.24%	2.17%	29.00%	5.32%	100.00%
	PV loss Payments	63.34%	0.33%	4.95%	23.82%	7.56%	100.00%
	PV premiums	68.66%	0.24%	4.83%	22.89%	3.39%	100.00%

Notes
1. Except "Loss/ claim" values, all figures are in Millions
2. All figures are calculated using cumulative values since 1978

POLICY_YR **(Multiple Items)**
POST-FIRM INDICATOR **Pre-FIRM**

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		ZONE					
	Data	A	D	V	X	(blank)	Grand Total
Absolute Figures	Sum of No. LOSSES	502,927	2,749	27,396	173,775	112,608	819,455
	Sum of CIF	30,278,271	136,829	1,104,188	13,763,244	3,747,876	49,030,408
	Sum of PV LOSS PAYMENTS	$10,496	$59	$702	$3,528	$1,485	$16,271
	Sum of PV COVERAGE	$3,848,690	$13,450	$173,965	$2,137,093	$257,337	$6,430,536
	Sum of PV PREMIUMS	$16,396	$61	$956	$4,897	$1,119	$23,428
Ratios	No. claims/policies (CIF)	1.66%	2.01%	2.48%	1.26%	3.00%	1.67%
	Ave. Loss/ Claim (Loss $/ No. claims)	$20,871	$21,486	$25,617	$20,304	$13,187	$19,855
	Premium/ coverage	0.43%	0.45%	0.55%	0.23%	0.43%	0.36%
	Loss/ coverage ($/$)	0.27%	0.44%	0.40%	0.17%	0.58%	0.25%
% of Total	Claims	61.37%	0.34%	3.34%	21.21%	13.74%	100.00%
	No. of policies, CIF	61.75%	0.28%	2.25%	28.07%	7.64%	100.00%
	PV loss Payments	64.51%	0.36%	4.31%	21.69%	9.13%	100.00%
	PV premiums	69.98%	0.26%	4.08%	20.90%	4.78%	100.00%

Notes
1. Except "Loss/ claim" values, all figures are in Millions
2. All figures are calculated using cumulative values since 1978

POLICY_YR **(Multiple Items)**
POST-FIRM INDICATOR **Post-FIRM**

		ZONE					
	Data	A	D	V	X	(blank)	Grand Total
Absolute Figures	Sum of No. LOSSES	86,334	212	8,701	41,817	2	137,066
	Sum of CIF	14,274,842	28,828	426,804	6,656,483	1,764	21,388,721
	Sum of PV LOSS PAYMENTS	$1,949	$6	$271	$1,153	$0	$3,380
	Sum of PV COVERAGE	$3,038,847	$4,067	$109,804	$1,410,968	$572	$4,564,257
	Sum of PV PREMIUMS	$6,324	$20	$642	$2,677	$1	$9,663
Ratios	No. claims/policies (CIF)	0.60%	0.74%	2.04%	0.63%	0.11%	0.64%
	Ave. Loss/ Claim (Loss $/ No. claims)	$22,580	$30,297	$31,125	$27,566	$47,569	$24,656
	Premium/ coverage	0.21%	0.48%	0.58%	0.19%	0.23%	0.21%
	Loss/ coverage ($/$)	0.06%	0.16%	0.25%	0.08%	0.02%	0.07%
% of Total	Claims	62.99%	0.15%	6.35%	30.51%	0.00%	100.00%
	No. of policies, CIF	66.74%	0.13%	2.00%	31.12%	0.01%	100.00%
	PV loss Payments	57.68%	0.19%	8.01%	34.11%	0.00%	100.00%
	PV premiums	65.44%	0.20%	6.64%	27.70%	0.01%	100.00%

Notes
1. Except "Loss/ claim" values, all figures are in Millions
2. All figures are calculated using cumulative values since 1978

Watershed Concepts, a FEMA contractor, has recently analyzed the area between the 1 percent flood line and the 0.2 percent flood line for the Mapping on Demand Team and FEMA using census data and GIS. It estimates that, in areas where detailed flood studies have been completed, there are 2 million to 4 million structures. In areas where only approximate studies have been completed there are 1.5 million to 3 million structures. Taken together Watershed Concepts estimates the total to be 3 million to 6 million structures. The current policy base includes 4.5 million structures and it is estimated that there are 117 million housing units in the United States (Edelman 2006). RAND estimates that number of single family homes (SFH) in SFHAs nationwide may be between 2.9 and 4.2 million (Dixon et al. 2006).

The NFIP claims data are inadequate for the purpose of estimating a relationship between flood frequency and damage. The market penetration of flood insurance in zones other than A or V is relatively small and probably not statistically representative of the properties in B/C/X zones. Thus, claims data outside the 1 percent floodplain are not representative of the risk in those zones.

Two indirect approaches were used to estimate the relationship of flood frequency to damage: (1) direct surveys by USACE in performing economic studies for flood hazard damage reduction projects and (2) HAZUS modeling studies of representative communities. In both cases, the analysis performs a full-enumeration accounting of properties located inside and outside the 1 percent floodplain as recorded in property tax rolls and other databases. The resulting damage estimates are forecasts, not records from historical floods, but they reflect the location and elevation of buildings within the floodplain and the publicly recorded (e.g., assessed) values of those properties.

4.7.1 USACE Economic Studies for Flood Hazard Damage Reduction Projects

In planning for flood hazard damage reduction projects, USACE performs economic analyses to ascertain whether proposed projects will return benefits to the U.S. economy in excess of their projected cost. These economic studies involve a detailed survey of structures within floodplain areas intended for protection and an assessment of the flood damages that could be avoided by projects providing various levels of protection. The levels of protection are measured by the flood frequencies against which levees, dams, or other project elements are to be planned. Thus, the USACE economic studies lead to fully enumerated surveys that assess a complementary cumulative frequency distribution (i.e., an exceedance curve) of flood damage as a function of flood probability.

In the course of this study, USACE economic analyses of flood damages were identified for 43 river reaches or basins and two coastal zones, and corresponding flood damage estimates were obtained. Cumulative damage estimates for each reach or basin were identified for the 10 percent, 2 percent, 1 percent, 0.5 percent, and 0.2 percent floods. In some cases, damages for other flood frequencies could also be determined. Damage exceedance values for a subset of these reaches are shown in Table 4-4 for various locations in the Midwest and Eastern United States. Similar data were obtained for various streams within the USACE Kansas City District and for various locations in California.

Table 4-4: Flood Damage Estimate Exceedances and Ratios for Various River Reaches within Various Midwest, Eastern, and California USACE Districts

River Reach:	Exceedance Probability					Damage Ratio to 100-year Flood			
	0.002	**0.005**	**0.01**	**0.02**	**0.1**	**"500/100"**	**"200/100"**	**"50/100"**	**"10/100"**
Mill Creek	867	800	768	702	129	1.13	1.04	0.91	0.17
Antelope Creek	2,085	1,800	1,514	1,008	365	1.38	1.19	0.67	0.24
Beargrass Creek, SF	123	75	46	24	7	2.70	1.65	0.53	0.15
Beargrass Creek, Buechel	4,325	3,500	2,812	2,279	890	1.54	1.24	0.81	0.32
Hamilton	22,000	8,000	5,000	2,100	100	4.40	1.60	0.42	0.02
Upper Passaic River, NJ	11,990	9,500	7,884	5,240	1,674	1.52	1.20	0.66	0.21
Fort Fairfield, Maine	7,296	6,000	5,159	4,031	1,229	1.41	1.16	0.78	0.24
Ada, MN	10,941	6,000	2,613	1,297	827	4.19	2.30	0.50	0.32
Valley City	23,925	22,754	11,007	7,757	4,500	2.17	2.07	0.70	0.41
St Mary's	788	745	690	625	414	1.14	1.08	0.91	0.60
St. Joseph	145	129	111	92	51	1.30	1.16	0.83	0.46
Maumee	495	486	474	457	382	1.04	1.03	0.96	0.81
Grafton	57,782	57,016	48,316	39,463	7,265	1.20	1.18	0.82	0.15
Dawson	2,963	2,500	1,872	1,425	363	1.58	1.34	0.76	0.19
Tehama	10,773	7,601	4,850	2,534	331	2.22	1.57	0.52	0.07
Auburndale	34,296	11,746	8,545	5,404	33	4.01	1.37	0.63	0.00
Fairfax	2,084,656	2,007,222	1,928,200	1,555,011	808,654	1.08	1.04	0.81	0.42
North Kansas City	1,555,178	1,440,814	1,317,424	1,058,220	539,828	1.18	1.09	0.80	0.41
East Bottoms	2,488,966	2,105,935	1,859,914	1,383,852	431,756	1.34	1.13	0.74	0.23
Birmingham	219,158	205,554	192,304	164,391	108,567	1.14	1.07	0.85	0.56
C.I.D.	418,753	354,481	285,154	204,025	41,771	1.47	1.24	0.72	0.15
Argentine	1,414,360	1,276,715	1,130,759	840,435	259,804	1.25	1.13	0.74	0.23
Armourdale	1,277,806	1,180,650	1,069,185	775,259	187,425	1.20	1.10	0.73	0.18
L-455 downstream	313,634	299,231	278,419	243,690	142,540	1.13	1.07	0.88	0.51
L-455 upstream	392,755	310,290	245,831	182,971	81,355	1.60	1.26	0.74	0.33
R-460-471 downstream	204,034	187,140	166,400	131,032	57,618	1.23	1.12	0.79	0.35
R-460-471 upstream	153,644	151,339	148,503	140,974	115,900	1.03	1.02	0.95	0.78
Waterworks	46,082	21,835	2,964	1	1	15.55	7.37	0.00	0.00
Auburndale	34,296	11,746	8,545	5,404	33	4.01	1.37	0.63	0.00
South Topeka	799,996	587,168	448,860	277,347	25,925	1.78	1.31	0.62	0.06
Oakland	521,835	336,929	209,471	105,379	8,133	2.49	1.61	0.50	0.04
North Topeka area 1	1,010,736	659,994	524,868	406,182	47,660	1.93	1.26	0.77	0.09
North Topeka area 2	938,417	677,306	567,006	463,236	125,685	1.66	1.19	0.82	0.22
Blue River Basin	1,718,100	1,335,900	823,700	533,000	14,200	2.09	1.62	0.65	0.02
Average						**2.24**	**1.48**	**0.71**	**0.26**
Std Dev						**2.50**	**1.06**	**0.18**	**0.21**

SOURCE: USACE.

How representative are these 43 river reaches of communities that are part of the NFIP? There is no quantitative answer, only intuitive ones. To begin, each of the reaches in the Corps studies is part of the NFIP, and thus the set represents a sample of all the communities within the program. The sample, however, is not random. To begin, each reach is the subject of a Corps of Engineers planning study in justification for a flood hazard damage reduction project. Such projects are not randomly located around the river basins of the country but occur where there is residential and commercial development to protect and where local stakeholders have some level of political influence to have projects planned. Second, the 43 projects are located principally in the greater Mississippi basin, the mid-Atlantic, and the Sacramento-San Joaquin valleys. Thus, they are not located in the highest damage States, namely, Florida, Louisiana, and Texas. To the extent that floodplain land use patterns differ significantly across these regions, the damage ratios also will differ.

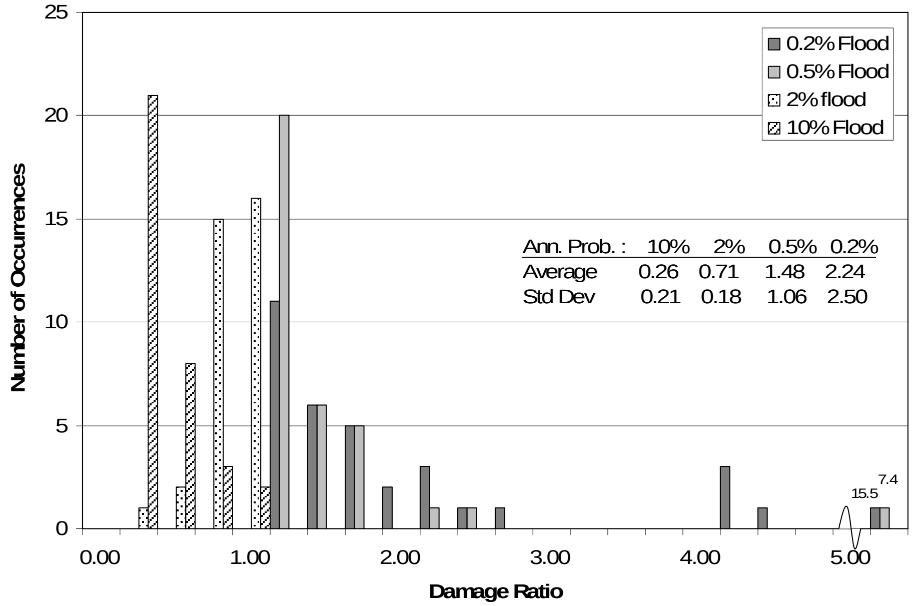
To summarize these damage estimates, ratios were calculated of the estimated flood damages caused by 0.2, 0.5, 2, and 10 percent floods, respectively, compared to estimated damages caused by a 1 percent flood. Histograms of these ratios for 34 river reaches are shown in Figure 4-8. The average damage ratio for the 0.2 percent flood is 2.24; for the 0.5 percent flood, 1.5. This means that the 0.2 percent flood is expected to cause 2.24 times as much damage as the 1 percent flood. The 0.5 percent flood is expected to cause 1.5 times as much damage as the 1 percent flood.

Only two V zone damage estimates were obtained; for Marin County, CA, and Union Beach, NJ. The 0.2 percent and 0.5 percent storm damage ratios in these studies are much lower than in the riverine cases. In the Marin County case, the 0.2 percent damages are essentially the same as the 1 percent damages.

4.7.2 HAZUS Analyses

Two sets of HAZUS runs were reviewed for comparison with USACE estimates of the ratio of damages at different flood frequencies. The first set comprised new HAZUS runs for a selection of river reaches approximately corresponding to USACE damage estimates (Table 4-5). These estimates should not be expected to exactly mimic those of USACE because the reaches are only approximately the same, but the numerical values are the same order of magnitude. However, the damage ratios generated by the HAZUS analyses were typically much smaller than those in USACE analyses. The average damage ratio for the 0.5 percent-flood relative to the 1 percent-flood was 1.11, and the average damage ratio for the 0.2 percent flood was 1.34. The second set was obtained from the University of Maryland, Eastern Shore (UMES), for various river counties in Maryland (Figure 4-9). These studies are relevant because they are among the few that could be identified that were both available in detail. The UMES study analyzed flood losses by county for the State of Maryland, generating estimates for the 2, 1, and 0.2 percent floods. As with the HAZUS analyses of USACE reaches, these show lower damage ratios than USACE studies. The 0.2 percent flood damage ratio is approximately 1.8 across the seven counties studied.

FIGURE 4-8: Ratio of Estimated Flood Damages for 10 Percent, 2 Percent, 0.2 Percent and 0.5 Percent Floods Relative to Damages Estimated for 1 Percent Flood, for 34 River Reaches.



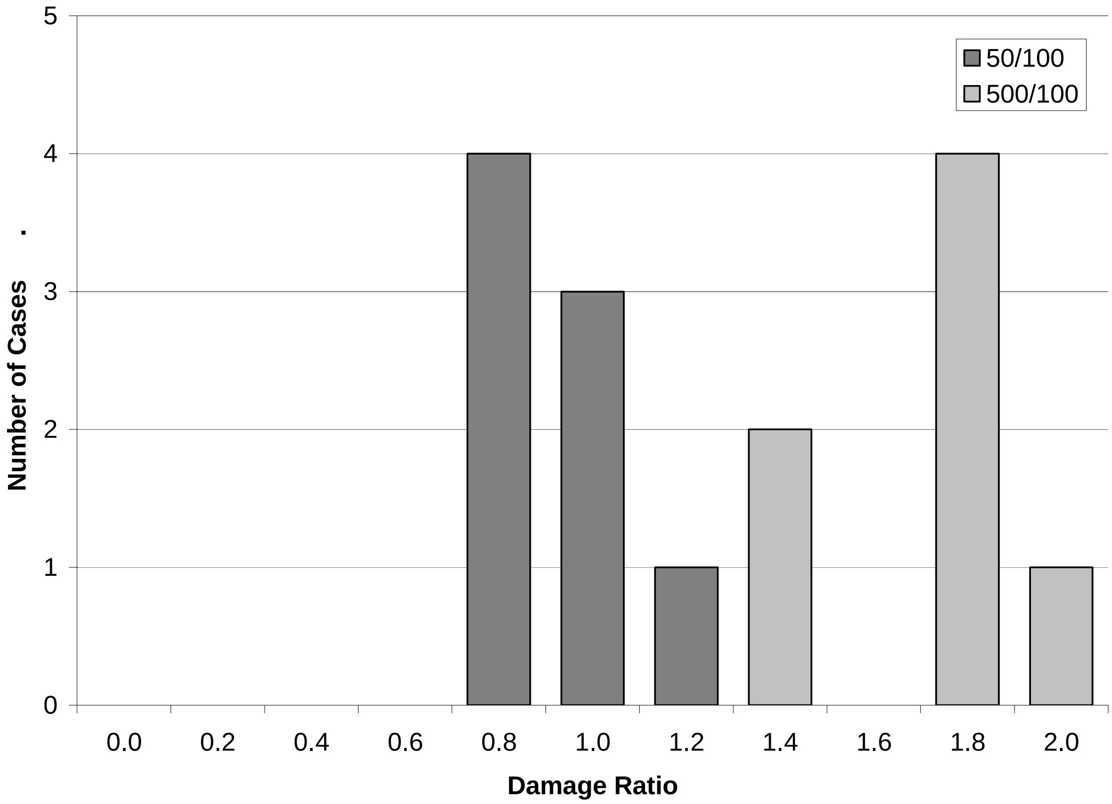
SOURCE: USACE.

TABLE 4-5: Exceedance Probabilities of Flood Damages for River Reaches Studied by the USACE Calculated Using HAZUS.

River reach	Exceedance Probability					Damage ratios to 100-year flood		
	0.1	0.02	0.01	0.005	0.002	**50 / 100**	**200 / 100**	**500 / 100**
Antelope Creek, NE, Residential, Tot.		15,851	18,330	19,340	24,576	**0.86**	**1.06**	**1.34**
Beargrass Creek, KY		4,703	4,875	5,829	7,148	**0.96**	**1.20**	**1.47**
Missouri River, Kansas City, MO, All	721	838	883	572	318			
Alamance, NC, All	750	963	1,137	1,196	1,260	**0.85**	**1.05**	**1.11**
San Jacinto River, TX, Res	3,169	6,730	7,861	9,453	8,539	**0.86**	**1.20**	**1.09**
Hamilton City, CA	4,951	6,213	5,946	6,645	7,046	**1.04**	**1.12**	**1.18**
Antelope Creek, NE, Residential, Pre		15,848	18,327	19,334	24,565	**0.86**	**1.05**	**1.34**
Antelope Creek, NE, All, Pre		16,499	19,151	20,399	25,751	**0.86**	**1.07**	**1.34**
Missouri River, Kansas City, MO	721	838	883	572	318	**0.36**	**0.65**	**0.95**
Alamance, NC, Residential	630	804	939	1,008	1,041	**0.86**	**1.07**	**1.11**
San Jacinto, TX, All	3,859	8,455	9,981	11,745	10,942	**0.85**	**1.18**	**1.10**
Hamilton City, CA, Depreciated	2,939	3,325	3,710	4,104	8,470	**0.90**	**1.11**	**2.28**
Mill Creek, OH (Hamilton Cnty.)[1]						**0.89**	**1.11**	**1.34**
Sacramento River[2]						**0.06**	**0.06**	**0.34**

SOURCE: HAZUS

FIGURE 4-9: Ratio of Estimated Flood Damages for 2 Percent and 0.2 Percent Floods Relative to Damages Estimated for 1 Percent Flood, for Eight Maryland Counties



SOURCE: University of Maryland Eastern Shore Data Based on HAZUS

4.8 Observations

The answers to the three primary questions addressed by the statistical analysis of the claims data are the following. First, do claims data suggest that the Nation is building to a 1 percent standard? The answer is yes, at least for riverine flooding. The rate of claims per policy and dollar loss per insured value is both comfortably below 1 percent for post-FIRM properties in SFHA A zones. For pre-FIRM properties the ratios are higher. However, both the claims ratio and loss ratio for coastal V zones are substantially greater than the nominal 1 percent, suggesting that building within V zones is not to the 1 percent risk standard. Inferences are more difficult to draw for properties in B/C/X zones, and both the claim ratio and loss ratio seem higher than would be expected for these properties, perhaps due to adverse selection of who in these zones purchases insurance.

Second, what fraction of flood claims and losses accrue to properties at lower risk than the 1 percent standard? Historically, about one-third of claims and losses accrue from properties that are rated as being in other than in SFHA A and V zones. This is also in proportion to the ratio of the number contracts in these zones. A noteworthy observation is that the ratios of claims per contracts in force and of losses to insured value are both slightly higher for properties in B/C/X and D zones than for properties in A zones.

Third, how would flood damages change by changing the standard (i.e., what is the distribution of loss as a function of flood frequency)? Forecasts by USACE and from the HAZUS model suggest that total damages for the 0.5 percent (200-year) flood average about 1 ½ times those for the 1 percent (100-year) flood, and that total damages for the 0.2 percent (500-year) flood average about two times those for the 1 percent flood. These estimates are for the condition of no levees, because in principle the damages for the 1 percent flood with levees should be negligible.

5. DETERIORATION OF THE LEVEL OF PROTECTION UNDER THE 1 PERCENT STANDARD: FUTURE CONDITIONS HYDROLOGY

Flood damages and fatalities have been higher over the past 25 years than the previous 65 years. Hurricanes have played a major role in this increase. The last 25 years have also been characterized by a high frequency of heavy rainfall events. The last century has witnessed continued filling of wetlands and natural flood storage. Thus, there is reason to hypothesize that the observed impact trends are at least partially the result of climate trends and the loss of wetlands. However, there has been no study of changes in societal exposure, and thus it is not possible to quantify the relative contribution of climate or wetlands loss. More research is needed to better link precipitation trends with damaging floods (Kunkel et al. 1999) and to better understand the role of wetlands.

Increased flooding potential in some areas of the country as a result of climate change and wetlands loss should be cause for concern. Although considerable uncertainty exists, climate change could bring more frequent and/or more intense floods. Given that development in and near floodplains is expected to last a considerable period of time and that the Nation's ability to predict the magnitude and frequency of future events is still limited, it may be prudent to consider the potential effects of climate change and wetland loss when decisions are made (or revised) about the type and amount of development allowed in vulnerable areas. In the absence of sufficient data, flexible and cautious policies are preferred.

In a separate report in the NFIP evaluation program, *Managing Future Development Conditions in the National Flood Insurance Program,* ABSG Consulting Inc. (Blais et al. 2006) examined the costs and benefits of managing future watershed development to limit the impact of development. One impact of development would be the potential to create higher flood stage elevations. This chapter reviews possible deterioration of the level of protection under the standard from climate change and the loss of wetlands and, talking into account the ABSG results, discusses the need to consider future conditions in the development of the 1 percent flood event.

5.1 The Role of Climate Change

One of the highest priorities for decision makers is to determine how climate variations, whether natural or human-induced, alter the frequencies, intensities, and locations of extreme events (NRC 1999). There is now compelling evidence that some natural climate variations, such as El Niño/Southern Oscillation (ENSO), Pacific Decadal Variability (PDV), North Atlantic Oscillation (NAO), and the Northern hemisphere Annular Modes (NAM) can significantly alter the behavior of floods (IPCC 2001). Studies of long-term trends in extreme events show that in many regions where average rainfall has been increasing, these trends are evident in extreme precipitation events (Arguez and Karl 2006).

5.1.1 Climate Variability

A question common to both short-term climate predictions and longer term climate change is how climate variability and change will alter the probability distributions of various quantities, such as temperature and precipitation, as well as related temporal characteristics (e.g., persistence), and hence the likelihood of extreme events. A key challenge is to develop improved methods for modeling or downscaling climate information to the scales required for extreme event analysis (IPCC 2001).

Also there is a need to develop better understanding of the processes by which climate variability and change impact extreme floods. Major research questions include:

- What is the range of natural variability in extreme events, by phenomena and region?
- How do frequencies and intensities of extreme events vary across timescales?
- What are observed and modeled trends in extreme events and how do they compare?
- How are the characteristics of extreme events changed by natural climate variations, for example, by ENSO, PDV, NAO/NAM, and Southern Hemisphere Annular Mode (SAM)?
- To what extent are changes in the statistics of extreme events predictable?
- How are behaviors of extreme events likely to change over this century, and what are the mechanisms that would be expected to produce these changes?
- How can the emerging findings on climate/extreme event links be best developed and communicated to evaluate societal and environmental vulnerability and opportunities?

Currently the ability to estimate 1 percent flood flows in the riverine environment is limited to evaluating past data which may or may not be reflective of future climate change; or using engineering models that utilize a rather simplistic assumption on rainfall events. The approach is in essence one premised on the idea that what has happened in the past is predictive of what will happen in the future. Our ability to adequately estimate future 1 percent flood events given climate change is severely limited.

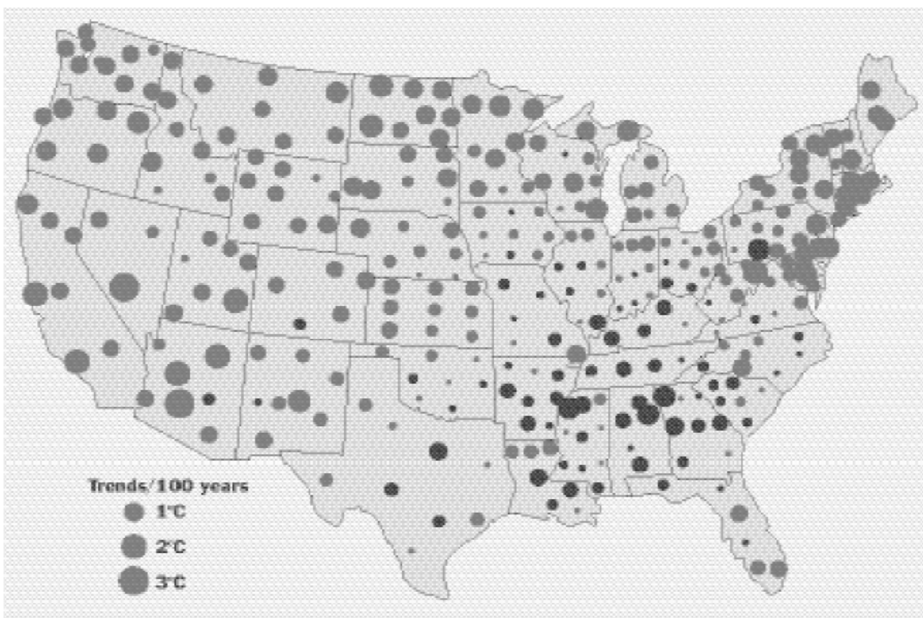
From the research that has been done so far, it is clear that many areas will experience earlier snowpack melt, increased levels of precipitation, and increased variability in severe storms. Likewise some areas may see the opposite or no impact. In general it is clear that climate change will result in different precipitation, flooding, and coastal storm damage characteristics than what we experience currently. In essence climate change is highlighting a risk factor that currently is not incorporated into the flood zone identification and mapping. However at the same time, we lack the ability to adequately project the specific impacts that will be experienced in terms of the magnitude of a given flood event for a given location. Recent climate change studies are summarized below.

Climate change is related to carbon dioxide emissions into the atmosphere. CO_2 concentrations cause global warming, which, in turn, causes increased precipitation and sea level rise. Theoretical considerations and model calculations assume that a global warming of the atmosphere will lead to an intensification of the hydrological cycle, that is, evaporation and precipitation will increase, and the differences between dry and high precipitation regions will intensify (Meehl et al. 2000). Present data collection methods do not address the question of whether worldwide precipitation did indeed increase substantially due to the global temperature increase over the last 100-years. On the other hand, individual well-documented regions in the mid- and high latitudes exhibit considerable trends, e.g. precipitation in the United States increased by 5 to 10 percent since 1900, by more than 10 percent in Canada, by about 5 percent over the territory of the former USSR, and, most significantly, by 10 to 50 percent over northern and western Europe (Watson et al. 1998).

Temperature and rainfall data collected by the National Climatic Data Center of NOAA are shown in Figures 5-1 and 5-2. Figure 5-1 indicates an increase in temperature across much of the country. Lighter circles indicate warming, while the darker circles indicate cooling. The relative size of the circles reflects the magnitude of the changes observed.

Figure 5-2 indicates that much of the country has experienced increased precipitation. Dark colored circles indicate increased precipitation, while the lighter-colored circles indicate reduced precipitation.

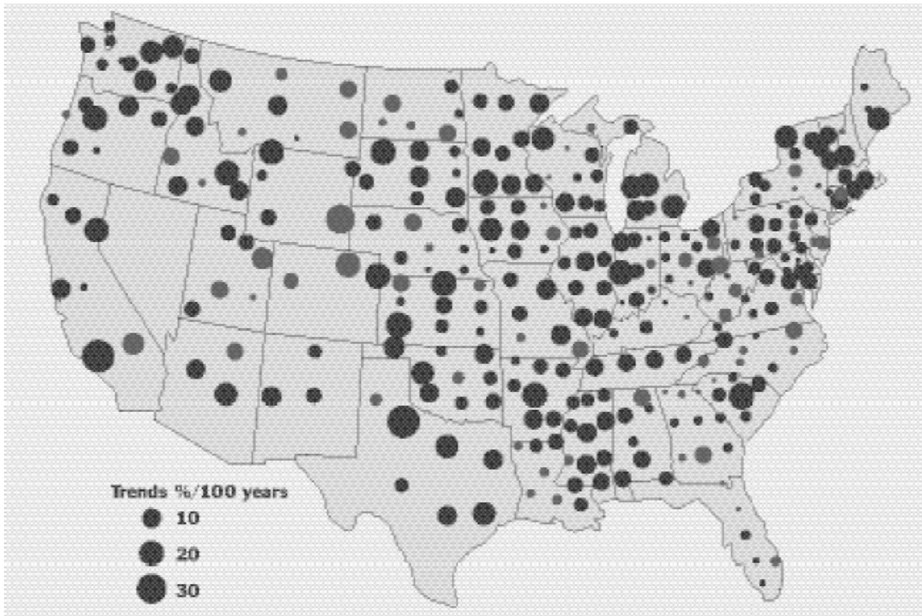
FIGURE 5-1: Temperature Trends in the Contiguous United States, from 1901 to 1998



SOURCE: National Environmental Satellite, Data and Information Service, National Climatic Data Center, National Oceanographic and Atmospheric Administration.

Generally it can be inferred from research that in regions with increasing precipitation, heavy precipitation will increase as well. The reason is that the atmosphere's capacity to absorb moisture, and thus its absolute water vapor content, increases with increasing temperatures. The saturation value of the air is enhanced by about 6 percent for a temperature increase of 1^{o} C. This means that, on average, there is a higher potential for heavy precipitation. In some regions, higher precipitation and heavy precipitation can substantially enhance the likelihood of floods, especially in mid- and high latitudes, where precipitation in winter will fall as rain instead of snow in a warmer climate. Rain generates more surface runoff than snow.

FIGURE 5-2: Precipitation Trends in the Contiguous United States, 1901 to 1998

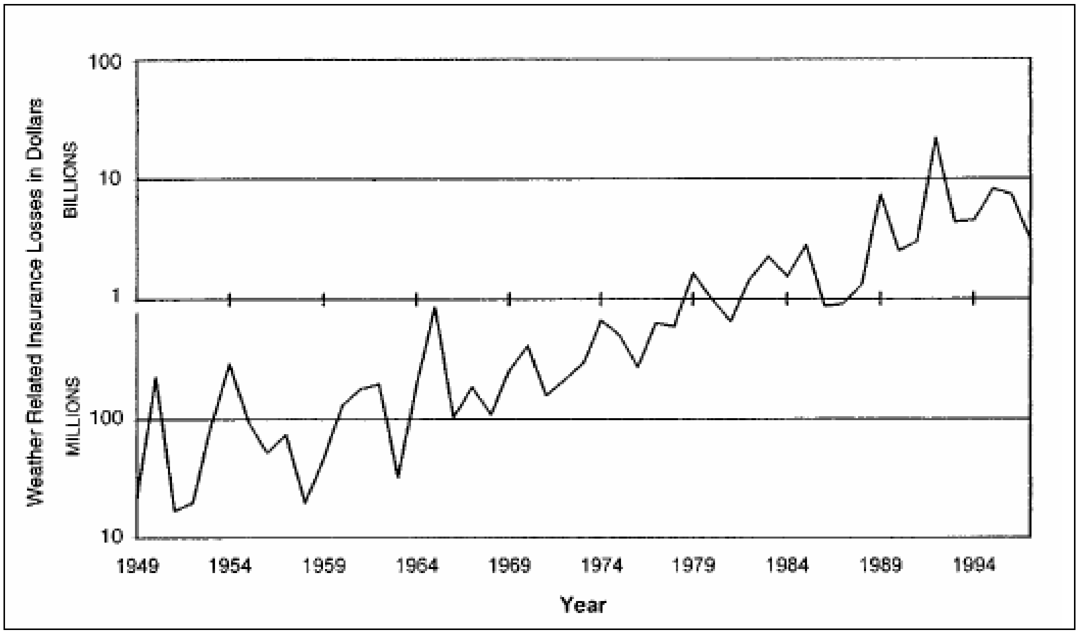


SOURCE: National Environmental Satellite, Data and Information Service, National Climatic Data Center, National Oceanographic and Atmospheric Administration.

Climate models predict a general increase of precipitation and precipitation extremes at increasing temperatures, especially in mid- and high latitudes. Some model results predict that extreme precipitation will increase even more substantially. These results from early calculations are confirmed by more recent model studies (Meehl et al. 2000). It was calculated that by doubling the CO_2 concentrations, mean precipitation will increase by 4 percent. In contrast, the extreme precipitation rate occurring every 20 years will increase by 11 percent, which would mean an eminent reduction of extreme precipitation return intervals, for example, in North America from 20 to 10 years (Zwiers and Kharin 1998). This is based on preliminary model results which still need to be calibrated and validated. The deterioration in the level of protection afforded by the 1 percent annual chance flood would need to be investigated further before trends can be extrapolated.

Kenneth Kunkel, Roger Pielke, and Stanley Changnon assembled data on annual losses to insured properties in the United States from weather extremes from 1949 through 1997. After careful adjustment for societal and insurance factors, it was observed that most storm loss data do not display upward trends with time but rather that the trends are flat, with randomly appearing fluctuations over the past 40 to 60 years. When this information is compared with the sharp upward trends in actual dollar losses (Figure 5-3) and when coupled with the locations of where the losses have grown the most (Southeast, South, and West), the results collectively indicate that the major cause of trends in losses related to weather and climate extremes is societal factors: the growth of wealth with more valuable property at risk, increased density of property, and demographic shifts to coastal areas and storm-prone areas that are experiencing increasing urbanization (Kunkel et al. 1999).

FIGURE 5-3: Annual Losses (in 1997 dollars) to Insured Property in the United States from Weather Extremes, 1949-1997



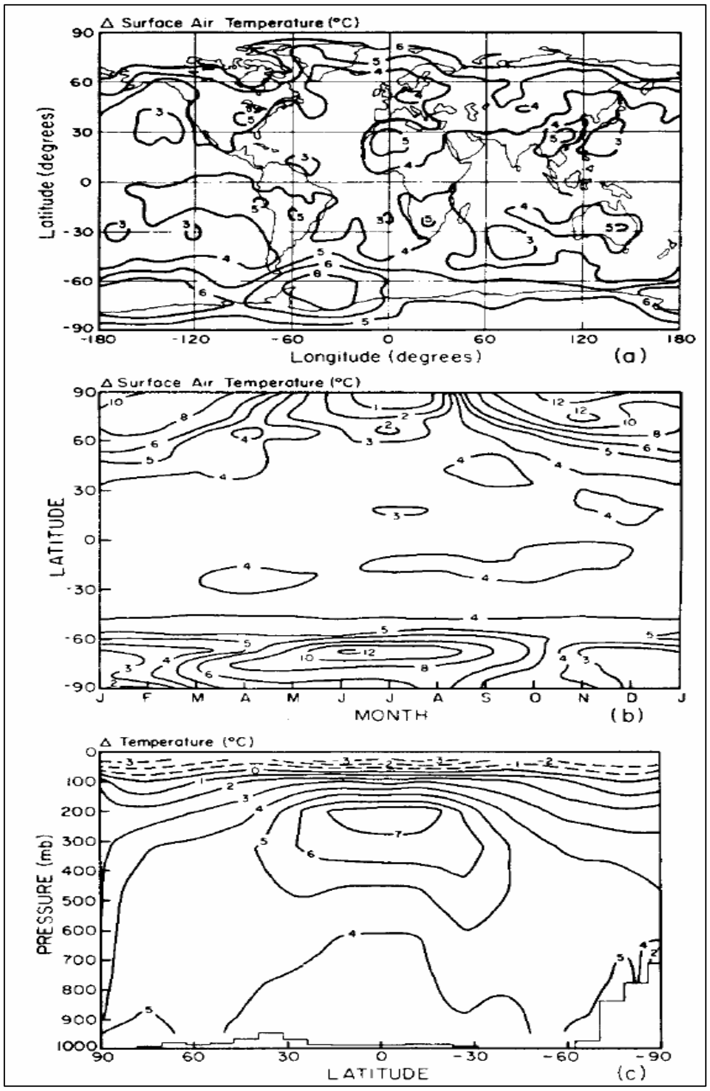
SOURCE: Changnon et al. 1997.

Field investigations of Hurricane Andrew's losses also showed building codes had not been followed, which increased losses by an estimated $4 to $6 billion (Roth 1996). The continuing growth in deaths caused by floods is also partly the result of social behavior, and whether the actual increases in hydrologic-defined floods contribute to this remains an open question (Pielke and Downton 1999).

Models have been constructed of climate change scenarios with varying levels of future CO_2 emissions. The net effect of reducing CO_2 emissions on average annual precipitation is a reduction in temperatures and consequent reduction in precipitation. Figure 5.4 shows the warming of air temperature due to doubled CO_2 in the 3-D global climate model of Hansen et al. Figure 5.4 (a) shows the geographical distribution of annual mean surface air warming, Figure 5.4 (b) shows the seasonal variation of surface air warming averaged over longitude, and Figure 5.4 (c) shows the altitude distribution of warming averaged over season and longitude.

Figure 5-5 shows the rise in sea level resulting from an unmitigated emissions scenario, an emissions scenario with atmospheric CO_2 concentrations at 750 ppm and 550 ppm. From the data used to create these charts, it can be inferred that a rise in sea level of 40 cm expected by the 2080s would be delayed by about 25 years with stabilization at 750 ppm CO_2 concentration in the atmosphere and by 40 years with stabilization at 550 ppm.

FIGURE 5-4 (a) (b) & (c): Increase in Air Temperatures Due to Doubled CO_2.



SOURCE: Hansen et al.1984.

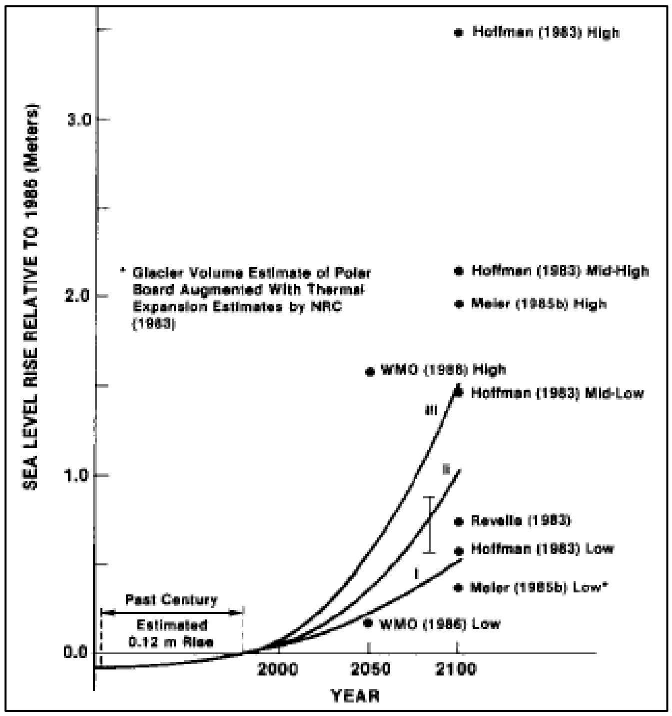
5.1.2 Potential Effects of Climate Change

Analyses of streamflow over the last 30 to 60 years have shown evidence of increasing and decreasing trends in flows, with marked geographic patterns to these trends. Thus far there has been less evidence of trends in annual flood data for natural pristine basins. However, based on scenarios of projected future atmospheric conditions, it is anticipated that there might be more pronounced alterations to the streamflow regimes in various regions of the world. If these projections are correct, more severe or extreme conditions may prevail.

5.1.3 Climate Impacts on Extreme Events

A number of studies on the potential impacts of climate change on flooding have been carried out as part of the work of the Intergovernmental Panel on Climate Change (IPCC). These studies indicate potential future increases in flood peaks of approximately 15 percent in temperate zones due to increased storm activity and overall increases in depth of precipitation. Currently, it is not possible to predict potential increases in flood peaks due to climate change for specific basins with the degree of certainty necessary for their incorporation into the design and planning process. However, the freeboard[16] on levees and other works can probably accommodate the potential modifications in extremes due to climate change through modified operating procedures of control structures.

FIGURE 5-5: Estimates of Future Sea Level Rise



SOURCE: Derived from Hoffman (1983, 1986) Meier, (1985) and Revelle, (1983).

5.1.4 Sea Level Rise, Subsidence, and Storm Surge

Coastal communities must also deal with the implications of sea level rise, tsunamis, subsidence, and ocean storm surge in preparing for flooding events. Sea level rise due to climate change can potentially result in decreased river slopes in reaches above where the river enters the ocean, thereby reducing the capacity of the channel to pass flood flows. This reduced capacity increases the elevation of floods in coastal cities. While the rate of sea-level rise is slow, most protective works or flood plain delineation exercises are sufficiently long-term in scope to warrant consideration of the predicted rise.

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[16] 44 CFR 59.1 defines freeboard as "a factor of safety usually expressed in feet above a flood level for purposes of flood plain management. 'Freeboard' tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed."

High-, low-, and mid-range assumptions in the table above were derived from models about each factor that determined atmospheric conditions, global warming, thermal expansion, ice and snow discharge, and thus sea level rise. By spanning a full range of estimates for these factors and coupling them on a yearly basis, conservative, mid-range, and high scenarios were generated on a yearly basis to the year 2100 (Table 5-1).

Table 5-1: Estimated Sea Level Rise Figures (inches) for the Period 2000 to 2100 under Climate Change Scenarios

		Mid Range Scenarios			Historical Extrapolation
Year	Conservative	Moderate	High	High Scenario	Year
2000	2.18	4.00	6.00	7.77	0.90-1.36
2025	5.91	11.91	17.86	24.95	2.04-3.75
2050	10.82	23.77	35.73	53.05	3.18-5.45
2075	17.27	41.91	62.18	96.68	4.31-7.05
2100	25.55	65.64	98.45	156.82	5.45-8.18

SOURCE: J. Hoffman et al. 1983.

5.2 Role of Wetlands

5.2.1 Wetland Definitions

There are a number of technical definitions of a wetland:

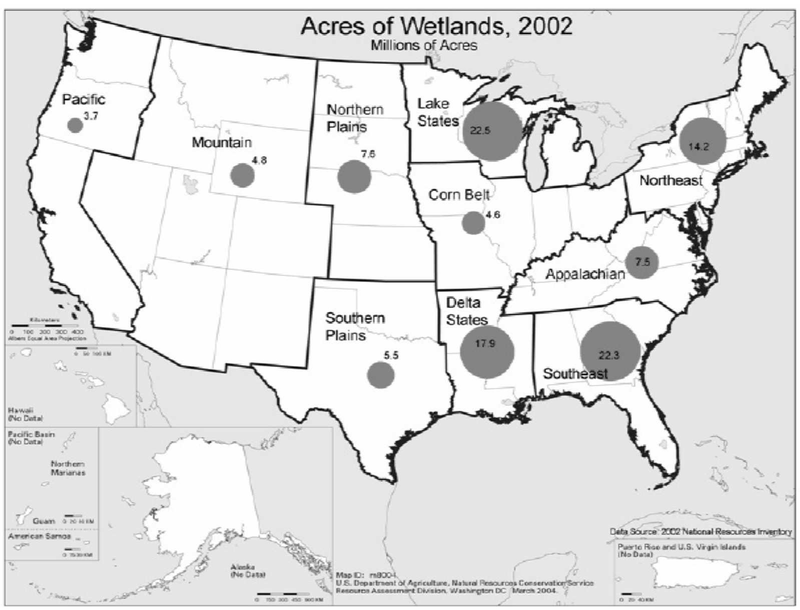
- "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrata are predominantly undrained hydric soil; and (3) the substrata is non-soil and is saturated with water or covered by shallow water at some time during the growing season of the year" (Cowardin et al. 1979).
- "A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physicochemical, biotic, or anthropogenic factors have removed them or prevented their development" (NRC 1995).
- The National Research Council goes on to define the required extent of inundation or saturation as a "duration of saturation approximately 14 days during the growing season in at least 50 percent of years in the upper root zone (e.g. 30 cms)" (NRC 1995).

5.2.2 Wetland Functions

Wetlands exist across the Nation (Figure 5-6) and serve many useful functions within riverine ecosystems. They influence flow regimes and water chemistry, contribute to groundwater supplies, and can modify the effects of floods and droughts. They also benefit wildlife and serve as valued habitat in regional ecosystems. From the early years of settlement, farmers were handicapped by wet land. Many lowland areas were not continuously wet, but during years of heavy snowfall or more than average rain they were not fit for cultivation. These areas were an impediment to agricultural productivity. To support increased crop production, government programs encouraged wetland drainage. Reliable figures on wetland drainage are not available, but it would appear that the vast majority of wetlands on rivers across the United States have been modified by human activity.

Depending on their structure and condition at the time of the flood event, wetlands may retain floodwaters and reduce peak flows or total flood volumes or both. Hydrologic analyses have shown that wetland storage can lower peak flows during smaller mainstem or tributary floods and minimally reduce the peaks of larger floods. Studies have also indicated that when larger areas are dedicated to wetland storage, the flood damage reduction and water quality improvements can be significant.

FIGURE 5-6: Acres of Wetlands in the United States, 2002

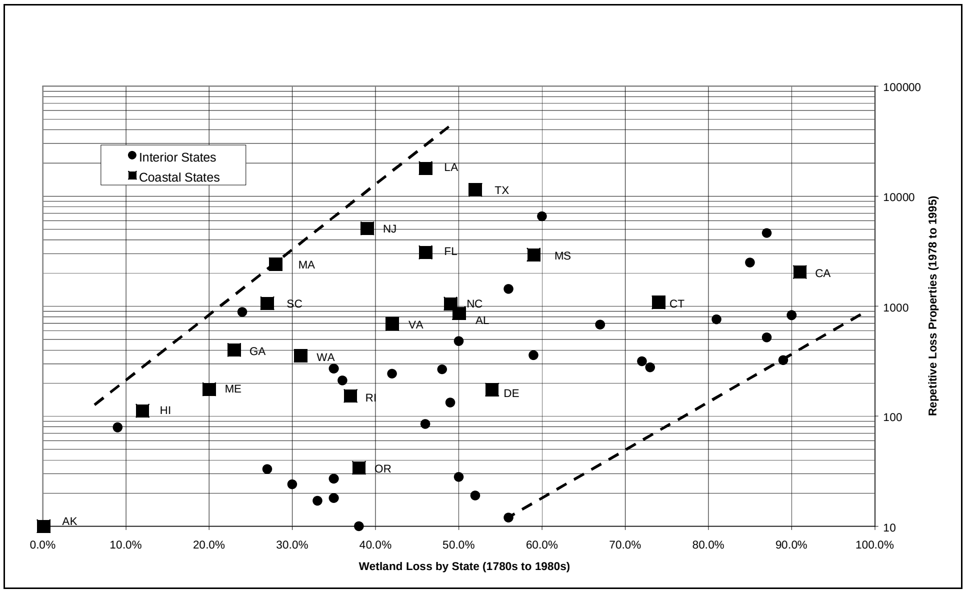


SOURCE: National Resource Inventory 2002

5.2.3 Impact of Wetland Losses

There is a consensus at the scientific and policy levels that wetlands best characterize the diverse functions provided by floodplains and that loss of wetlands can exacerbate flood hazards. However, a comprehensive nationwide database on wetlands, their losses, and relationship to FEMA 1 percent floodplains and flood damages is lacking. A visual representation of these data, through the application of terrain mapping and GIS, can guide decision makers and inform the public as to the spatial extent and importance of wetlands in floodplain management. A preliminary national nonspatial evaluation of wetland loss and repetitive loss properties is provided in Figure 5-7. While there is significant scatter in the data, a general trend of increasing repetitive loss properties with increasing wetland loss can be discerned.

Fig 5-7: Repetitive Loss Properties Plotted Against Wetland Loss Data by State



SOURCE: Derived from FEMA 2006b and USGS 2006.

The restoration of wetlands as a means of flood risk management has been widely recommended. What is less clear is how and when wetlands are more effective than any other form of storage. A large flat area is potentially a very useful means of flood risk management. It needs to be flat both parallel and perpendicular to the direction of flow, but it can be a wetland, a lake, a detention basin, or a reservoir. Indeed, in terms of flood risk management, not much differentiation can be made between a wetlands and a reservoir. Such a large flat area can:

- Slow down the flows. The high frictional resistance of wetlands helps.
- Store some of the flood flow. The potential advantage of any system of storage is that it can reduce the flood peak of any flood, however large it may be. It can only do so if both inflow and outflow are controlled. The annual flood is allowed to flood the area, but when an extreme flood is occurring, the storage needs to be held empty until the flood peak arrives and it is this flood peak that is then stored.

Agricultural land is most commonly used to convey and store extreme floods. This is because extreme floods occur out of the growing season, and it is not then possible in economic terms to justify protecting agricultural land to a design standard of more than the 20 to 10 percent flood. In locations where extreme floods occur in the growing season, the crops may be too valuable an investment, and hence the land may not be opened for conveyance and storage of floodwaters.

As a storage system, wetlands and reservoirs can function in similar ways. The primary difference is that wetlands will tend to be shallow and require large land areas, whereas reservoirs typically tend to be deeper and for the same volume of storage will occupy less land. Beyond this similarity each provides unique environmental, recreational, and in some cases agricultural opportunities.

5.2.4 1993 Midwest Flood

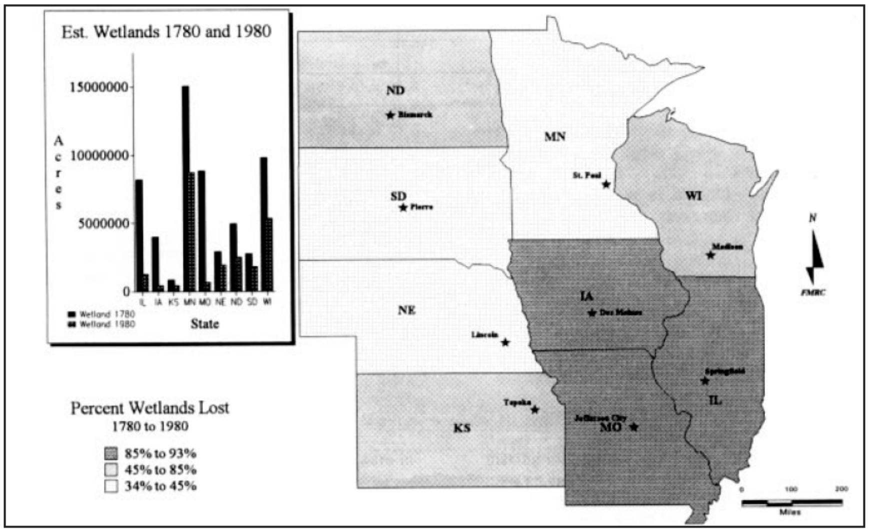
The Midwest Flood of 1993 serves as a typical example of the effects of wetland losses on the magnitude of flood damages. The 1993 flood was a significant hydrometeorological event. Wet antecedent soil and swollen river conditions, record rainfall, and significant upland runoff resulted in 1993 flood flows that ranged from below the 1 percent level up to the 0.2 percent magnitude at many locations. It was claimed that the loss of wetland areas in the uplands of the Mississippi River Basin exacerbated the severity of flooding throughout the basin.

Between 1780 and 1980 an estimated 53 percent of the Nation’s original 221 million acres of wetlands was drained. In the nine Midwestern States affected by the 1993 flood, 57 percent of the wetlands have been converted to other uses. Figure 5-8 shows the wetland acreage loss per State between 1780 and 1980 in the Upper Mississippi River Basin. Further, the Swamp Land Acts of 1849, 1850, and 1860 resulted in the transfer of nearly 65 million acres of wetlands in 15 States from Federal to State administration for the purpose of expediting their drainage. Pre-1850 historical records indicate that even prior to the clearing of wetland areas, major floods occurred in the Mississippi River Basin. As part of economic development in the Midwest a substantial percentage of agricultural lands were created by drainage of wetlands and hydric soils. Hydric soils, good indicators of past and present wetland locations, represent 10.4 percent of Mississippi and Missouri basin soils. Flooding would have been reduced had more wetlands been available for rainfall and runoff storage. An evaluation of the upper Mississippi River Basin’s capacity to store rainfall runoff estimates that the soil profile has 10 times more storage capacity than above-ground storage in depressional potholes, because much of the basin was depleted and unable to store water from the rains of June and July.

Surface depressions or potholes occur throughout the glacial landscapes of north central Iowa, east South Dakota, and North Dakota. When these depressions fill, surface waters flow from pothole to pothole through an ill-defined network, eventually finding an outlet to a surface stream. This intricate network of depressions slows runoff. A different pattern of runoff occurs in the remainder of the basin. There surface runoff flows through an open network of streams, with only minor areas of surface water storage available. Historically, shallow wetlands and wet prairies, which occurred in these areas, served a similar but less effective function than potholes.

Topography has a direct impact on water movement and soil formation. In the Mississippi River Basin case, the upper portion of the basin is characterized by two distinct kinds of landscape: open systems, which drain externally, and closed systems, where drainage is trapped within a common depository. Due to the extended period of rain preceding the 1993 flood, the impacted area became completely saturated and surface depressions were filled; therefore, storage available for additional runoff could only be found in the deep depressional areas located in the prairie pothole region of the Dakotas, Minnesota, and Iowa.

FIGURE 5-8: Estimated Wetland Losses, 1789-1980.



SOURCE: Based on GAO/RCE D-92-79FS, November 1991.

Reviews were performed of four hydrologic studies for watersheds representative of upper Mississippi River Basin areas. All model runs used antecedent moisture condition II for the start of modeling conditions. Condition II is defined as the average soil condition prior to the annual flood event. For the 1993 flood antecedent conditions were condition III in most areas. Condition III indicates near-saturated soils prior to the storm and gives significantly higher runoff that antecedent II. Because the model analyses used a lower antecedent moisture condition than was actually experienced in the 1993 flood, the peak discharge reductions resulting from the model analysis are greater than would have occurred. In areas where opportunity exists, wetlands and small detention structures can aid in lowering peaks. However, flood peak discharge reduction is dependent on the topography of the watershed, the percentage of the basin containing deep depressional storage, and the intensity and volume of the rainfall.

In the watersheds modeled, the maximum reduction for floodplain wetlands was 6 percent of 25- and 100-year storm events. Wetlands are more effective in upland areas with more deeply incised potholes. Observed reductions in such watersheds were 23 percent of the 1-year event, 11 percent of the 25-year event, and 10 percent of the 100-year event. In areas of shallow depressions, restored wetlands reduced peak discharge by 9 percent of 1-year event, 7 percent of the 25-year event, and 5 percent of the 100-year event.

With the installation of a combination of land treatment measures and restored wetlands in the watershed, the models indicate that runoff reductions of 12 to 18 percent are possible for the 25-year or less event. This indicates that these practices could be effective for smaller storm events.

Wetland restoration in the uplands could function much the same as small upland reservoirs. It was shown more than three decades ago that small flood damage reduction dams are effective in the reach immediately downstream, but their effect diminishes rapidly with distance. As far as a series of small headwater dams is concerned, they are essentially ineffective under conditions in which major floods occur on large rivers.

A State of Illinois report (ISGS 2003) concluded that for certain watersheds, peak flow increases as wetland areas decrease. In very small watersheds (less than 100 square miles), peak flow rates increased by an average of 3.7 percent for each decrease in wetland area equivalent to 1 percent of the area of the watershed. While wetlands may have some impact on peak flow in the smaller watersheds during smaller storms, their effects in larger watersheds during both small and large events has not been sufficiently documented and requires further study.

Previous watershed evaluations, such as the study of Devils Lake in North Dakota (a closed basin), indicate reductions of peak flow rates up to 41 percent for one 100-year storm (IFMRC 1994b). These widely ranging results from the aforementioned studies demonstrate that alternative watershed practices produce varying degrees of success in reducing flood runoff rates depending (in addition to the magnitude and intensity of the rainfall and antecedent moisture conditions) on the percentage of the basin treated, and basin topography. Generally, as drainage areas increase, upland treatment measures, wetlands, and small detention structures have less effect in decreasing peak flow rates. In short, land treatment and detention storage (principally in the form of upland wetlands) can play a role in reducing peak runoff in some watersheds but are not the single solution for solving flood problems. Only a combination of upland and floodplain management practices can reduce floodplain damages in the future.

Based on two studies on wetland impacts on flooding, it can be concluded that a reduction of total flood volume is possible with the expansion of wetlands, but large-scale wetland restoration programs do not appear to be an economically feasible way to reduce damage from major floods in most large river floodplains. Wetlands are frequently restored or constructed for their water quality and habitat values with little concern for flood control capabilities and are considered wise public investments. It may also be possible to farm restored wetlands during most growing seasons to minimize the economic impact on agriculture. The more comprehensive potential environmental and social benefits that might accrue from preservation or restoration of wetlands deserve further investigation.

5.3 Observations

Over the past century there has been a significant increase in temperatures and in precipitation within the United States, resulting in higher flows and more frequent large floods. Sea level rise is a fact. While, at present, damage statistics seem to be more heavily influenced by demographic factors, the future must be considered. Increased precipitation and sea level rise will likely have major impacts on the computation of the 1 percent flood elevation.

Hydrologic analyses indicate that wetland storage can lower peak flows during smaller mainstem or tributary floods and minimally reduce the peaks of larger floods. Studies have also indicated that when larger areas are dedicated to wetland storage, the flood damage reduction and water quality improvements can be significant. The more comprehensive potential environmental and social benefits that might accrue from preservation or restoration of wetlands deserve further investigation. Wetland storage can provide an economically and environmentally beneficial method of reducing flood flows for frequent, smaller floods, but wetland storage alone is unlikely to significantly reduce the peaks of large floods on large river basins.

Flood conditions as related to the NFIP have for the most part silently benefited or been influenced by wetland conservation/conversion practices. Since wetland protection is a relatively new phenomenon, there undoubtedly are areas and regions where the flood hydrology has changed due to wide-scale wetland conversion. Whether wetland loss and the timing of the loss is sufficiently significant as to impact how the 1 percent flood is estimated needs to be considered on a case-by-case basis. It is clear that, in small and moderate-sized watershed/floodplain complexes many are seeing increasing flooding due to lack of watershed controls. This speaks to future conditions.

5.4 Future Conditions Hydrology

Future condition impacts such as climate change, sea level rise, wetlands loss, and watershed development, create future risks to the NFIP. Historically the NFIP has postured itself as an insurance program, suggesting that it is inappropriate to account for some yet unrealized risk. Yet this same policy decision will results in increased financial exposure to the flood insurance fund and the taxpayers of the Nation. There is a need to account for these future risks either quantitatively, such as with modeling and probability evaluations, or when this is not feasible, through the incorporation of some factor of safety that measures impacts that cannot yet be quantified. This should apply to both how the BFE is calculated and the areal extent of land considered in floodways and coastal V zones.

FEMA regulations governing the mapping of the 1 percent floodplain base the computations on hydrologic and hydraulic (H&H) conditions at the time the mapping study is carried out. They do not permit analysis, for the purposes of delineating the 1 percent flood, of the H&H of potential future climate conditions or consideration of the impacts of potential upstream or downstream development.

The expansion of major urban areas into nearby rural areas has changed the pattern of runoff in communities across the Nation. Some future conditions hydrology has been developed by communities interested in using the data to better identify future land use challenges. In its study on the impacts of future development, ABSG Consulting indicates that building in a watershed does change the flood conditions and can greatly increase the damage to structures by multiple orders of magnitude depending on the flood conditions. Examination of one county indicated that development-related future conditions flooding represents a nearly 440 percent increase from the existing conditions flooding and in another a 1,300 percent increase in flood losses (Blais et al. 2006).

The practice of managing to “current” conditions hydrology in essence requires engineers and scientist to develop estimates based on history. However, failing to consider changing climate conditions, sea level rise, wetland losses, and intensification of the use of floodplains and upstream watersheds, will lead in implementation to a deterioration of the protection afforded by using a current conditions approach to estimating the 1 percent flood. The ultimate result will be increased damages, more frequent and costly claims, and unless mitigated through significant flood insurance policy rate increases, an increasing need for taxpayer subsidy during more frequent years of “extreme” loss.

6. FLOOD DAMAGES AND THE 1 PERCENT FLOODPLAIN

Aggregate flood damages in the Nation are increasing, as indicated in Chapter 2, even though NFIP claims for riverine flood damage are not. These aggregate damages in addition to NFIP-covered property losses, include losses associated with noncovered residential property, commercial buildings, infrastructure, agriculture, and costs related to debris removal, temporary housing, and other emergency response and recovery operations. The 1992 Federal Interagency Assessment reported that damages per capita in the Nation had doubled since the early 1900s. ASFPM Managers and others have reported that flood damages have grown from less than $1 billion per year in real dollar terms in 1900 to $6 billion per year in 2003. The impact of the 2005 hurricane season has not yet been considered, but it is clear that annual flood damages per capita will continue to grow.[17] This chapter examines available flood damage data and identifies, as an extension of Chapter 4, where floodplain aggregate losses occur (the damages that occur inside and outside of the 1 percent floodplain.) It also identifies the States/regions in which most losses occur.

6.1 Flood Damage Data

Overall the manner in which damage data have been collected over the years is best suited to provide a rough estimate of total damages by State.[18] The low resolution of these data and their sampling processes do not allow for formal statistical analysis. However, the specificity in types of damages, events that caused specific damages, and categorizing damages between agricultural losses, infrastructure losses, building losses, and recovery costs has not been a focus of these data efforts. As such we have data that suggest the magnitude of the problem, but at best the Nation has anecdotal information on the relative magnitude of specific types of damage and the relative degree of success in controlling damages and associated costs.

6.1.1 Total Estimated Damage Data

The National Weather Service (NWS) has been the primary collector of flood damage data. The first significant improvement and evaluation of NWS data was performed by the University Corporation for Atmospheric Research (UCAR) in Boulder, Colorado. UCAR recently completed a study reanalyzing national flood damage data originally collected by the National Weather Service (NWS) and others (Figure 6-1 and Figure 2-2).

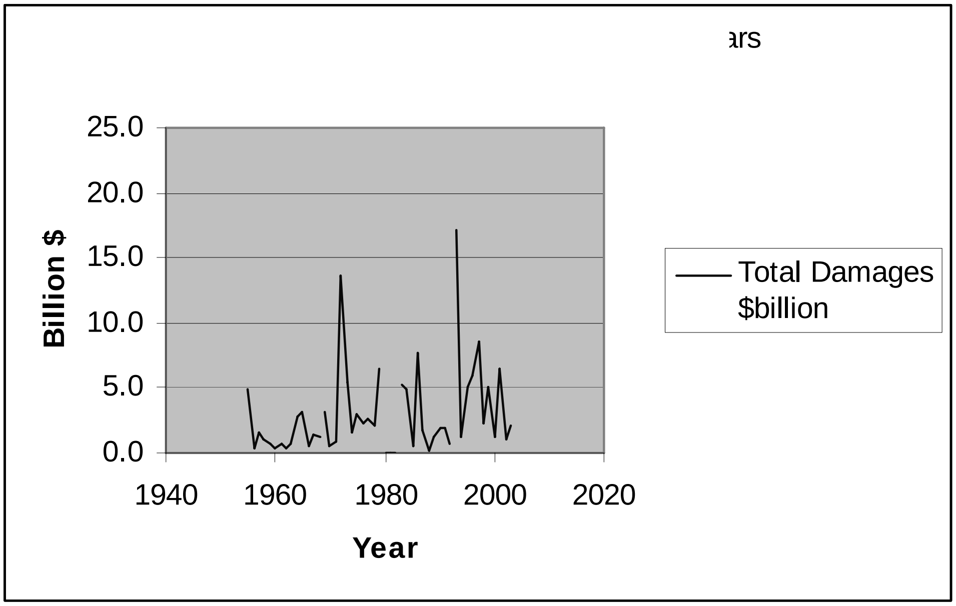
Flood damages have been historically accumulated at the national level with little consistency among reports at the State level. The UCAR report provides estimates of flood damages at the State level from 1955 to 2003 (Pielke et al. 2002). These data rely on records of the NWS and provide an annual reporting of flood damages by State for 1955-1979 and 1983-

[17] The real-dollar GDP in 1900 was $376, while in 2005 it was $11,134 (Johnson and Williamson 2005). This represents s a 30-fold growth. Damages as a percent of GDP have declined 80 percent from 1900 to present. Some would argue that this statistic indicates that, given the impressive increases in the strength of the economy, the impact of flood damages on the economy has significantly decreased over time. Since both the Flood Control Act of 1936 and the NFIP had social goal components, this economic argument may not be relevant to the issue of the impact of flooding on the population of the Nation.

[18] For administrative purposes, the Federal government collects most data on a State rather than a river basin level.

2003. There are a number of gaps in these data, especially in early years where it appears that only significant floods were reported.

FIGURE 6-1 U.S. Flood Damages, 1955-2003, Normalized in 1995 Dollars



SOURCE: UCAR and NWS-NOAA,

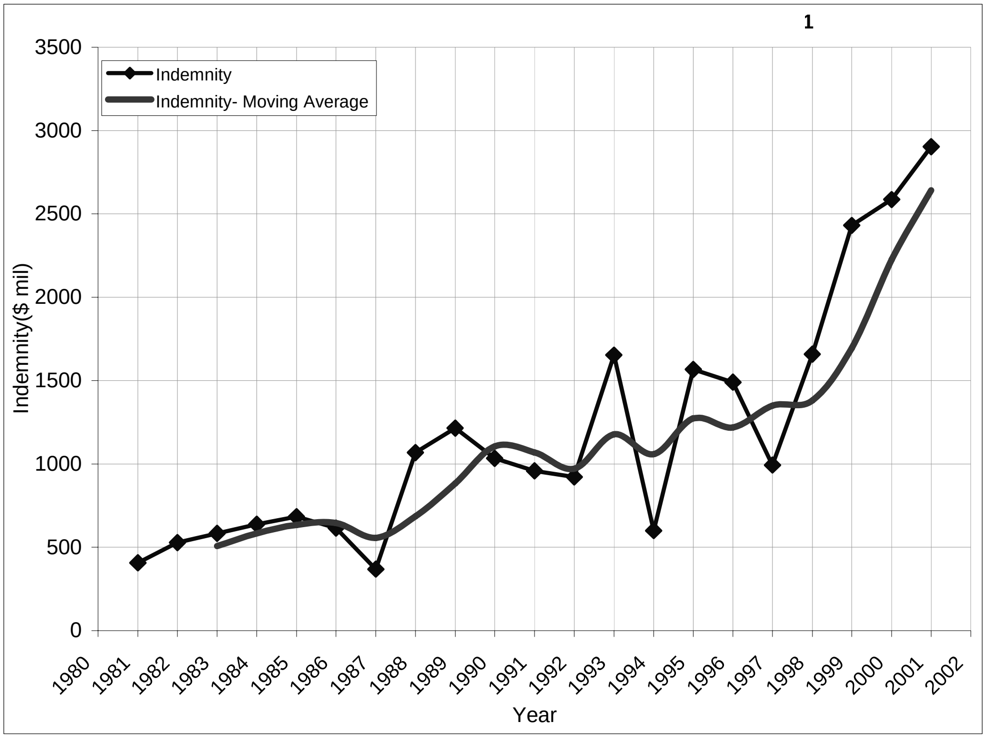
6.1.2 Agricultural Damage Data

Since 1980 the principal form of crop loss assistance in the United States has been the Federal Crop Insurance Program. The Federal Crop Insurance Act of 1980 replaced disaster programs with a subsidized insurance program that farmers could depend on in the event of crop losses. Crop insurance was seen as preferable to disaster assistance because it was less costly, hence could be provided to more producers, was less likely to encourage moral hazard, and was less likely to encourage producers to plant crops on marginal lands (U.S. General Accounting Office (GAO) 1989]

Despite growth in the program, crop insurance failed to replace other disaster programs as the sole form of assistance to farmers. Over the past 20 years, farmers received an estimated $15 billion in supplemental disaster payments in addition to $22 billion in crop insurance indemnities. Indemnity payments made from 1981 to 2001 show an increasing trend, as seen in Figure 6-2.

Agricultural losses comprise a large percentage of flood disaster costs. The 1993 U.S. Midwest floods, for example, caused $6 billion to $8 billion in farm damages, accounting for half the total losses from the flood, according to FEMA.

FIGURE 6-2: Indemnity for Federal Crop Insurance Program, 1981-2001



SOURCE: Glibber and Collins 2002.

6.1.3 Infrastructure Losses

Only recently has FEMA begun to track damage to infrastructure specifically associated with flooding. Nationwide FEMA Public Assistance Data were obtained from the Public Assistance Branch of FEMA R&R Division. The data show losses for categories C, D, E, F, and G for the years 1998 through 2003 (Category C: Roads and Bridges, D: Water Control Facilities, E: Public Buildings, F: Public Utilities, G: Recreational and Other) (Table 6-1).

TABLE 6-1: Nationwide FEMA Public Assistance Data (1998-March 31, 2005)

	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other	Sum:
1999	$ 19,885,112	$ 11,644,104	$ 16,533,242	$ 24,489,159	$ 23,739,057	$ 96,290,674
2000	$ 19,643,713	$ 337,554,545	$ 1,035,070	$ 6,877,621	$ 2,283,728	$ 367,394,677
2001	$ 31,918,976	$ 3,678,547	$ 224,248,930	$ 8,176,765	$ 4,302,129	$ 272,325,347
2002	$ 38,732,823	$ 4,399,015	$ 6,021,635	$ 10,447,622	$ 12,568,267	$ 72,169,362
2003	$ 25,498,297	$ 4,651,188	$ 7,413,307	$ 10,013,880	$ 17,084,547	$ 64,661,220
2004	$ 44,125,626	$ 3,658,649	$ 8,177,354	$ 23,334,606	$ 36,709,832	$ 116,006,068
2005	$ 1,080,925	$ 4,999,565	$ 2,908	$ 2,271,848	$ 781,252	$ 9,136,498
Sum	$ 180,885,473	$ 370,585,614	$ 263,432,446	$ 85,611,501	$ 97,468,812	$ 997,983,845

Source: FEMA Public Assistance Data.

Damages for 2000 were $370 million. That year the infrastructure damages amounted to more than 27 percent of total damages Nationwide. With this exception, the funds committed for Public Assistance Projects (categories C through G) generally amount to under 5 percent of the total cost of flood damages. (Table 6-2.) The National Emergency Management Information System (NEMIS) database shows that for one 4-year period (1999-2003), $820 million (10 percent) of FEMA's total expenditures in response to flooding were in Category C, Roads and Bridges (NEMIS Data, May 2004). It is important to realize that this yields a far from complete measure of the impacts. It does not account for expenditures by other State and Federal agencies, nor does it include indirect costs. More important, FEMA's disaster assistance is available only after floods that prompt declaration of major disasters. Most floods (sometimes even those exceeding the magnitude of a 1 percent annual chance flood) may not be declared a Federal disaster, and hence FEMA funds are not available for such a disaster. The full costs of recovery from these floods are unaccounted for in FEMA figures, as they are borne by local affected communities.

TABLE 6-2. Infrastructure Damages as Fraction of Total

Year	Total Damages	Infrastructure PA	Infrastructure/Damages
	UCAR ($1,000)	FEMA ($1,000)	Percentage
1999	$5,450,375	$96,291	1.77
2000	$1,336,744	$36,7395	27.48
2001	$7,158,700	$272,325	3.80
2002	$1,116,959	$72,169	6.46
2003	$2,405,685	$64,661	2.69

Source: UCAR and FEMA.

A breakdown of the data by disaster at the State level was not available. Such data would have helped develop a better understanding of the effects of a flood higher than 1 percent. Additionally, FEMA public assistance data do not differentiate between infrastructure data for losses inside the 100-year floodplain versus infrastructure losses outside the 1 percent floodplain. These data would have helped differentiate damages caused by floods greater than the 1 percent level from the rest of the floods.

Unlike seismic and fire hazards, there are very few standards associated with the location and placement of infrastructure related to floods. Notable exceptions are the construction of bridges within mapped floodplains, dams, and to a lesser extent levees within floodplains. Bridges in particular fall under specific scrutiny for their impact on the water surface elevation within the regulatory floodway, leading to a better understanding of the impact a 1 percent flood might have on that structure. In an unrelated measure, bridges in the Nation have undergone evaluation for failure by being weakened by scouring of the river. Levees are examined primarily for their ability to convey the 1 percent flood, but often little attention is paid to geotechnical conditions to gain certification. As demonstrated in New Orleans during Hurricane Katrina, the cost of levee repair pales in comparison to the total damages that came about due to levee failures. Finally, in those areas where dams are regulated following model programs there is a significant degree of attention paid to hydrologic, hydraulic and geotechnical performance during floods, from the 1 percent flood up to the probable maximum flood. Unfortunately not all areas regulate dams, and most do not have the resources to pay for correcting deficiencies.

Other infrastructure that remains damage prone includes that in unmapped floodplains, in areas where only approximate flood zones are determined, or other types of infrastructure including water and wastewater lines, electrical, telecommunication, pipelines, and standard roadways that might be inundated. Limited data exist regarding infrastructure damage; anecdotally some in the profession consider infrastructure losses to be a significant factor in escalating damages.

The primary form of regulation of "nonflood control" infrastructure relates to whether the infrastructure represents an obstruction to flow within a regulated floodway. For example, the construction of a bridge or culvert across a mapped floodway generally is allowed providing that no additional increase in the floodway elevation is detected in a hydraulic model. Likewise, some local governments require an "all-weather" access for the 1 percent flood for those buildings constructed on elevated pads within the floodplain, but again there are generally no provisions to protect infrastructure to a given flood level.

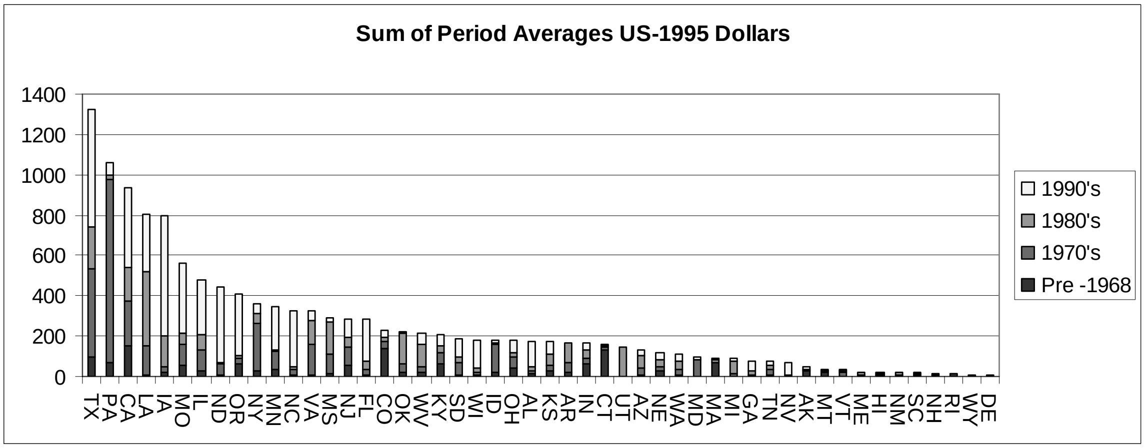
6.2 Analysis of Flood Damage Data

The UCAR data set provided the most consistent basis to evaluate flood damage for the Nation. Agricultural losses and infrastructure damage data sets are relatively incomplete or lacking when attempting to track flood damages.

The UCAR flood damage data were grouped into four periods: 1955-1968 (pre-NFIP years) and then three 10-year blocks, 1969-1980, 1983-1992, and 1993-2003. (Figure 6-3.) For each period, average flood damages per year were estimated for each State. If data for any given year within a State were missing or unreported, it was assumed that the damages are unknown, and for purposes of estimating averages that year was removed from the data set and the sample size reduced. The available damage data were all inclusive in that the data considered agricultural damages as well as damages to the built environment as a single value. It was not possible to distinguish between those factors that might be influenced by NFIP standards (new construction) versus those that would not necessarily be influenced by the NFIP (agricultural crops). A further challenge with the data is that the magnitude of flooding was not related to the level of damage. As such some years might be dominated by a series of floods smaller than the 1 percent flood, or there might be years where the damages were dominated by an event that was larger than the 1 percent event.

The following graphs depict the sum of the averages for each period (1995 dollars). (Figure 6-4.) The value on the y-axis is meaningless except for purposes of demonstrating the magnitude of the flood event. The sum of the averages was chosen as a display mechanism because it quickly amplifies where consistently high flood damages occur by State. The following five graphs display groupings of 10 States for display purposes; all States are depicted from highest to lowest damages. Within the group graphics it is possible to visually determine whether certain periods have relatively higher or lower damages compared to other periods for that State. For 19 States (38 percent), the 1990s were the period when the highest average damages were experienced.

FIGURE 6-3: UCAR Flood Damages by State and Decade



SOURCE: UCAR.

The relative comparison of magnitude is significant. Based on the sum-of- averages approach, Texas had the highest value, or approximately the same total value as the lowest 20 States (DE, WY, RI, NH, SC, NM, HI, ME, VT, MT, AK, NV, TN, GA, MI, MA, MD, WA, NE, AZ, UT, CT). Or for the sum-of-average approach 50 percent of the total damage could be attributed to eight States (TX, PA, CA, LA, IA, MO, IL, ND).

FIGURE 6-4: Sum of Period Averages of UCAR Flood Damages by Group

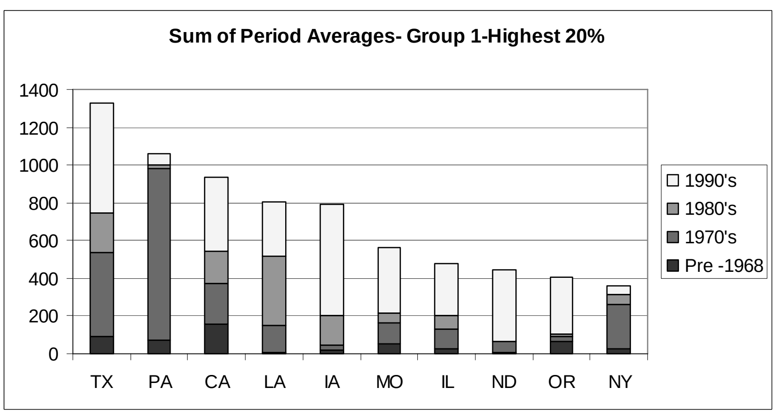
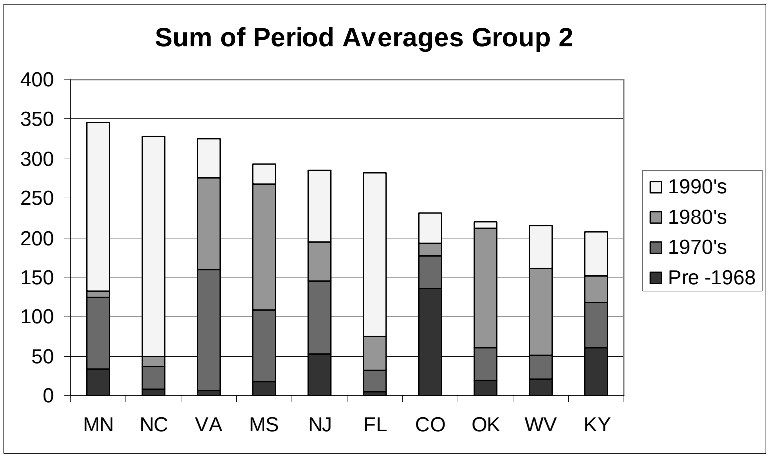
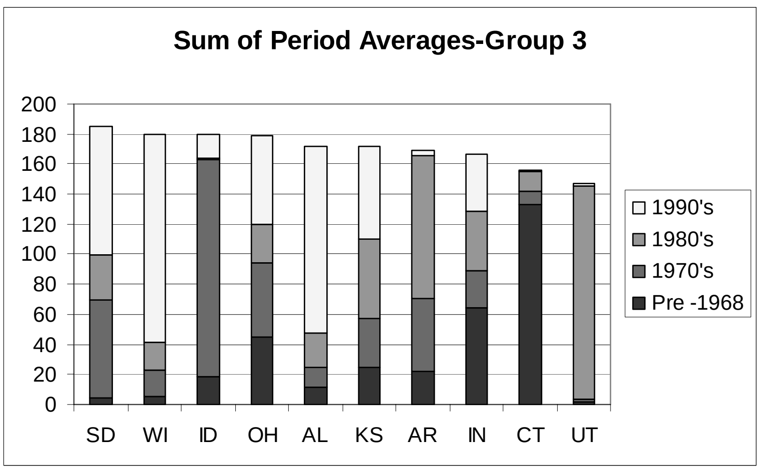


FIGURE 6-4 (Continued)





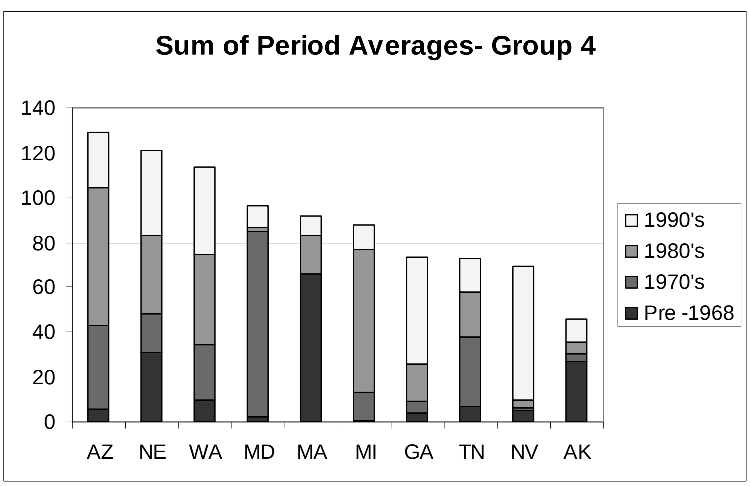
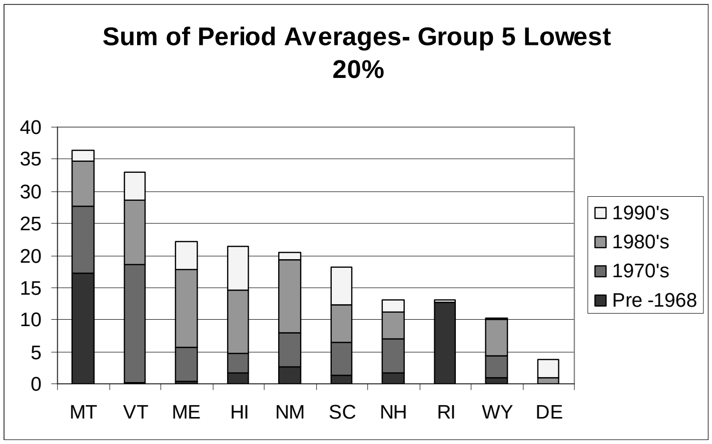


FIGURE 6-4 (Continued)



SOURCE: Derived from UCAR.

Two methods were used to classify damages. Method 1 did not attempt to relate flood size to damages. Recalling that the data were grouped into four time periods and that average damages per State were estimated for each period, this method simply eliminated the high and low flood periods for the four periods analyzed. Method 2 attempted to identify flood events that exceeded the 1 percent flood and, when greater than 1 percent floods were identified, damages for that State for that year were removed from the damage data. To facilitate the removal of these flood events, the USGS Report, *Summary of Significant Floods in the United States, Puerto Rico, and the Virgin Islands, 1970 through 1989* (Perry et al. 2001), was used. The report includes tables on each State that indicate the significant floods by stream gage during this period and in many cases assigns a return period (e.g. >1 percent) to events. It also includes the largest flood events for the stream gage for the life of the gage. The tables generally include data to 1994, but the report only considered 1970-1989.

The USGS report was utilized to identify flood events larger than the 1 percent flood, and for those larger events the damage data were removed from the record. This was accomplished by visually evaluating the data in three different ways.

These base data were first searched for flood events that exceeded the 1 percent flood. If a large number of gages for that given flood event indicated that the flood event exceeded the 1 percent, then the damage data were eliminated for purposes of calculating average damages for that given State and year. It should be noted that it was not possible to exactly define what constitutes a large number of stations because of variability in stream size. However, in general, if more than 50 percent of the gages in a State would indicate that a large flood had occurred this would be interpreted as indicating that the damages were influenced by a significant flood. Likewise, if a major river system had a flow larger than the 1 percent flood, this also would indicate that the damages attributed to that year were influenced by a significant flood.

A second search of the USGS data was performed for flood years that significantly exceeded average flood damages, in order to be able to search outside the time frame of 1970-1989 to determine if damages then were due to a flood event attributable to a record stage at the gage. If the event led to a record stage, that stage was compared to the 1970-1989 data to determine if that flood event might exceed the 1 percent event, and if so the data were removed from the data set.

Finally, a third search was performed where extreme events at the State level could be attributed to a known flooding event generally considered to exceed the 1 percent event. For example, the 1993 flooding and associated damages in the Great Midwest flood are generally assumed to be larger than a 1 percent flood, and gages on the major river systems support this conclusion. However, many of the stream gages within the watersheds, most notably the upper basin States, indicate that the flooding event on the watersheds was less than a 1 percent flood. In total the 1993 flood was determined to be an event that exceeded the 1 percent flood and damages were removed.

6.3 Concentration of Flood Losses and Flood Risks

There is significant geographic variability in flood losses and flood insurance claims. As indicated in this and previous chapters, flood losses and flood vulnerabilities are concentrated in certain states. While flooding occurs in all states, the most significant challenges and NFIP losses are limited to a relatively few states.

The RAND study of market penetration indicated that single family homes (SFHs) in SFHAs "are highly concentrated in the South. Nearly 60 percent of SFHs in SFHAs nationwide are in the South, even though less than one-quarter of homes in NFIP communities nationwide are in the South" (Dixon et al. 2006).

As illustrated by Figure 4-5, over the 1978-2004 history of the NFIP, losses due to both major riverine floods and hurricane events have been concentrated in Texas, Florida, and Louisiana and non-hurricane losses have been concentrated in Texas and Louisiana. Seven other states stand significantly above the remaining states. Analysis of aggregate flood data in this chapter (Figure 6-3) indicates that 12 of the 16 top NFIP loss states are in the top 16 in aggregate losses.

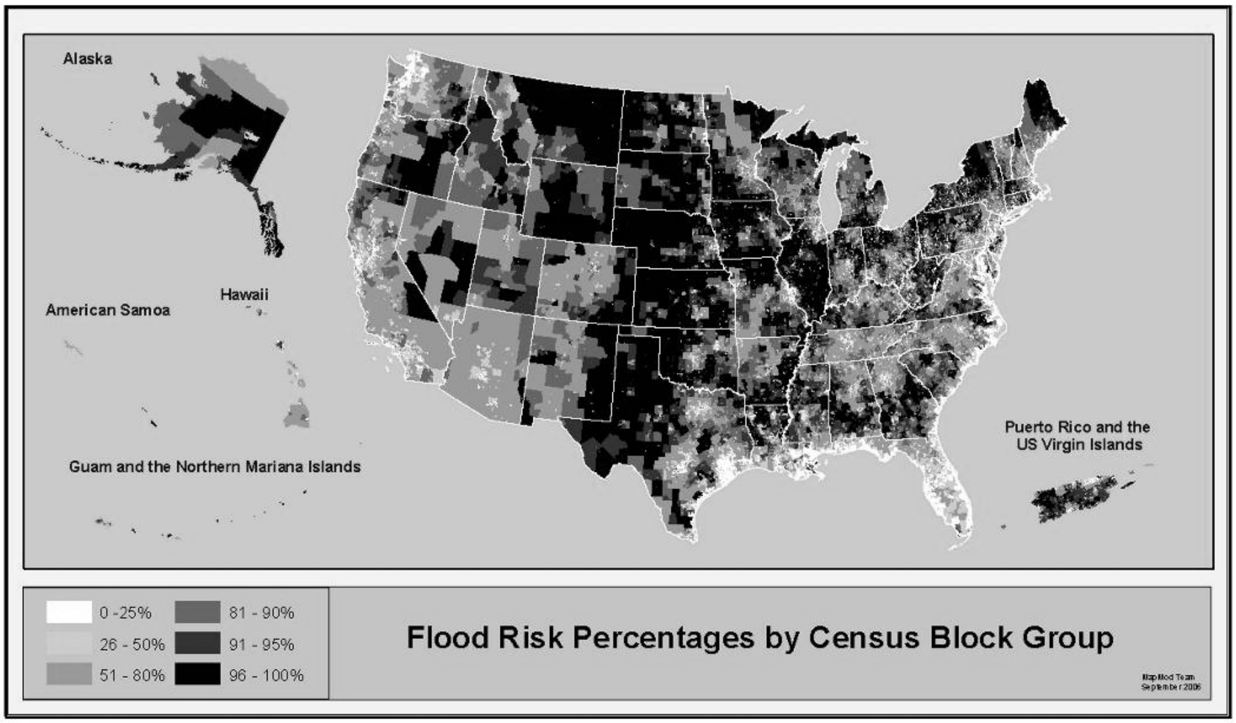
As part of the Map Modernization program, FEMA calculated census block risk to flooding based on eight parameters, including total population density, housing unit density, county-wide population growth 1990-2000, flood policy density, claims density, repetitive loss density, repetitive loss property density and declared disasters.[19] Figure 6-5 illustrates the distribution of the risk across the Nation; the lower the percentage, the higher the risk. Risks are not uniformly distributed within states or across the Nation.

Following Hurricane Katrina, FEMA examined the distribution over time of repetitive flood losses by FEMA Regions (Figure 6-6).[20] The data illustrate the concentration of repetitive

[19] Flood risk is the product of the probability of occurrence of a flood and the consequences of that flood. In this case FEMA used repetitive loss and declared disasters as surrogates for probability.
[20] A repetitive loss represents two or more claims on the same property.

losses in the regions servicing the Atlantic and Gulf coast areas, further emphasizing the concentration of flood challenges in selected states.

Figure 6-5. Flood Risks by Census Block Group; the Lighter the Color, the Higher the Risk



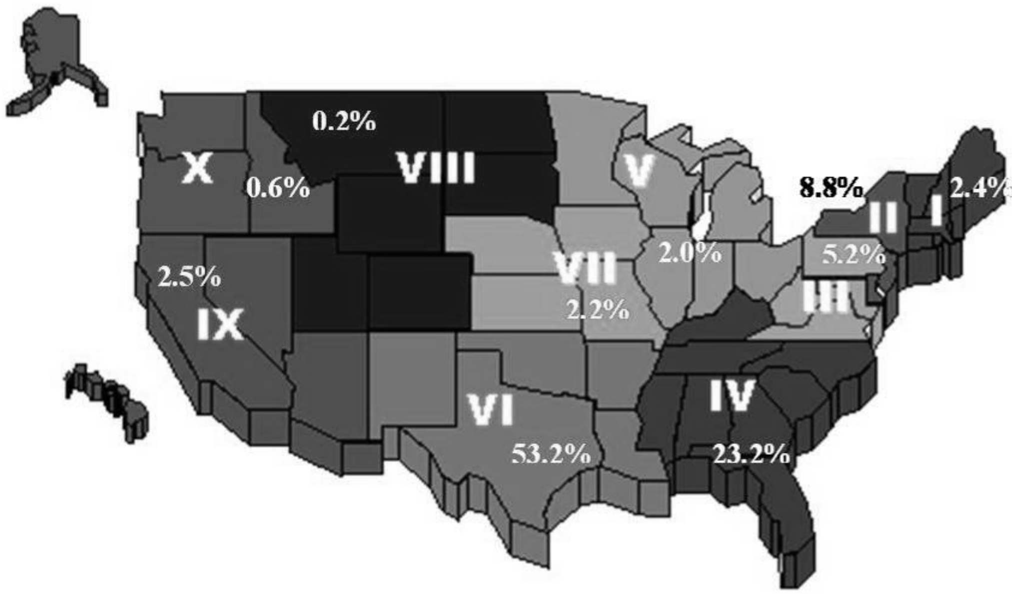
SOURCE: FEMA Mitigation Division; Watershed Concepts

However, the NFIP has primarily been implemented as a homogenous National program with a single minimum standard for the nation. One exception is the CRS program which first tied higher regulatory standards to individual premium reductions. State and local governments are not prevented from adopting standards that exceed the FEMA minimum criteria, however the results are sporadic and higher standards many times have not been adopted in States with historically high losses. Freeboard or the elevation of a structure above the estimated one percent floodplain is a good example of these challenges.

Table 1 of Appendix 4 of this report captured several standards or practices, one of which was freeboard. According to ASFPM (2003b), twenty one States have adopted freeboard requirements of one foot or more. While freeboard clearly has benefits for any structure, the largest impact to the nation most certainly will result where there are large concentrations of structures in relatively flat broad floodplains. Freeboard in those cases not only protects from future conditions, but for those flood events that exceed the one percent flood level. The Gulf Coast states, including Texas and Florida as previously mentioned, continue to have some of the highest damages and flood claims in the Nation. Further the five Gulf Coast states would realize significant benefit from a freeboard criterion. However as of 2004, Alabama was the only Gulf Coast state that had adopted any freeboard requirements on a state wide basis. This is only one example of how geographic variability may be influencing damages, and points out the need for

States to be more actively engaged in adapting NFIP minimal criteria to State and local geographic conditions.

FIGURE 6-6: Distribution of Repetitive Losses



SOURCE: FEMA Region VI.

6.4 Observations

The following observations are relevant:

- When comparing total flood damages in the Nation from 1955 to 2003, events assumed to be larger than the 1 percent flood, using the previously described methodology, accounted for 33 percent of the damages.
- When evaluating trends at the State level, flood damages increased in 32 States.
- When evaluating all damages, and when events larger than 1 percent were eliminated, flood damages increased in 36 States.
- There were no apparent reductions in flood damages.
- Flood losses are concentrated in certain States and differ between total losses and NFIP losses. Not all States face the same flood challenges.

The damage data itself indicate that States that have large land areas in agricultural production tend to have extensive flood damages, much of which is crop loss. For example, Florida is considered to be a highly floodprone State with significant claims in the NFIP. Yet from the period 1955 to 2003, Florida and Minnesota had total damages that were comparable, and California, Illinois, Iowa, Louisiana, Missouri, North Carolina, North Dakota, Oregon, Pennsylvania, and Texas had damages that significantly exceeded those of Florida. In contrast, when events larger than the 1 percent flood were removed from the record, only California, Louisiana, Texas, and Oregon had total damages that exceeded Florida's. The challenge to the

NFIP occurs when frequently flooded agricultural land is developed for home sites or industry and the new development is subject to flooding.

These observations suggest the following:

- A significant percentage of total damages are attributable to events larger than the 1 percent flood. Flood damages are generally escalating across the Nation and not just in isolated areas.
- Agricultural losses may play a significant role in total damages, and extreme flood events may be a significant factor in agriculturally dominated States.
- For events that exceed the 1 percent event on major rivers, it appears that the level of flooding within watersheds did not exceed the 1 percent event, yet there were high damages, especially within agricultural States. It may be that agricultural losses do not distinguish between a flood event (a temporary overflow of a river) versus a ground saturation event due to extended periods of precipitation.
- The challenge faced by States varies by geography. States along the major rivers and along the Gulf and Atlantic coasts face the largest challenges. Coastal states are exposed to coastal conditions as well as losses from poor drainage in the coastal plain.
- If a State or local government evaluates the political challenges with increasing the standard to account for geographic differences and perceives a “low probability” of flooding for what they perceive as a “Federal responsibility,” there is very little short-term motivation for State and local officials to adopt standards that reflect these geographic differences. This will remain a problem for the NFIP and for the goals of the NFIP until such time that disaster assistance and other related Federal funding are more directly tied to proactive mitigation actions at the State level.

7. OTHER APPROACHES FOR PROVIDING A STANDARD

The adequacy of the 1 percent standard is partly a function of what other options exist for setting standards for the flood insurance program. This chapter examines standards and approaches used in other countries, the risk-based approach currently used by USACE, and options for standards proposed at the Forum to determine how these approaches meet the goals of the NFIP and might be implemented in all or part of the United States.

7.1 Other Countries

Nations across the globe have faced the challenge of protecting lives and property from flooding. For most of recorded history, the first approach taken typically has been construction of flood control works such as levees, floodways, and retention dams or through elevation of structures. More recently efforts have been made to regulate the use of the floodplain and to restrict development that would be at risk. The approaches taken to deal with flood hazards vary considerably and depend on the nature of the expected flood, the ability of the central or local government to restrict the actions of those who live and work in floodplains, and the availability of resources to support flood damage reduction structures.

The approaches can be defined by the level of protection they provide, to what they apply (land control, structures), whether they are mandatory or voluntary, and at what level they are developed and controlled. The level of protection specified in a national or local floodplain management literature may apply to structural levels of protection, land uses, insurance, or all three. The standards may be universally applied or have limited application and they may be voluntary or mandatory. Finally, they may represent national standards or standards administered by local jurisdictions. Table 7-1 summarizes these factors for a number of developed countries.

Review of the standards for other nations indicates certain commonalities. First, the establishment of these standards reflects the risk level that accompanies the potential flood events. Some nations differentiate between risk of property damages and risk of life. It is clear, however, that where the potential for catastrophic losses exists, the level of protection is high. In many older cities, provision of high-level flood protection has been limited by necessity to preserve the older built environment near the flooding river, and thus these types of cities remain vulnerable (Figure 7-1). National capitals and large cities are typically protected to a high level, while the suburbs and agricultural areas receive less or little protection.

TABLE 7-1: Floodplain Management Strategies across the World

Country	Standard of Protection	Compliance Voluntary-V Mandatory-M	Level of Control	Comments
Australia[1]	1 percent in most use but only guideline	V	State	New consideration being given to SPF based on risk-based analyses
Austria[2]	1 percent in urban; 3.3 percent in remainder; Vienna 0.01 percent	M	Federal	
Canada[3]	Varies by province from 1 to 0.2 percent; Ontario's regulatory flood uses the Hurricane Hazel rainfall, the Timmins storm (a storm of record), or the 1 percent flood.	M if province seeks Federal support	Province; municipality with Federal support	Federal government cost-shares in disaster relief and supports mapping, flood studies, etc., when federal/provincial governments do not build, approve or finance flood prone development in a designated flood risk area; Governments do not provide flood disaster assistance for any development built after an area becomes designated (unless in the flood fringe and adequately flood proofed). Provinces encourage local authorities to zone on the basis of flood risk.
China[4]	1 percent for major cities (practice)	V	Federal	
England[5]	Defined flood zones Flood Zone 1— Little or no risk Annual probability of flooding: River tidal & coastal < 0.1 percent (i.e. 1 in 1,000 year) – Few constraints. Flood Zone 2— Low to medium risk Annual probability of flooding: River 0.1 - 1.0 percent, Tidal & coastal 0.1 - 0.5 percent - Flood risk assessment needed; consider evacuation planning. Flood Zone 3 – High risk Annual probability of flooding with flood control where present: River 1.0 percent or more, tidal & coastal 0.5 percent or more. See comments.	V	Federal guidelines; application varies by locality	Within Zone 3- Zone 3a - Suitable for residential, commercial & industrial development, provided that the appropriate minimum standard of flood control can be maintained for the lifetime of the development. Suitable evacuation procedures are required. Zone 3b - Generally not suitable for residential, commercial & industrial development. Zone 3c - Development should be wholly exceptional & limited to essential transport & utilities infrastructure.
France[6]	Risk areas identified Strong risk – no new building authorized (1m depth or >1m/sec flow) Median Risk – infrequent hazard (>,5m depth or .5m/sec flow) Weak Risk – few restrictions	M	Federal	
Germany[14]	Risk areas are identified by States; risk-based methodologies define specific levels of protection for community. Insurance industry rates areas by risk zones: a. <2 percent b. 10 to 2 percent c. >10 percent	V	State	Federal government encouraging multi-faceted approach: use of natural flood storage areas, limiting new residential or other settlement in risk areas; improvement of flood warning system; increased safety of hazardous materials.
Israel[7]	50 to 20 percent in "minor" locations; 2 to 1 percent in major developed areas or where threat to human life	V	Ad hoc	Federal government developing plan for management of runoff which will include flood protection

Italy[8]	Flexible guidelines and regulations and standards	V	River authorities	
Japan[9]	0.01 percent (10,000-year) protection for coastal areas with large populations 0.5 percent (200-year) protection for riverine population centers	V	Federal	
Netherlands[10]	0.01 percent (10,000-year) protection for coastal storms 0.08 percent (1,250- year) protection for major rivers; 0.5 percent (200-year) for rivers where threat is reduced	M	Federal Water Boards Municipalities	
New Zealand[11]	Standard varies from 2 percent to 0.2 percent; major urban areas have higher protection (Christchurch- 0.5 percent) 1 percent standard is most common.	V	Regional Municipal	National Building code states : Surface water, resulting from an event having a 2 percent probability of occurring annually, shall not enter buildings
Norway[12]	Varies by structure and threat (risk of fatalities (F) or Risk of substantial damage to property (S)) Outbuildings 1 percent(F); 5 percent (S) Domestic bldgs 0.1 percent(F); 1 percent (S) Critical facilities <0.1 percent (F) <0.5 percent (S)	V	Municipalities	0.5 percent frequently selected when there is a mix of threats; flood return intervals from 10 to 500-years with a zone without inundation but with risk of flooding in basements also are calculated.
Spain[13]	Only two regions have standards; standards vary by river basin	V	Regional	Arid region with little flooding in most of country; flash floods common

Note: Table is based on and expands report of Firas Makarem and Vincent Parisi to Gilbert F. White Forum.

1. Smith 2004.
2. Shrubsole et al 2003; Makarem and Parisi 2004 ; Kallio 2005.
3. Flood Disaster Investigation Team 2003.
4. Li 2006.
5. Makarem and Parisi.
6. Paquier 2005; Makarem and Paris; Martini 2006.
7. Shamir 2005.
8. Makarem and Paris.
9. Oda 2005.
10. Eijgenraam, 2006.
11. Hamilton 2005.
12. Makarem and Parisi; Berg 2005.
13. Segura 2005.
14. Probst 2006.

FIGURE 7-1: Dresden, Germany during 2002 Elbe River Flood

SOURCE: Technische Universitat— Dresden.

Many nations recognize that different areas are subject to different types of flooding. Some are affected by flash floods, while others must face hurricanes, typhoons, or riverine floods of extended duration. In some case the differential between the stage of the 1 percent flood and the stage of the 0.2 percent flood is minimal, and in other cases the differential is large and different standards are employed for each. Nations like Australia have defined a standard but permit the States to determine whether or not the standards should be applied in each case.

The United States was an early nation to adopt a 1 percent standard, and this has led to the standard's adoption by other nations. Dingle Smith, a water resources expert from Australian National University, pointed out "On numerous occasions I have encountered, across three continents, senior planners that state they recommended the 1 percent standard because their legal experts informed them that the 1 percent standard was used in the United States and that this provides legitimacy for its wider use. Floodplain management across the world owes much to the pioneering work in this field in the United States but it is to be regretted that the fixation on the 1 percent standard flood has become an integral part of such endeavours" (Smith 2004).

7.2 U.S. Flood Damage Reduction Standards

In the United States the 1 percent standard is tied to the National Flood Insurance Program and establishes the base level for control of development in floodplains. As noted earlier, it has been a de facto standard for other forms of land use control by governments and businesses. The NFIP standard, on the other hand, does not define the extent of protection that should be provided by flood damage reduction works of governments, either at the Federal or State level, although it has heavily influenced those determinations.

7.2.1 Executive Orders 11988 and 111990

Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*, which were issued by the Carter Administration in early 1977, reflected the new president's desire to reduce flood damages and to preserve and protect the riverine environment. Executive Order 11988 directs Federal agencies to "provide leadership and … take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains." Agencies were required to address floodplain issues when:

- Acquiring, managing, and disposing of Federal lands and facilities;
- Providing Federally undertaken, financed, or assisted construction and improvements; and
- Conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

The order required "the construction of Federal structures and facilities to be in accordance with the standards and criteria and to be consistent with the intent of those promulgated under the National Flood Insurance Program." It defined the floodplain to include "at a minimum, that area subject to a one percent or greater chance of flooding in any given year" (EO 11988). As a result of EO 11988, the 1 percent chance flood became the standard for most Federal actions.

Executive Order 11990 directed Federal agencies, in carrying out their responsibilities to "provide leadership and … take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands."

U.S. Water Resources Council *Floodplain Management Guidelines for Implementing EO 11988*, issued on February 10, 1978 introduced the concept of the 0.2 percent chance flood standard for "critical actions." Critical actions were not explicitly addressed in EO. 11988, but the concept evolved during the drafting of the guidelines with the recognition that the impacts on human safety, health, and welfare for many activities could not be minimized unless a higher standard was used (FEMA 1983). This topic is discussed further in Chapter 10.

Taken together, the orders reflected a presidential intent to reduce flood damages through avoidance of the flood hazard while concurrently enhancing the quality of the riverine environment. The report of the Interagency Floodplain Management Review Committee following the 1993 Mississippi flood indicated that the executive orders were not observed by some Federal agencies (IFMRC 1994a).

7.2.2 USACE Risk-Based Methodology

As previously discussed, the NFIP uses elevation as the foundation for its national standard. Base flood elevations are used to regulate construction in the SFHA, and insurance is tied to elevations of the structures being insured. To be recognized as providing a level of protection that relieves those behind levees of the mandatory insurance purchase requirement, a levee's crown must be at or above the BFE plus 3 feet of freeboard (NRC 2000). In addition, the levee must meet specified geotechnical standards and must be operated and maintained in accordance with FEMA regulations and policies. When a levee meets the specified standards, a professional engineer must certify this compliance. FEMA's regulations do provide that other Federal agencies may certify that a levee is in compliance using the agency's methodology. In 1997, FEMA and USACE signed an agreement that permits USACE risk-based analysis procedures to be used in levee certification. (For further discussion of levees, see Chapter 9.)

In 1996, USACE determined that it would move from the design of levees against a specific return interval target to a design approach that focused on careful consideration of the economic, geotechnical, hydrologic, and hydraulic parameters, taking into account risk and uncertainties connected with these parameters. Levees designed under this approach are not marked as providing a recurrence interval-based level of protection but are given a "conditional nonexceedance probability," which is the probability that "failure will not occur during a flood of a given frequency. For example a levee may have a 90 percent chance of not being overtopped when exposed to a 100-year [1 percent].flood" (NRC 2000). According to USACE, "The three key features of risk analysis are: 1) A conscious focus on accurately estimating flood probability and risk, documenting the findings, and communicating the results to interested parties and decision makers – thus lessening reliance on buffers and safety factors as concepts to ensure performance; 2) acknowledging and quantifying uncertainties in key flood damage reduction study factors, such as flood frequency, flood stage, structural and geotechnical performance, flood damage and costs, and documenting and recording findings to interested parties and decision makers; and 3) emphasizing residual risk (probability of flooding and consequences thereof) as a key element in project development and analysis for all flood events, including those that exceed project capacity" (USACE 2005a). As FEMA conducts its modernization of flood maps, any validation of certification or new certification conducted by USACE for a levee sponsor will be accomplished using the risk-based methodology.

7.3 Other Approaches for Regulating the Floodplain

During and prior to the Forum, the participants wrote about and discussed both methods through which the current standard could be improved and other options for regulating the floodplain. During the Forum, the participants discussed and proposed options, but the Forum made no attempt to reach a position on any of the proposals.

7.3.1 Improving the Current Standard

Methods of application of the current standard by government agencies and floodplain managers vary significantly across the Nation because of a wide variety of factors. Some of the variation leads to a reduction in the standard; other variations lead to use of a higher standard. By increasing attention to several factors, slipping standards can be raised to or above the 1 percent level. Dealing with the former is essential since a failure to do so places those who use this information at risk. Floodplain residents should expect the government to provide accurate information.

There is concern that because of a combination of factors such as “changes in land use since mapping and studies were done, inaccuracies in data and calculations, uncertainty, and other factors” that the 1 percent standard as used in reality represents some level less than 1 percent (2 percent, 4 percent, etc.) (ASFPM Foundation 2005, Jones 2004, Lulloff 2004). (In some few cases, data inaccuracies could be raising the standard). Addressing this lessening of the standard would require greater attention to the above factors, and in some cases, such as the gathering of data, preparation of computational models, development of new algorithms or refinement of older approaches, it would result in significant resource demands.

During the Forum, there was “general agreement…that improvements could be made in the policies, regulations and implementation” of the standard to make the current standard “more accurate and effective.” Among the actions suggested by the participants were:

- Integration of protection of natural values into management in the 1 percent floodplain could enhance the quality of the environment and, in some circumstances, provide needed flood storage.
- Elimination of the one-foot rise in flood elevations permitted in the regulatory floodway would eliminate or reduce rise in the regulatory floodplain. Such an approach would complement the No Adverse Impact campaign of ASFPM, which proposes that no actions be taken in the floodplain that would cause adverse impacts up or downstream.
- In calculation of the 1 percent floodplain, institute use of hydrology that takes into account future conditions to account for potential changes in land use in the basin.
- Add additional freeboard to the base flood elevation of levees or first-floor elevations to compensate for incomplete or old data or problems with mapping.
- Improve the quality of hydrologic data through additional State and Federal investment in improving the quality and extent of data collection. A first step would be to increase the number of stream gage stations.

These approaches are discussed further in Chapter 12.

7.3.2 Developing New Approaches

As an alternative to dealing with modifications to the existing standard, participants suggested consideration of several new approaches:

- Develop a two-tiered standard that leaves the existing 1 percent standard in place for most of the floodplain but creates a higher standard, most likely the 0.2 percent standard, for areas where there are critical or vulnerable facilities. (Chapter 10 addresses the current procedures for protection of critical facilities.) The recent experience of New Orleans in protecting key governmental activities, the aged, and the disabled offers solid reasons for consideration of such an approach.
- Institute mandatory flood insurance for all buildings in the country, with the insurance costs based on the exposure to flooding. Technology now offers at a reasonable cost the capability to rapidly and accurately determine the elevation of structures so that policies could reflect the risk. As was illustrated by the 1993 Mississippi-Missouri flood, considerable flood damage can be attributed to long-term rainfall event to overland flow

(sheet flow across fields as opposed to river overflow). The blanket insurance program would provide a hedge against any such events. To those not in a defined floodplain, the mandatory insurance rule would likely be seen as a tax rather than as part of broad insurance coverage and might have the effect of weakening the impact of the mandatory purchase requirement in discouraging floodplain development.

- Use a risk-driven benefit-cost analysis to determine not only the level of protection to be provided but the extent and level of floodplain management that would be applied. This approach would require considerably more analysis than is currently being performed and would still require the hydrologic and hydraulic information as well as the highly accurate topography for mapping.
- Drop the NFIP and move to a market-based program that would require those choosing to live or build in floodplains to bear the cost of flooding and, conceivably to apply for disaster assistance from the government. Communities would still exercise their health and safety prerogatives to prevent floodplain occupants from extreme risk or from causing problems for those upstream or downstream. Such an approach would require a public that was well educated about the dangers of floodplain occupancy and elected officials, who would, after a flood, resist the temptation to “bail out” those who did not take precautionary measures. The transition from present to future conditions would be difficult.

7.4 Observations

It is evident that around the world and around this Nation there are many ways in which governments and individuals address the topic of standards to govern land use in floodplains and the provision of mitigation measures such as insurance to those who are at risk.

At one end of the spectrum are standards that seek to prevent catastrophic losses to life or property. In these cases governments have indicated that they will attempt to provide protection that will prevent damages from all but the “unthinkable flood” event. Design levels are based on either postulation of the most severe storm experienced or hypothesized or a statistical extrapolation to a very high recurrence interval (e.g. 1/10,000 or the 0.01 percent). As indicated above, such standards are used in Japan and the Netherlands for coastal protection where the consequences of flooding are extraordinary. The Japanese flood management community suggests that the provision of economic and personal safety is a first-order priority for governments.

At the other end are standards that represent a balance between protection costs and flood consequences. In these cases, the potential damages are periodically examined along with the costs of providing protection or requiring development that is free from threat and a standard chosen that generally reflects a favorable *economic* benefit-cost analysis. To be effective, this approach requires that governments do in fact, carry out periodic reevaluations, something that has not been done in the United States.

Management of flood *standards* can be accomplished at the Federal level, delegated to subnational governments, or established as guidelines to assist the public in making land use decisions. Delegation from the Federal level to lower levels permits adaptation of the standards to the particular geographic and demographic characteristics of an area and the nature of the flood threat that the area faces. Such an approach requires that the subnational governments not only assume part of the responsibility for standard setting but also for disaster assistance should floods occur. As seen, this delegation of responsibility from the Federal to the State or local level is in wide use around the globe. In many cases, determination of flood damage reduction strategy is left, *within guidelines*, to the State or local government to determine.

Discussions at the Forum clearly indicated that problems existed in implementation of the standard and that these problems made the standard less effective for land use regulation and the BFE less realistic. In addition to use of future conditions hydrology as discussed earlier in Chapter 5, participants suggested several other approaches for improving implementation. These are discussed in detail in Chapter 12.

Modern technology that permits very accurate identification of a structure's location (to include elevation) offers the opportunity for consideration of even more adaptation of standards to the circumstances of an individual structure and a more comprehensive assessment of the impact this structure might have on the floodplain activity in general. Unfortunately, while technology has provided the opportunity to carry out such analyses, because of limited budgets, resources have not been made available to accomplish such tasks. As a result, as the costs of using this technology are reduced, governments at all levels will begin to take advantage of them to improve the effectiveness of their implementation of whatever standard exists.

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8. IMPLICATIONS OF CHANGING THE STANDARD

Any change in the 1 percent standard will force changes to be made in all programs that are based on or take their lead from the standard. Given the significant potential for damages in the zones above the 1 percent zone (as noted in Chapter 4), the change should be to a higher or more restrictive standard. The most significant changes then will be seen at the local level where a greater area, and thus more structures, might be included in the SFHA or be subject to regulation. Post-flood activities in an area would require reconstruction of both pre- and post-FIRM substantially damaged structures under the new, higher standards. The consequences of these changes would be increased short-term costs. There are three approaches to both decrease risk and long-term flood damage costs and minimize the impact of changes on the local communities:

1. Raise the standard from 1 percent to some other numerical standard with the new standard (higher BFE and larger SFHA) applying to construction and mandatory insurance requirements in the new zone, regulation within the new zone or some component of that new zone.
2. Leave the standard as it is but strengthen the implementation as suggested in Chapter 7 and 12, and use a larger SFHA for mandatory insurance purposes.
3. Some combination of the first two.

Changes in standards that increase the BFE or add more area to the SFHA for floodplain regulation and/or insurance purposes will have positive impacts in terms of increasing the coverage of the NFIP and reducing or limiting floodplain occupancy. This chapter focuses on the costs of possible changes on programs and practices that are affected by the 1 percent and other floodplain management standards. Changes in standards could affect the construction of new structures, reduce the increase in available building stock, modify the implementation of floodplain management at the local level, modify the structure of the flood insurance program, and influence other factors including natural and beneficial functions and other floodplain activities.

To better focus the analysis, this chapter will examine a change in the standard from 1 percent to 0.2 percent under two scenarios. In the first scenario BFE and floodplain management requirements would apply only in the 1 percent zone while mandatory insurance would apply throughout the entire area (the 0.2 percent floodplain). In the second scenario, BFE, floodplain management, and insurance requirements would apply throughout the 0.2 percent zone. The impacts of applying the same scenario to a standard somewhere between 1 percent and 0.2 percent would be less. However, because accurate information on the population in these other zones is not available, little specific information can be developed.

8.1 Raising the BFE to a New (Higher) Elevation

Any change in standards that would result in a raise in the BFE would have significant impacts.

8.1.1 Impact on Existing Structures and Future Construction

Chapter 4 indicated that there are between 3 million and 6 million structures in the zone from the 1 percent line to the 0.2 percent line. Under the first scenario, regulation inside the 1 percent zone and mandatory insurance in the entire zone, the new SFHA would be the 0.2 percent zone but the BFE for land use regulation would remain at the 1 percent elevation. Insurance ratings and land use regulations for structures currently within the 1 percent zone would not be affected. Individuals living in the area between the 1 percent and 0.2 percent lines would have to purchase insurance if they carried a Federally related mortgage.

The second scenario, mandatory insurance and floodplain regulation throughout the entire 0.2 percent zone, would place all of the noncomplying pre-FIRM structures in the 1 percent zone further below the national standard and would move all the structures that were outside the 1 percent SFHA into the newly defined SFHA and subject them to mandatory insurance and elevation requirements. It would immediately remove from compliance all of the structures in the current 1 percent zones whose first-floor elevations were at or above the 1 percent BFE and below the 0.2 percent elevation and create a new population of pre-FIRM policyholders. It is not known what percentage of the estimated greater than 3 million structures have first-floor elevations below the 0.2 percent level, but one could anticipate a relatively large number.

Raising the standard would also affect government facilities located within the newly defined SFHA. Federal agencies are required under Executive Order 11988 to carry out their activities and programs in consonance with the 1 percent standard. Critical Federal facilities are already required to be protected against the 0.2 percent flood (see Chapter 10). Unfortunately, there is no inventory of Federal or other structures in the 0.2 percent floodplain or any indications of their elevations. Since many of these structures are probably located near the 1 percent boundary, it is likely that the number below 0.2 percent BFE would be large.

The impact of the second scenario on future construction could be significant. Any change in standards that results in an increase in BFE would require builders to adjust their new construction plans to accommodate the additional elevation of the first floor to meet NFIP requirements. The actual costs of the change would be dependent on the actual increase in elevation and the topography of the area in which the structure is being built. Calculations performed during the NFIP study by Chris Jones and Associates (2006) indicate that "the additional costs of adding freeboard at the time of construction are small, and would generally return benefits in excess of the costs, particularly in V zones and Coastal A zones, and in non-coastal A zones with low Flood Hazard Factors." Jones conservatively estimates that in coastal zones subject to wave action it is cost-beneficial for someone building in this flood zone to the old BFE to spend 2 to 3 percent more to raise a new building by 1 foot at the time of construction, up to another 5 to 6 percent to raise it by 4 feet. This would equate to an increase of $8,000 to $24,000 on a $400,000 home (home value, not including property). These figures do not depend on building size, number of stories, foundation type, or absolute construction cost, but rather on the height the building would be raised, and the economic discount rate for funds being employed, the building's useful life, and depth-damage functions. In an A zone, according to Jones, it is always worth spending an additional 0.5 percent of the initial construction cost at the time of construction for 1 foot of freeboard above the BFE, and this addition may be worth as much as 4 percent in benefits.[21]

A new, higher elevation standard would also impact post-disaster recovery activities. Substantially damaged homes that will be rebuilt on the same site would have to increase their first-floor elevations to the new BFE and would now have to be rebuilt at a higher elevation raising the costs. This would increase the costs to the insurance pool for the reconstruction component of the policy. More likely, some of these structures would not be rebuilt in the SFHA, which would be seen positively by floodplain managers. The costs of raising existing structures will be higher than those discussed earlier for new construction and will vary by the type of building that must be raised.

In some flood-prone communities where the amount of buildable land is limited by topography (steep valley wall, wetlands, etc), increasing the size of the SFHA could reduce the number of homes constructed in the community and force an increase in the density of structures in the non- flood-prone areas.

8.1.2 Property Values

Expanding the area within the SFHA would have an initial negative impact on properties that were brought into the new zone. An NFIP Study by Sarmiento and Miller (2006) indicates that the NFIP insurance subsidy to policyholders with pre-FIRM policies "artificially inflates" the value of these homes by an average of $24,020 and has "contributed to market demand for pre-firm structures located below BFE." However, current literature (Tobin and Montz 1997; Montz and Tobin 1988, Chivers and Flores 2002) indicates that the long-term impact of inclusion in the SFHA on property values may be minimal, even after a flood event, as most new occupants do not fully appreciate the risk they face. Unless there was a significant increase in education about the risks of floodplain occupancy, the inclusion of higher elevation property in the SFHA might have a lesser impact than has been seen in property values within the current 1 percent SFHA.

8.1.3 FEMA Mitigation Programs

FEMA's mitigation programs are designed to incrementally reduce the number of homes at risk. Increasing the size of the SFHA and raising the BFE would require mitigation programs that include building elevation to fund the incremental costs of rebuilding a structure in place at the new BFE. If the mitigation involved buy-out of the structure, the short-term costs would be higher because more structures potentially would be purchased, but the long-term potential for losses would be significantly reduced. The costs of individual buyouts would not change because they are based on demolition costs.

[21] Natural hazards management consultant Elliot Mittler (2006) indicates that in many areas of the country, housing prices are rising faster than construction costs, so the additional construction cost is actually decreasing proportionally to the total cost, thus causing less of an effect on the number of potential homeowners than in the past. Such market conditions would be favorable to a change in the standard

Even though recent studies show that the FEMA mitigation activities produce $3.65 in benefits for every Federal dollar expended ($5.00 for floods); (NIBS 2005), the FEMA budget for mitigation has been constrained over the years. Increases in costs of mitigation without a concomitant increase in funding would result in a smaller mitigation program – fewer structures receiving Federal support.

8.2 Implementation of Change

Within the decade following the establishment of the standard, there was considerable debate about the impacts of the initiation of a standard at the 1 percent level and a move toward a lower standard by the development community. A 1983 FEMA report to OMB related the following issues raised by State and local governments concerning a possible change in the standard (FEMA 1983);

- "The 100-year flood is a reasonable standard which provides for public safety without unduly infringing on individual rights."
- "Technically or administratively, any modification of that standard would be unbelievably disruptive to all the efforts that have been made, and are presently underway…."
- "The benefits derived from retaining that flood standard far outweigh possible negative impacts that may be ascribed to economic losses due to denial of development opportunities."
- "If FEMA were to adopt…[a] variable standard…then FEMA would generate a program [NFIP] which we believe could never be administered equitably."
- "A change from the 100-year standard to some other standard would without doubt be very disruptive *or* totally destroy what we feel is an excellent floodplain management effort."

The success of the NFIP in influencing sound land use in and near the SFHA is dependent on the activities at the community level. While the level of sophistication of local programs varies considerably, all must have in place land use regulations controlling new construction in the SFHA. Raising the BFE would expand the area under community supervision and increase community workload. If the new SFHA were quickly mapped, communities would be able to deal with new construction in the revised SFHA just as they have had to for the existing SFHA. However, it is likely that the new mapping would take several, if not many, years to accomplish. The political implications of a change are not as easily evaluated and will depend heavily on the current use of the land that would be included in the new SFHA. If the area is largely undeveloped, as indicated earlier, a change to a higher BFE will only add marginal costs to the construction of any future development.

In interviews conducted as part of this study, flood plain management personnel at all levels expressed concern over any changes that would precipitate major administrative burdens. They see that any changes in BFE, other than those which might occur through periodic re-mapping, as challenging the credibility of the NFIP. Such changes would appear to many people to be changing the "rules in the middle of the game."

8.3 Flood Insurance Program

As mentioned earlier, expanding the SFHA would increase the number of participants in the flood insurance program. If those brought into the new SFHA were charged actuarial rates for their insurance, the base costs would not increase; however, since the Federal government is ultimately responsible for the health of the program, the increased insurance exposure created by the incorporation of additional flood-prone areas, increases the possibility of significant losses under a catastrophe (but reduces the need for Federal assistance.)

8.4 Flood Damage Reduction Activities

Structural flood damage reduction activities such as construction of levees and dams, and elevation of structures in flood hazard areas, have taken place in the United States over two centuries and, as noted in Chapter 3, the level of protection provided by these programs varies considerably across the Nation and changes as new hydrology, site conditions, and upstream activities occur. The major flood damage reduction efforts initiated by the Federal government under flood control acts in 1928 and 1936 were initially established to provide protection against significant flood events – the "catastrophic floods." Today, there is no national standard for the level of protection provided by Federal programs and the protection provided varies from the greater than 0.2 percent protection found in the lower Mississippi Valley to the 1 percent protection provided to the city of Sacramento, California, to a considerably lower level with levees protecting farmland (and that are not part of the NFIP). Much of the effort over the past two decades has been focused on getting communities out of the mandatory purchase requirements of the NFIP. As far back as 1980, FEMA had evidence that "the use of a 100 year standard was encouraging construction of levees to the 100 year design level for the sole purpose of removing an area from the special flood hazard designation" (Jimenez 1980).

Some flood damage reduction projects are constructed by local sponsors without Federal support. They are certified as providing at least 1 percent protection and meeting the FEMA guidelines for inclusion in the NFIP by professional engineers who attest to their worthiness. The number, condition, and location of these structures, mostly levees, are currently not tracked by Federal agencies and most States. Completion of the FEMA flood map modernization program will identify these levees, but that work will not be completed until 2008. Both FEMA and USACE have begun an effort to create a national levee database that would include such information and would enable analysis of the extent and level of the protection provided.

Any change in the standard that would raise the BFE would necessitate a project by project examination to determine if structures that currently provide the 1 percent level of protection to a community would provide protection to the 0.2 percent level. The current level of protection provided by many structures is not generally known by the responsible agencies. Anecdotal information obtained from FEMA, USACE, and State floodplain management officials also indicates that many projects provide protection at or near the 1 percent level but would require rehabilitation and upgrade to meet higher standards. It is important to recognize that increases in the height of levees are accompanied by a substantial increase in the width of the levee at its base (with attendant need for increase in project right-of-way) or a total redesign of floodwalls in order to increase their height. Because of the costs involved in raising the level of protection to the new standard, it would be many years before upgrades would be completed. During the interim period, the NFIP might have to accept this lesser level of protection.

Dams and floodways also support flood damage reduction. Dams hold water that would otherwise add to the river flows downstream. These waters normally are released from the "flood pool" when the downstream dangers have been reduced. Areas in floodplains have been removed from the 1 percent zone and a lower levee height has been made possible though this upstream storage. Floodways allow floodwaters to bypass choke points or critical areas in a river system. Channel improvements provide a specified carrying capacity to move floodwaters past a protected area; however, if the capacity of the dams, channels, or floodways is exceeded or the systems were to fail, the results could be catastrophic.

The costs for modifications to existing projects would depend on the increase in elevation required to meet the new standard. Some projects could be modified by additions to the existing structures; in other cases, the increase in required elevation might require totally new construction at considerably higher costs. The high costs associated with immediate levee repair and upgrade of the 350 miles of New Orleans levees damaged by Hurricane Katrina (approaching $10 billion) gives some indication of the potential expenditures that might be required to upgrade structures to provide a higher level of protection.

8.5 Flood Map Modernization Efforts

In 2004 FEMA initiated a five-year, $1 billion program to modernize its flood maps by moving them to a digital format that permits more frequent updates and inclusion of locally produced data relative to the floodplain. This program is in its third year and has already produced a large number of digital maps. Production of a new map requires the program participants, contractors, and cooperating technical partners to use the best-available digital elevation information and hydraulics and hydrologic information (either existing or developed for the modernization) to develop a digital flood insurance rate map (DFIRM) based on the current 1 percent standard. The intent of the program is eventually to shift responsibility for map maintenance and periodic updates to the local level (State or community). Data obtained during the map modernization program would be provided to the local governments and would permit them to use the information in the conduct of their floodplain management programs.

Depending on the timing of any change in standards, responsibility for updating the DFIRMs would fall to either the Federal government or the local governments which are slowly assuming responsibility for map maintenance. While hydraulics and hydrology (H&H) information is being used in the map modernization program, much of the H&H is data that were obtained at the time of the preparation of the initial map. With the map modernization program in place, changes in delineation of the SFHA will be easier than they would have been under the paper map era; however, development of DFIRM for a new SFHA would not be a trivial effort. Each step in the map development process would have to be repeated and in many cases older H&H would no longer be sufficient for use.

As part of the Watershed Concepts analysis of the number of structures in the 1 to 0.2 percent zone, it also estimated the cost of mapping this additional area should it be added to the

NFIP. The firm indicated that if this additional mapping were to take place following completion of the current map modernization effort, the cost would be approximately $770 million. Were it to be initiated as early as 2007, the costs would drop to approximately $590 million (Edelman 2006).

8.6 Other Impacts

Raising the standard could have impacts on the floodplain as a whole. The delineation of an SFHA identifies to those residents in the area that they are at risk, and over time many may choose or be supported in efforts to leave that area. Bingham et al. (2006) reports that the percentage of pre-FIRM polices has decreased from 85 percent of the total of policies in 1985 to 25 percent in 2005. This may indicate some decrease in human occupance of the floodplain (although many pre-FIRM occupants may have either dropped their insurance or replaced a pre-FIRM structure with a newer one on the same land) and could open some vacated areas for use by natural systems and the possible restoration of the floodplain. Increasing the size of the SFHA would increase the area subject to relocation and would improve the possibility of land being returned to natural systems. Changes other than expansion of the SFHA might have the same effect. Actions that would sensitize floodplain residents to the risks that they face might ultimately cause some residents to move from the floodplain.[22]

8.7 Other Modifications to the Standard

If other approaches were taken to modify the standard, such as geographically selective application of higher standards or tying insurance rates to the specific elevation of a structure, the impacts would mirror those indicated in the previous section, but at a lesser level of impact.

8.8 Observations

Any change in the standards will have significant impacts. On the positive side, an increase in the number of structures covered under the mandatory insurance provisions increases the insurance pool and ensures that the owners of many flood-prone structures, who now contribute nothing to offset potential flood losses, share in the risk mitigation. Tightening the standards might also increase awareness of the flood threat among those who are at risk and could lead to increased removal of structures from the floodplain following major flood events. Although there is no specific evidence to support this hypothesis, anecdotal information suggests that it might occur.

On the negative side, any change that results in the raising of the base flood elevation will expand considerably the number of structures that would fall under the mandatory insurance

[22] Mittler (2006) points out the social dynamics that occur following floods: "In general, land near water, especially on the coasts and river fronts near populated areas, sells at a premium. After floods, the less-well-to-do who cannot afford to rebuild sell their homes to the rich, who tear them down and build more palatial structures. If one looks at census data over the past three decades, it is apparent that those areas have undergone tremendous social changes. Floods have become part of the process to remove the poor to middle classes from prime areas and make our shoreland the exclusive property of the well-to-do. A consequence is lower densities to accommodate larger buildings."

provisions of the NFIP and the exposure of the Federal government to insurance losses. The costs of post-flood mitigation would also increase as substantially damaged structures would have to be raised to a higher elevation than before. The costs of new construction would also increase to accommodate the requirement for a higher BFE. Unless the new standard were substantially higher than the existing standards and the difference was readily apparent in contrasting new and old structures, the impacts on property values would likely be minimal relative to the price of housing overall.

Since many national and local flood damage reduction projects were developed in consideration of the NFIP, many of these projects would have to be modified in order to retain the insurance exemption provided by the presence of these structures. The costs of such work would be high and would lead to increased pressure on USACE and/or FEMA to fund such work.

9. LEVEES AND THE 1 PERCENT STANDARD

There are only two kinds of levees; those that have been overtopped and those that will be.

Anonymous

Levee - "…a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding."

44 CFR 59.1

9.1 The Levee Challenge

The purpose of this chapter is to examine FEMA's treatment of levees in the NFIP. It will examine the background of levees in the Nation's flood damage reduction program, the standards applied to their construction, the nature of the protection they provide, the role they play within the NFIP, and the appropriateness of the 1 percent standard as a benchmark and the related removal of structures behind such levees from the mandatory insurance requirement.

The failure of elements of the hurricane protection system of levees and other structures protecting New Orleans following Hurricane Katrina in 2005 focused the world's attention on the viability of levees for flood protection. Flood disasters in the Mississippi-Missouri basins in 1993 and at Grand Forks North Dakota in 1997 had shown that the levees could be overtopped or could fail and that the consequences could be large, but Katrina exposed the catastrophic potential of levee failures. Several cities around the country would be similarly affected by levee failures (e.g., Sacramento, CA).

FIGURE 9-1: Levee on Kansas River

SOURCE: USACE

Levees have been part of the history of flood damage reduction activities in the United States. They are found along rivers all around the world and date back to antiquity. By the second decade of the 20th century, levees had been linked together along many major U.S. river systems to form works that protected vast areas of the floodplain for farming and human occupation. Major floods in 1927 and 1936 led to significant damages and solidified in policy the notion of a "Federal interest" in flood control. The passage of the 1928 and 1936 flood control acts introduced an era where the Federal government assumed principal responsibility for construction of flood control projects across the country, including the construction or strengthening of levees and oversight of the maintenance of levees protecting many parts of the country. Levees built by the Federal government generally were turned over to local sponsors for operation and maintenance, but remained under the oversight of USACE.

Since the Federal government was not always able to support timely flood protection or because the benefits from proposed local projects did not exceed their costs, local groups sometimes assumed responsibility for building their own levees to protect farmlands, small communities, developments, or even individual homes. In 1941 Congress authorized USACE (PL 77-228) to conduct emergency repair or rehabilitation of flood control works damaged by floods, and subsequently permitted similar work for restoration of Federally authorized coastal protection structures damaged by extraordinary wind, wave, or water action (PL 84-99). PL 84-99 applies to both Federal projects turned over to local sponsors and locally built flood projects that meet certain criteria and are periodically inspected by USACE. While many local systems were brought under USACE oversight through this program, many others have either not qualified for inclusion, did or do not desire Federal relationships, or did or do not know of the program and thus have remained largely undocumented and without oversight by Federal or State governments.

Early in the development of the NFIP, HUD determined that when local flood protection works provided protection at or above the 1 percent level, the areas so protected would be removed from the Special Flood Hazard Area and insurance and land use regulation would not be required of those who lived in those areas. Thus, it became advantageous for communities in the NFIP with large areas in the floodplain, to have levees with at least 1 percent protection (NRC 1982). As indicated earlier, FEMA officials believed that the use of a 100-year standard was encouraging construction of 100-year levees just to remove areas from the insurance requirements (Jimenez 1980).

Given the experience of Katrina and the ubiquitous nature of levees on the American landscape, what is the role of levees in the NFIP and, if they have a role, what standards should govern their inclusion?

9.2 Challenges Associated with Levees

There are five fundamental challenges associated with levees:

- Levees must be well built.
- Levees must be well maintained.

- Levees must be modified when changes occur to the predicted river flows they must pass during a flood event or when there are changes in the channel hydraulics.
- Levees must be designed to remain in place when they are overtopped when their design level of protection is exceeded. Overtopping must not cause catastrophic failure of the levee.
- Provisions must be made to handle the drainage that is trapped behind levees (and prevent internal flooding) when the river is in flood stage and gravity drainage is not possible.

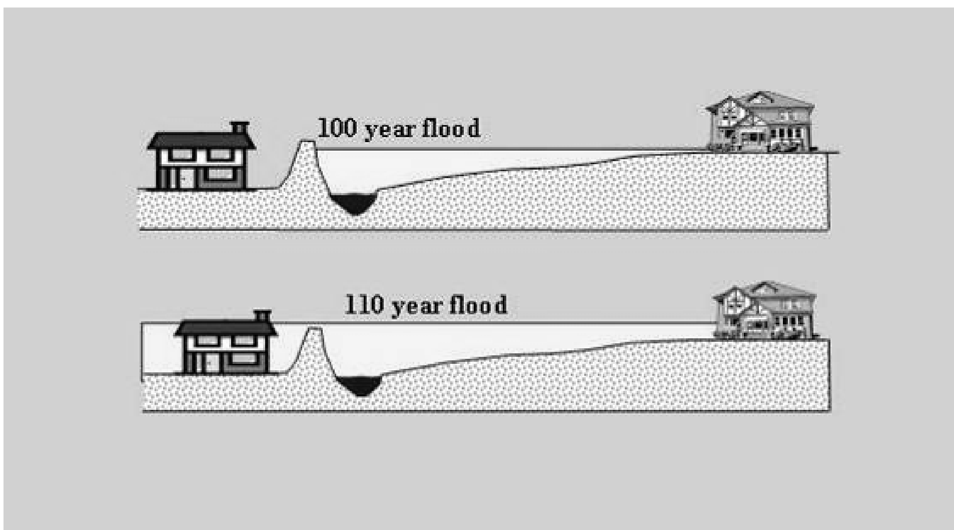
Levees are earthen structures that have been built in a wide variety of ways. The ideal levee is founded on solid ground, raised by careful placement and compaction of selected soils to its design height, and dressed with grass or other vegetation that holds the soil in place. Over time a levee is well maintained to prevent growth of trees or large shrubs on its surface and infestation by animals whose burrows can provide seepage paths from the river to the land side of the levee and is carefully monitored to ensure that its weight has not caused the foundation to subside and reduce its effective height. Where subsidence does take place, corrective actions are taken. In order to maintain stable side slopes, as a levee's height grows, the width of its base also increases and as a result high levees have large footprints. Where space is at a premium, more expensive to build concrete floodwalls are often substituted for levees. These floodwalls require similar consideration of foundation conditions and use of designs that provide for their stability under pressure. In some cases, where there are layers of permeable material below the foundation, sheet piling is often driven through the levee down to depths that would cut off any movement of subsurface flows beneath the levee or floodwall. In other cases, where the permeability of the material used in the levee does not ensure that flow will be stopped from moving through the levee, slurry or sheet pile walls are placed in the levee to achieve this cutoff.

Unfortunately, construction of levees across the country has not always followed the ideal approach. In some cases a levee began as a row of earth that resulted from the grading of a field (a windrow). This small mound eventually became a levee. Material on the site, whether suitable or not, was incorporated into the levee along with logs and other decayable materials that found their way into the structure. After the decay of logs and wood products, the levee was riddled with large voids or tunnels. In other cases, highway or rail embankments served as de facto levees, in spite of the fact that these embankments may have never been designed to act as levees. Even when levees were more carefully designed, engineers frequently have been limited by the material locally available and the foundation that exists at the levee site. Once built, many levees are not maintained and fall into disrepair.

The challenge in dealing with levees, once they are identified, becomes determining their geotechnical condition, the status of their foundations (have they subsided?), and the actual height along their entire length. Problems with any one of these factors could compromise levees' integrity or their ability to pass the flood for which they were designed. Detailed geotechnical investigations are very costly ($60,000-$100,000 per mile) as are elevation surveys. In addition to dealing with the levees themselves, those responsible for levees must continuously monitor the hydrologic and hydraulic conditions that were used to develop the height of the flood against which the levees were designed. Changes in weather patterns, upstream development, and changes in the channel cross section above and below the levees can raise the height of the design flood and drop the level of protection below the original design protection (see Chapter 6). When levees recognized by the NFIP lose their structural integrity or no longer provide protection to the 1 percent level plus 3 feet of freeboard, their recognitions are terminated and those behind the levee with Federally-related mortgages must obtain flood insurance and the community must initiate land use regulation.

The final levee challenge is the residual risk that exists for those who are protected by levees and the binary nature of the protection that levees provide. If a levee is properly designed, constructed, and maintained, it should provide protection to the design height. When a flood exceeds the design height, the levee is overtopped by the flowing waters and begins to erode and fail. The consequences on the land side can be catastrophic. In a matter of minutes an area can go from being fully protected to being underwater, endangering lives and severely damaging property. If overtopping causes a substantial and immediate breach in the levee, the wall of water that races in creates a tsunami or surge effect in the flooded areas.

FIGURE 9-2: Residual Risk. In the upper drawing the 1 percent flood is contained by the levee and does not affect the house on the right at 1 percent elevation. In the lower drawing the levee is overtopped and the area behind the levee is flooded while the home on the right receives only minor flooding.



SOURCE: Adapted from and courtesy of John Cain and Matt Kondolf, University of California, Berkeley

During the 1993 Mississippi River floods, homes near levee breaches were crushed by the rush of water as it came through the openings. When a levee protects land that is at an elevation well below the crest of a large levee, 15 to 20 feet of water could immerse structures on that land as the area behind the levee fills. The flooding of New Orleans occurred relatively slowly in contrast to the more rapid filling that occurred on breached Mississippi River levees.

Another aspect of residual risk is internal drainage. When an area protected by a levee is subject to intensive rainfall and the river outside the levee is in flood, the storm waters cannot drain into the river through gravity structures and must be either held within the leveed area or pumped into the river. A lack of adequate pumping capability can cause interior areas to flood. In the case of New Orleans, the risk of internal flooding is such that large areas in the city and the surrounding communities are shown on FIRMs as being in the 1 percent risk zone from internal flooding**.** As a result, over 200,000 buildings in these communities had flood insurance even though they were located behind levees.

FEMA on Levees

In 1982, FEMA shared with an NRC committee studying levee policy for the NFIP its concerns about levees (see 10.4.1):

"1. It is estimated that levee overtopping or failure is involved in approximately one third of all flood disasters.

2. The 100-year flood is generally found to be a low design standard for structures protecting densely populated areas because of the relatively low cost of raising or upgrading the levee compared to the damages that can that can be prevented.

3. Only a fraction of all earthen levees built with crown elevations at the computed l00-year flood elevation can he expected to provide protection to the true 1 percent event because of (1) the uncertainty involved in establishing flood elevations, (2) changing hydrologic conditions and (3) the possibility of structural failure before overtopping.

4. The degree of protection to be expected from a100-year design levee is less than that obtained by elevating individual buildings to the l00-year flood elevation because of the possibility of levee failure during smaller floods and the greater depths of flooding experiences in unelevated structures upon levee overtopping or failure.

5. Crediting a levee system with protection against the 100-year flood would, under present interim procedures remove essentially all floodplain management requirements, lender notification requirements, and insurance purchase requirements within the leveed area (provided that flooding from interior drainage did not trigger such requirements). This could violate the spirit of the National Flood Insurance Act by encouraging development in areas subject to major flood damage. It could be financially burdening for the program should the people in the area purchase flood insurance at rates that apply outside special flood hazard areas.

6. Results of the U.S. Army Corps of Engineers nonfederal dam inspection program suggest that a large percentage of private or locally built levees as well as dams are or can be expected to be poorly designed and maintained" (NRC 1982).

9.3 Levees and the NFIP

9.3.1 Standards

Under current FEMA regulation, 44 CFR 65.10, when an areas is protected by a levee that has been designed to pass the 1 percent flood flows or higher, meets certain structural conditions, and provisions have been made to handle internal drainage, the levee is shown on the FIRM as protecting that area. The area is area is then mapped as outside of the 1 percent zone.

As previously indicated, people who live in the area are not required to obtain insurance or institute land use regulation. To be recognized as providing protection from the 1 percent annual chance flood on NFIP maps, levee systems must meet, and *continue to meet*, minimum design, operation, and maintenance standards.

According to the regulation, the levee's height must meet or exceed the elevation of the 1 percent flood and, under most circumstances, provide 3 feet of freeboard if it is a riverine levee system or, in a coastal environment, 1 foot above a 1 percent wave or maximum wave run-up associated with the 1 percent stillwater surge (whichever is greater). Freeboard has been used to provide a margin of safety to compensate for those conditions and situations that cannot rationally be quantified in the design of the levee system. Additionally, levee systems must meet engineering standards governing embankment protection, embankment and foundation stability, and potential settlement. The levee owners, government or private, must also ensure the safe operation of the system, provide for maintenance of the levee and for interior drainage behind the levee. All structural aspects of the levee design must be certified by a professional engineer or by an appropriate Federal agency.

As discussed in Chapter 7, in the early 1990s USACE began to examine the use of risk-based planning for the design of levees under its flood damage reaction program. Under this program USACE determined that it would not design levees to a specific level of protection, but would select a level that would take into consideration the risk faced by the community, the economics of the project, and the geotechnical and H&H considerations of the project. In 1996, FEMA accepted this method of design as an alternative to the standard 1 percent protection and modified its regulations to indicate that when a levee was designed in accordance with comparable standards of another Federal agency, the levee would be approved for inclusion in the program.

Unfortunately, in the early days of the NFIP many older levees were credited by the program with little detailed information about their condition, and funding has not been available for FEMA to conduct any extensive analysis of their current conditions.

9.3.2 Map Modernization

As indicated in Chapter 8, in 2004, FEMA began a five-year $1 billion flood map modernization program. The program is designed to establish a map production environment that will provide communities with maps that are frequently updated with the best available information and are available in digital form. Under this program, as an existing map comes up for review and modernization and a levee is shown on the map as providing protection to a community, the mapping contractor must follow a procedure that requires the owner of the levee (government or private) to produce the original certification of the levee's compliance with 44 CFR 65.10 and to *indicate that the levee remains certifiable.* If the owner is not able to do this, the levee is not mapped as providing protection and those previously exempt from the mandatory insurance provisions of the NFIP must obtain insurance. Many original certificates are old, and much development has occurred since the original date that would cause increase in flows. In some cases, levees, as a result of foundation or levee subsidence, may no longer provide the required height. As a result, the remapping effort has focused considerable attention on the levee issue.

9.3.3 Levee Maintenance

As part of the Federal-local agreement for development of any Federally supported flood damage reduction project, the local sponsors agree to operate and maintain the levees and attendant structures that have been built. USACE periodically inspects these levees and identifies maintenance deficiencies for correction by the local sponsors. Levees constructed by nonfederal activities and local developers do not receive periodic inspection and there is little or no record of their reliability. Across the Nation there is a considerable backlog of maintenance on levees (for example, because of changing H&H conditions, approximately 300 miles of Federal levees on the Mississippi River are below the grade and section necessary to protect against the flood against which they were originally designed).

9.3.4 Level of Protection

Hurricane Katrina has focused national attention on the issue of the level of protection provided by levees and other flood protection works. There is no national standard for the level of protection to be provided by Federally constructed or supported levees. Following the 1927 flood on the Mississippi River, USACE established a “project flood” level of protection for the Lower Mississippi Valley, defining that flood as one that would result from the combination of the largest storms that could be anticipated to occur in the Mississippi River Basin. Following the 1936 floods across the country and passage of the 1936 Flood Control Act, USACE and TVA sought to provide protection against the Standard Project Flood (SPF). Both the project flood and SPF provided protection against at least the 500-year (0.2 percent) flood.

In 1983, President Reagan promulgated *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies,* which established that “The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements” (U.S. Water Resources Council 1983).

Over time, mostly for economic reasons, the level of protection has declined and the level of protection for more recent projects reflects a combination of the level that optimizes national economic development, meets USACE standards of reliability, and satisfies local interests. Such projects are assumed to provide protection to at least the 1 percent level and may be considerably higher. The establishment of the 1 percent standard for the NFIP has also influenced the level of protection sought by communities in levee protection. In 1986, Federal-local cost sharing became a component of Federal projects and local sponsors quickly recognized that getting to 1 percent brought relief from insurance requirements and going above that level would cost them more money. Hurricane Katrina raised the issue of what should be the standard for protection of urban centers and other areas.

Discussion of the level of protection goes back to the last days of HUD's control of the NFIP. In June 1977, USACE reported to HUD, in commenting on the level of protection being considered for a levee in Texas, that "setting the design of levees in urban areas at the 100-year level could be imprudent since that is not a high degree of protection." USACE recommended that a larger flood, such as the (SPF), be adopted as the required level of protection (Wilson 1978). In September 1977, the director of FEMA's engineering division recommended to senior management that the Administration strongly consider a Federal policy that would recognize only levees designed to provide protection against the SPF (Crompton 1977). In 1979, USACE issued a policy memorandum establishing that "on the assumption that exceedance of the design flow would cause a catastrophe, the standard project flood (SPF) is the desirable minimum level of protection that should be recommended for high levees, high floodwalls and high velocity channels in urban areas" (Wilson 1978).

In 1980, Gloria Jimenez, Administrator of the Federal Insurance Administration, recommended to FEMA Director John Macy "consideration of a standard in excess of the 100-year flood, such as the Standard Project Flood, for local protection works to be recognized by FEMA." She also noted that USACE had recommended this to FIA (Jimenez 1980). In 1981, FEMA requested the assistance of the National Research Council for the conduct of a study on levees (see next section).

9.4 Levee-Related Studies

Levees and their role in the NFIP have been the focus of or have been components of several nationally recognized studies

9.4.1 National Research Council - Levee Policy

In 1982, FEMA asked the National Research Council to review the role of levees in the NFIP. The NRC committee examined FEMA's then interim policy concerning accreditation of levees and the role of levees in the overall NFIP as well as the general structure of related NFIP regulations. As a basis for its analysis the committee established that flood loss mitigation is promoted:

> "…through six basic measures or dimensions that are either direct requirements of or closely associated with the NFIP:
>
> 1. Provision of flood insurance at rates guided by actuarial risk
> 2. Land development and building construction regulation
> 3. Mandating the purchase of flood insurance in high risk areas
> 4. Regulation of restricting the placement of critical facilities in hazardous locations
> 5. Notification of flood hazard to occupants of property at risk
> 6. Contingency planning, including warning and evacuation during floods.
>
> While all six measures apply in mitigating flood losses to properties in the 100-year floodplain, none pertain to areas outside the 500-year floodplain.

> Recognition of a levee by the NFIP is recommended when the levee reduces flood risk to properties behind it to the extent where one or more of these measures would no longer be used. The applicability of the several measures logically varies with level of protection provided by a levee, the structural integrity of the levee, and the property elevation. … Any levee runs the risk of overtopping and structural failure during floods. Accordingly (based on a reasonable risk before requiring a given activity), a levee may be recognized with respect to none, all, or only selected ones of the above listed measures." (NRC 1982).

The Committee recommended tying NFIP actions to the level of protection provided and suggested other actions that would recognize the fragile nature of levee protection: The report stated that:

- "FEMA should require purchase of flood insurance in all areas where the ground is lower than the unconfined 100-year flood level except where protected by a levee built to contain the 500-year flood."
- "New levees should be recognized for the purpose of reducing insurance rates where they provide protection against the 100-year or larger floods and where they meet specified structural design criteria including freeboard."
- Critical facilities should be "prohibited in areas protected by levees where the ground is lower than the 500-year flood level" unless there is no practical alternate location.
- Contingency planning, including waning and evacuation, should even consider those outside the natural 500-year floodplain but subject to flooding or isolation by levee failure.
- Owners, tenants, and lenders occupying areas designated as protected by levees should be notified periodically by responsible local officials that their land in the levee-protected area is still subject to flooding in the event of levee failure.

The committee noted that, because flood stages change over time due to a variety of factors (e.g., increased urbanization, removal of natural valley storage, construction of reservoirs in upper reaches of large river systems), "FEMA should monitor watershed and channel changes where hydrologic risk is increasing and respond to significant changes with restudies and subsequent map and rate revisions."

The committee also recommended that each levee be individually evaluated, hydrologically and structurally, before acceptance into the NFIP and that FEMA should inventory all levees previously credited as providing protection from the 100-year flood, set priorities, and schedule communities for restudy to reevaluate the levees.

As a follow-up to the NRC report and other internal actions, in 1987, FEMA issued its regulations prescribing the criteria for levee recognition by the NFIP but did not reevaluate existing levees, alter the required level of protection, or move on other nonengineering recommendations.

9.4.2 Floodplain Management Assessment

L. R Johnston Associates (1992) prepared for FEMA an assessment of floodplain management in the United States. The report included discussion of the use of levees in floodplain management. Most significantly, Johnston reported that “levees and floodwalls provide only partial protection from flood problems” and that “areas behind levees may be subject to greater than normal risk of flood damage.” Johnston noted that:

- “Floodplain residents [protected by levees] may believe they are protected from floods and not take proper precautions.
- Development may continue or accelerate based on expected flood protection.
- A levee breach is similar to a dam break and can release floodwaters with high velocity.
- After a breach, [segments of the levee system] may also act as a dam prolonging the flooding behind it.”

Johnson also noted that there was no national database of information on the condition and safety of levees. The recent experience of New Orleans would indicate that Johnston’s observations still hold true.

9.4.3 Interagency Floodplain Management Review Committee

In 1993, following disastrous Mississippi River floods, the White House commissioned an interagency study of the causes of the flood and sought recommendations for modification of the Nation’s floodplain management program. A considerable part of the study effort examined the role of levees in flood damage reduction activities. In 1994, the Interagency Floodplain Management Review Committee (IFMRC 1994a) reported that:

- “Activities in the floodplain, even with levee protection, continue to remain at risk. …
- Many locally constructed levees breached and/or overtopped. Frequently, these events resulted in considerable damage to the land behind the levees through scour and deposition [of material from the river channel and the levee itself]. …
- Levees can cause problems in some critical reaches by backing water up on other levees or lowlands. ...
- The current flood damage reduction system in the upper Mississippi River Basin represents a loose aggregation of Federal, local, and individual levees and reservoirs. …
- Many levees are poorly sited and [as a result] will fail again in the future.”

The committee indicated that the standard project flood should be the target flood for population centers protected by levees and that, noting the residual risk to those behind levees, the government should take action to:

- “Reduce the vulnerability of population centers to damages from the standard project flood discharge.
- Reduce the vulnerability of critical infrastructure to damage from the standard project flood discharge.

- Require those who are behind levees that provide protection against less than the standard project flood discharge to purchase actuarially based insurance.
- Ensure proper siting, construction, and maintenance of non-federal levees."

No action was taken by either Congress or the Administration on these recommendations.

9.4.4 NRC Committee on Risk and Uncertainty in Flood Damage Reduction Studies

In 1996, Congress directed the Secretary of the Army to request the National Research Council to evaluate new risk-based methodologies used in the formulation of flood damage reduction projects instituted by USACE. In 2000, an NRC committee reported the results of its analysis and indicated that it supported the use of risk-based methodologies in the determination as opposed to the FEMA methodology that relied on some level of certainty of passing the 100-year flood. It recommended that FEMA and USACE move toward a common, risk-based approach to levee certification (NRC 2000).

9.5 Levee Inventories

As indicated above, levees of one form or another are found along most rivers where the floodplain has been settled. Neither the Federal government nor most State governments know where all of these levees are located or their condition. There is no Federal inventory of levees, and only a few States have lists of where levees are located. There are geographically scattered lists of Federal levees and those in the Federal programs, but they are maintained in the local Federal offices responsible for the region in which they are located and the information about the condition of these levees is generally incomplete. Information on private and most nonfederal levees is normally not documented by Federal agencies. FEMA, which includes the locations of levees on flood maps for communities protected by the levees, has a FEMA Levee Inventory System (FLIS), but the database covers only a small percentage of existing levees and does not provide information about the condition of levees. FLIS is the successor to a Credited Structures Inventory (CSI) which was established in 1984 to capture information on levees, floodwalls, dikes, and other structures that could be credited with providing 1 percent protection and remove areas from the SFHA. CSI did not provide coverage of all the levees accredited by FEMA or other levees that might affect activities in the floodplain.

Both FEMA and USACE have recently launched programs to capture levee data and are coordinating their efforts, but it will be some time before the information is collected and placed into a usable format. The State of California, with support from FEMA, has initiated development of a levee database and has assigned its contractor the first task–locate where levees are in the State.

9.6 ASFPM Foundation Gilbert White Forum

Levees were frequently discussed during the Forum. The Forum report indicted that "The 1 percent annual chance standard has proven to be poorly applicable to levees. The 1 percent chance flood level is too low for a levee that protects densely developed areas." The report further indicated that:

- When a community protected by a levee is removed from the mandatory insurance requirement, it also makes building standards optional and if the levee fails or is overtopped, the community is not only unprotected but uninsured.
- The 1 percent standard, when applied to levees, does not adequately communicate the residual risk faced by those behind levees.

9.7 State of California

There are more than 6,800 miles of levees in California, possibly more than in any other State (Pineda 2004). Since the occurrence of a major flood in 1997, the State of California has commissioned three reviews of the status of floodplain management. All three reviews focused considerable attention on levees.

Immediately following the 1997 flood, a Flood Emergency Action Team (FEAT) was created to identify immediate actions that should be taken by the State. The FEAT reported (CRA (California Resources Agency) 1997) that:

- In urban areas, a need exists for a higher level of levee protection than the minimum 100-year provided under the NFIP, such as 200-year or even 500-year in some areas. The 1997 flood event emphasizes that many levees (even those certified by FEMA or USACE) did not provide the expected 100-year protection. This was particularly evident when private levees were involved. Many private levees failed due to unstable conditions, such as building the levee over old river bed, poor foundations built to unknown standards at the time of construction, and poor maintenance. This allowed subsequent seepage problems and eventual levee breakthroughs.
- When development takes place in areas which are protected by levees, it must be understood that no levee is 100 percent safe and not all levees provide 100-year or more protection.
- Higher State elevation requirements are needed because FEMA's minimum elevation criteria under its NFIP do not take into account the effects of future development on the 100-year flood elevation. Also, the minimum criteria do not provide any safety factor to accommodate inaccurate floodplain maps or future changes in hydrology.

The FEAT then recommended that a State Floodplain Management Task Force examine options of:

- Requiring future urban developments to exceed the minimum NFIP floodplain management elevation requirements by imposing State standards in statute.
- Imposing mandatory flood insurance for structures protected at less than the 200-year level of protection in statute.
- Requiring future urban developments to exceed the minimum NFIP floodplain management elevation requirements by imposing State standards in statute.

In 2002, the California Floodplain Management Task Force (CRA 2002) reported to the governor that the communities of Sacramento, West Sacramento, Yuba City, Marysville, Los

Angeles, and Orange County "are all working toward protection against floods that exceed the often discussed 100-year flood." It then recommended to the Governor that:

- As with other types of floodplains, local agencies should assess the risks of the reasonably foreseeable flood instead of relying solely on the 100-year flood.
- Local communities should be encouraged to require new and substantially improved buildings to have their lowest floor elevations be at least one foot above the NFIP's base flood elevation, factoring in the effect of full build out of the watershed. The effects of new or additional flood management measures should be reflected in an updated base flood elevation.

In 2005, the CRA, faced with dwindling resources, the loss of a major court case regarding levees[23], and a deteriorating levee structure throughout the State, issued a White Paper, *Flood Warnings: Responding to California's Flood Crisis,* that once again reviewed the levee and floodplain situation in the State. The paper noted that:

- California's Central Valley flood control system of levees, channels, and weirs is old. Many levee reaches were built more than a century ago on foundations that are subject to seepage and movement. Over time, the levee system has significantly deteriorated, partly due to deficiencies in the original design and partly due to deferred maintenance.
- People who live and work behind levees have a false sense of protection. Many believe that the levees will protect them against any level of flooding.

The paper recommended that the State:

- Reduce its liability by requiring that all homes and businesses in areas at risk of flooding, regardless of the level of protection, have some form of flood insurance. This will require legislation to enable the State to implement a system of flood insurance similar to the NFIP yet more comprehensive.
- Develop a strategic long-term flood control plan that would dictate improvements over time to provide high levels of flood protection for urban areas and to restore ecosystem functionality.

9.8 Observations

The treatment of levees in the NFIP has been debated, studied, and staffed for over 30 years. Levees were recognized as part of the NFIP because it seemed to make sense that, if levees provided protection that created protection parity with elevated homes or other flood

[23] "The November 2003 *Paterno vs. State of California* decision found that when a public entity operates a flood control system built by someone else, it accepts liability as if it had planned and built the system. The *Paterno* ruling held the State responsible for defects in a Yuba County levee foundation that existed when the levee was constructed by local agricultural interests in the 1930's. When the levee failed in 1986, hundreds of homes and a shopping center in the city of Linda were flooded. The *Paterno* decision makes it possible the State will ultimately be held responsible for the structural integrity of much of the Central Valley flood control system—1,600 miles of levees that protect more than half a million people, two million acres of cultivated land and approximately 200,000 structures with an estimated value of $47 billion" (CRA 2005).

damage reduction works, those protected by levees should be treated, for insurance purposes, in the same manner as those receiving the other types of protection. Unfortunately, because of residual risk, they are not receiving the same level of protection, and the uncertainty connected with levees–hydrologic, structural, and anthropogenic–is large. The consequences of a levee failure or overtopping are far more critical than the slow rising inundation of a home near a river.

For over 30 years, governments and practitioners at all levels have pointed to the underfunding of levee maintenance, the absence of thorough inspections, and even the lack of information about where levees are located.

As discussed in Chapter 2, when the Federal government assumed greater responsibility for levee construction in the late 1920s, the standard was set high. No one wanted to face a repeat of earlier catastrophic floods. Over time, the level of protection has dropped as economics, cost sharing, and the mistaken belief that, because the government accredits a 1 percent levee, the government is indicating that 1 percent protection is all that is needed.

Several internal and external studies have recommended that levees protecting urban areas should be built with a higher level of protection. The experience of other countries as well as our own national experience bears this out. Yet little is done to move in this direction. If the Federal government does not move to a higher standard, it, in effect, is creating a *moral hazard*[24] in that it is aware that the public does not understand lesser levels of protection and sees government approval of the lesser level as government endorsement of the safety of these structures**.**

[24] "In providing support for a range of floodplain activities, does government create a "moral hazard?" This phrase is used in the insurance industry describe the situation when an insured party has lower incentive to avoid risk because an enhanced level of protection is provided. If an individual or government entity does not bear the financial consequences of an action there is little reason to mitigate the danger; therefore, the insured party is more likely to be at risk (or will expend too little effort to avoid risk) than one who has to bear all consequences" (IFMRC 1994).

10. PROTECTION OF CRITICAL FACILITIES

The 1 percent standard has been used as a minimum standard for purposes of risk identification and management. In a parallel policy line, the 0.2 percent standard (500-year flood) has been identified as the minimal level of protection for critical actions undertaken by the Federal government in floodplains. Recent floods have highlighted the problems that are created when important or critical facilities are not available or accessible to support the community during periods of stress. This chapter examines the statutory and regulatory requirements for protection of these facilities both under the NFIP and under other programs and guidance and examines the relationship between these requirements and the 1 percent standard.

10.1 Executive Order 11988

Executive Order 11988, signed by President Carter in 1978, requires all executive agencies to take special care when undertaking actions that may affect floodplains, directly or indirectly, and may be the genesis of the critical facility concept. The order requires agencies to avoid disrupting these areas wherever there is a practicable alternative and to minimize any environmental harm that might be caused by Federal actions. The order directed all agencies to provide national leadership by taking actions to encourage sound land use practices. Critical "actions" or facilities while not directly mentioned in the language of the order was included in the Administration's guidance (prepared by the Water Resources Council) to agencies for developing each agency's policies and procedures for complying with the order. A critical action and a critical action floodplain were defined by the WRC (1980) as:

> "**Critical Action.** Any activity for which even a slight chance of flooding would be too great.
>
> Floodplain … The critical action floodplain is defined as the 500-year floodplain (0.2 percent chance floodplain)."

Examples of critical actions are contained within agency-specific procedures. Department of Commerce Orders (1979) define:

> *.06 Critical Action.* A critical action is an action which, if located in a floodplain, poses a greater than normal risk for flood-caused loss of life or property. The minimum floodplain of concern for critical actions is the 500-year floodplain. Critical actions include, but are not limited to, actions which create facilities or extend the useful life of facilities:
>
> a. which produce, use, or store highly volatile, flammable, explosive, toxic, or water-reactive materials;
>
> b. such as schools, hospitals, and nursing homes, which are likely to contain occupants who may not be sufficiently mobile to avoid the loss of life or injury should flooding occur; and

c. such as emergency operation centers, essential public utilities, and data storage centers, which contain records or services that may become lost or inoperative should flooding occur.

10.2 Critical Facilities and FEMA

Subsequent Federal actions related to critical facilities made use of the principles laid out within the guidance for the implementation of EO 11988.

For the purpose of floodplain management, FEMA defines a critical action in its regulations for implementation of EO 11988 and 11990 (44 CFR 9.4) as an action for which even a slight chance of flooding is too great. The regulation goes on to state: “The minimum floodplain of concern for critical actions is the 500-year floodplain, i.e., critical action floodplain. 44 CFR 9 is the FEMA implementing regulations for Executive Orders 11988 and 11990, and applies to all FEMA actions and programs. The regulations in 44 CFR 9 cover most actions that deal with critical facilities, especially with respect to disaster assistance. The regulations also discuss critical facilities as applied to FEMA mitigation programs.

FEMA’s implementation procedures, which are similar to those of other Federal agencies, states that “Critical actions include, but are not limited to, those that create or extend the useful life of structures or facilities:

- Such as those that produce, use or store highly volatile, flammable, explosive, toxic or water-reactive materials;
- Such as hospitals and nursing homes, and housing for the elderly, which are likely to contain occupants who may not be sufficiently mobile to avoid the loss of life or injury during flood and storm events;
- Such as emergency operation centers, or data storage centers which contain records or services that may become lost or inoperative during flood and storm events; and
- Such as generating plants, and other principal points of utility lines.”

Subsequent to implementing EO 11988 procedures, FEMA incorporated principles associated with critical facilities in other programs. Examples include:

FEMA’s Public Assistance Guide (FEMA 1999) states, "A critical facility is a structure that, if flooded, would present an immediate threat to life, public health, and safety. Critical facilities include hospitals, facilities that produce toxic materials, and emergency operations centers.”

FEMA Regulation 44 CFR 206.226, *Restoration of Damaged Facilities*, states that "Eligible private nonprofit facilities may receive funding under the following conditions…The facility provides critical services, which include power, water (including water provided by an irrigation organization or facility in accordance with § 206.221(e) (3)), sewer services, wastewater treatment, communications, emergency medical care, fire department services, emergency rescue, and nursing homes."

FEMA State and Local Guide (SLG) 101: *Guide for All-Hazard Emergency Operations Planning* provides the following examples of what might be considered critical facilities:

- “Emergency service facilities and equipment (fire stations; police stations; custodial facilities, such as jails and juvenile detention centers, hospitals, and other health care facilities; rescue squads; public works facilities, etc.).
- Communications networks (telephones, emergency service radio systems, repeater sites and base stations, television and radio stations, etc.).
- Water supply system/facilities, to include wastewater treatment.
- Utilities (power plants, substations, power lines, etc.).
- Transportation networks (roads, bridges, airports, rail terminals, maritime ports).
- Homes, businesses, public facilities, etc."

FEMA's guidance document *What Is a Benefit? Guidance on Benefit-Cost Analysis of Hazard Mitigation Projects* includes police, fire and medical buildings, emergency operations centers, and emergency shelters in the category of critical facilities. However, the document also mentions infrastructure for utilities such as electric power, potable water, and wastewater, as well as roads and bridges, as distinct from ordinary buildings, stating that "Ordinary buildings include residential and commercial buildings, and public buildings used for non-critical functions, such as schools and administrative buildings." This document links critical facilities to the lifelines supporting them.

10.3 Critical Facilities and the NFIP

Unlike FEMA disaster programs, the level of protection to be provided for critical facilities in not defined on an NFIP-wide basis. Rather, States or individual counties may opt to specify in their ordinances the level of protection required for such facilities in their respective jurisdictions.

There is no requirement in the NFIP specifically limiting the location of critical facilities. However, FEMA, through the CRS, encourages communities and local jurisdictions to enact ordinances that prohibit the construction of critical facilities within the 0.2 percent annual chance floodplain. Model ordinances distributed by some States to communities contain language that discourages development of critical facilities in the 0.2 percent floodplain if there is a feasible alternative. The model ordinances are used as a starting point by communities at the time of issuance of new flood maps, when they update their floodplain management ordinances.

The 2003 ASFPM publication “Effective State Programs” lists 11 States that have regulations set up for protection of critical facilities. Most of these States have some flood standard to which they regulate the construction of critical facilities. Other States have regulations protecting critical facilities but do not employ a set standard. Some States have model ordinances set up to encourage the protection of critical facilities but do not enforce these using regulations. The States and the levels to which protection is provided, either through regulation or through model ordinances, are listed in Table 10-1.

TABLE 10-1: Critical Facilities Protection by State

State	Critical Facilities Protection Required by Regulation?	To What –Standard (Year)?
AL	No	500
IL	No	500
KY	Yes	25
MI	Yes	500
MS	Yes	500
NC	Yes	500
NY	Yes	100
OH	Yes	500
PA	Yes	100
PR	Yes	0
VA	Yes	0

Various State governments also specify the location of the critical facilities in their ordinances. For instance, the State of Arkansas specifies, "Construction of new critical facilities shall be, to the extent possible, located outside the limits of the Special Flood Hazard Area (SFHA) (100-year floodplain). Construction of new critical facilities shall be permissible within the SFHA if no feasible alternative site is available. Critical facilities constructed within the SFHA shall have the lowest floor elevated three feet or to the height of the 500-year flood, whichever is higher. Access to and from the critical facility should also be protected to the height utilized above. Floodproofing and sealing measures must be taken to ensure that toxic substances will not be displaced by or released into floodwaters. Access routes elevated to or above the level of the base flood elevation shall be provided to all critical facilities to the extent possible."

Additionally, the State of California categorizes critical facilities into three classes with decreasing order of importance, with Class 1 being the most important category of critical infrastructure to protect:

- Class 1: Communications infrastructure
- Class 2: Police Stations, Fire Stations, Emergency Response Centers
- Class 3: Schools, Shelters, and Medical Centers

The State of Washington enacted a law in 1987 that specified that new critical facilities must be, to the extent possible, located outside the 100-year floodplain, unless no feasible alternative site is available. If they are constructed in floodplains, they must have their lowest floor elevated 3 feet above the BFE or to the 500-year flood level, with access to the facility protected. Communities with this provision also received special credit under the CRS.

10.4 CRS Impact

The CRS includes in its list of critical facilities, schools, fire/police stations, nursing homes, hospitals, chemical storage tanks, and other facilities that, if impacted by floodwaters, could have a significant negative impact on water quality, special populations and emergency response. It credits communities for critical-facility protection under section 430 of the program "higher regulatory standards" The point value for critical facilities are:

- 50 Points- "… new and substantially improved critical facilities are required to be protected from damage and loss of access as a result of the 500-year flood or the flood of record , whichever is higher."
- 100 Points- " If new critical facilities are prohibited from the 500-year floodplain."

Currently, there are 100 total credit points available for Critical Facility standards. As compared to other point totals in section 430 it receives fewer points than activities that more directly relate to insurable structures under the NFIP (such as elevation criteria, building codes); but more points than criteria related to more general floodplain management concepts (such as natural and beneficial functions regulation or protection of floodplain storage capacity criteria). Considering that to achieve the next level in the CRS a community needs to demonstrate an additional 500-points in rating, a reasonable critical facilities standard in the community would achieve anywhere from 10% -20% of the points necessary to achieve the next level (FEMA 2006b)

As of August 2006 there were 65 communities claiming a CRS credit for critical facilities. Forty-two communities have point totals that would suggest that new and substantially improved critical facilities would be protected to the 500-year level, 6 communities added a requirement that there be all weather access for the 500-year or flood of record (whichever is higher) and 17 communities prohibit the placement of any new critical facilities within the 500-year floodplain. Of the 65 communities, 36 were in two states (19 in Washington and 17 in Michigan). Also of note, of the 17 communities that are currently prohibiting all new critical facilities within the 500-year floodplain, 4 are on or within 5 miles of coastal waters (Braintree MA, Bay St. Louis MS, Myrtle Beach SC, Gloucester Co, VA) and one county is adjacent to the Mississippi River (West Baton Rouge Parish, LA). Bay St. Louis MS was extensively damaged as a result of Hurricane Katrina (FEMA 2006d).

10.5 Observations

The implementation of a critical facility policy within the context of the NFIP has been limited. This may be due to concerns about extending the influence of the Federal government to control of state and local facilities. Even so, it is clear from previously referenced studies of levees and other floodplain actions that the 1 percent standard has not been deemed adequate for purposes of protecting critical facilities whether they are Federal or nonfederal.

Many of the specified critical facilities are not eligible for insurance under the NFIP, and as such the flooding of critical facilities may have little or no impact on the NFIP. Yet, as was illustrated, other FEMA programs do consider the issue of critical facilities for purposes of funding and presumably for disaster assistance. As such the treatment of critical facilities within the NFIP does not appear to adequately support other lines of policy designed to minimize the impacts of disasters.

To that end, based on the experiences to date of the NFIP, incorporation of an explicit critical facility standard into community programs is warranted. FEMA should ensure that NFIP guidance and program activities clearly indicate that critical facilities should be located outside the 0.2 percent floodplain or, if that is not practicable, be protected to that elevation.

11. IMPACT OF THE 1 PERCENT STANDARD ON NATURAL AND BENEFICIAL FUNCTIONS OF THE FLOODPLAIN

This chapter examines the policy framework that governs many efforts to manage floodplain lands and the relationships between the 1 percent standard and the natural and beneficial functions of floodplains. It also examines the map revision process, and in particular the Letter of Map Change (LOMC) process for the 1 percent flood, recent FEMA initiatives to better achieve protection of floodplain functions, and related environmental legislation. It also reviews current research on natural and beneficial floodplain functions from a variety of disciplines and examines the papers presented at the Forum in the context of the 1 percent standard.

The NFIP and the 1 percent standard, provide several mechanisms to influence protection of the natural and beneficial functions of floodplains. This chapter evaluates what influence the 1 percent standard has had on the management of natural and beneficial floodplain functions, how NFIP regulations that use this standard impact these functions, and how the NFIP or the standard might be modified to better protect these functions.

The policy framework that governs many efforts to manage floodplain lands is reviewed first, with specific examples of both incentives and disincentives for protecting floodplain functions provided. Relationships between the 1 percent standard and the natural and beneficial functions of floodplains are then discussed by considering spatial, temporal, and economic aspects.

The map revision process, in particular the Letter of Map Change (LOMC) process for the 1 percent flood, is evaluated to determine whether there are factors that should be considered in addition to the traditional hydraulic engineering considerations through the LOMC process. Relatively recent FEMA initiatives to better achieve protection of floodplain functions, and related environmental legislation, are evaluated for their relationship to this issue.

Efforts were made to obtain and review current research relative to natural and beneficial floodplain functions published after the 2002 publication of the *Federal Interagency Floodplain Management Task Force on Natural and Beneficial Functions of Floodplains* report and to introduce literature not cited as references in this 2002 publication. Current studies from the AIR research program were also reviewed. Particular attention was given to discussions at the Forum and interviews with selected floodplain managers at the Federal, State, and local levels.

11.1 Background

In Section 1302(c) of the National Flood Insurance Act of 1968, Congress directed that the objectives of a flood insurance program should be integrally related to a unified national program for floodplain management. Over the intervening years the Unified National Program reports to Congress have increasingly emphasized the need to protect the natural resources of floodplains (Conrad 2004). In 1994, FEMA published a revision to *A Unified National Program for Floodplain Management*. The report set forth a broad conceptual framework for managing the Nation's floodplains and expressed a national policy for managing floodprone lands in terms of two co-equal goals: 1) to reduce the loss of life, the disruption, and the damages caused by floods and 2) to preserve and restore the natural resources of the Nation's floodplains.

This evolution of an environmental goal for floodplain management is interesting, because it is not a legislative mandate under the NFIP; rather it is derived from other Federal environmental legislation and policies and presented in *Unified National Program for Floodplain Management*. Congress considered adding an environmental goal for the NFIP when developing the National Flood Insurance Reform Act of 1994, but when the 1994 Act was signed into law only three environment-related provisions were included: the definition of "natural and beneficial functions of the floodplain" (which limits these functions to those that reduce flood damages); a provision that directs FEMA to provide credits under the CRS for environmental activities; and, the establishment of the Task Force on the Natural and Beneficial Functions of the Floodplain which was to make recommendations on how to protect natural and beneficial floodplain functions that reduce flood damages.

The NFIP regulations were formulated to assist communities in implementing the floodplain management standards and implementing the mandatory purchase requirement of the program. As discussed in Chapter 1, there is currently no explicit environmental goal associated with the NFIP. This may limit FEMA's ability to be responsive to environmental issues on floodplains. However, as flood damages have continued to increase and as natural floodplain functions are becoming better understood and valued, the NFIP and the 1 percent standard are increasingly looked upon as additional mechanisms to protect floodplains. Efforts to protect floodplain functions typically result in decreased flood damages, which would satisfy the historic mandate of the NFIP while accommodating this growing environmental interest.

The natural resources of floodplains are characterized by their natural and beneficial functions. These functions are associated with various physical, biological, and ecological processes; habitats for fish and wildlife; and economic, intrinsic, and aesthetic values to humans. Section 4121 of the National Flood Insurance Act of 1968 defines natural and beneficial functions "the functions associated with the natural or relatively undisturbed floodplain that (i) moderate flooding, retain floodwaters, reduce erosion and sedimentation, and mitigate the effects of waves and storm surge from storms, and (ii) reduce flood related damage; and ancillary beneficial functions, including maintenance of water quality and recharge of groundwater, that reduce flood related damage."

Prohibition under the NFIP of development within the 1 percent floodplain to protect natural and beneficial functions is not feasible. However, there are actions that the NFIP can take to discourage or limit floodplain development. Several existing provisions of the NFIP do serve to discourage floodplain development and minimize environmental impacts. These provisions include:

- The mapping of SFHA to direct development away from flood-prone areas.
- The requirement that communities review development proposals to ensure that all necessary permits have been obtained, including Federal and State environmental permits.

- The establishment of more stringent building codes in flood-prone areas such that higher development costs may deter development.
- The establishment of a regulatory floodway requirement that limits development in the most environmentally sensitive areas of riverine floodplains.
- Support of the Community Rating System to provides incentives through flood insurance premium reductions to protect floodplain functions, among other activities.
- The encouragement in NFIP regulations for communities to adopt approaches that rely more on nonstructural floodplain management techniques than on flood control measures.

11.2 The 2002 Natural and Beneficial Functions of Floodplains Task Force Report

The passage of the National Flood Insurance Act in 1968 made available Federally supported flood insurance to those communities that adopted the minimum standards of the NFIP. The NFIP also marked the turning point at which our national flood policy started changing from a sole focus on flood control to the inclusion of nonstructural flood management techniques. Over these intervening years, FEMA has chaired the Federal Interagency Floodplain Management Task Force and led several initiatives to define the role of nonstructural approaches and the characteristics of the natural and beneficial functions of the floodplain.

The most recent task force addressing these issues was convened in 1994 as the Task Force on Natural and Beneficial Functions of Floodplains, under Subtitle E, Section 562, of the National Flood Insurance Reform Act of 1994. The task force was established to identify the natural and beneficial functions of floodplains that reduce flood losses and, recommend how the Nation can further reduce flood losses through the protection and restoration of the natural and beneficial functions of the floodplain.

A report was issued eight years after the formation of the task force in 2002 summarizing past efforts and recommending future efforts to protect and restore the natural and beneficial functions of floodplains (FEMA 2002a). Eight recommendations were made with a goal of reducing flood losses while protecting and restoring the natural resources and functions of floodplains. The recommendations include the following:

1. Develop a national policy on the protection and restoration of the natural and beneficial functions of floodplains as an integral part of all Federal, State, tribal, and local government program, actions, planning, policies, regulations, and grants.
2. Encourage a proactive and long-term approach to floodplain management, including the development of pre- and post-disaster plans for flood damage reduction and preservation/restoration of natural and beneficial functions.
3. Enhance the capabilities of State, tribal and local programs and planning processes that protect and restore natural and beneficial floodplain functions.
4. Focus restoration and protection efforts on those floodplains or portions of floodplains identified as having the greatest flood risk and significant natural and beneficial functions.

5. Improve the analytical approaches to floodplain management by providing scientific and technical assistance, including economic guidance, to organizations with floodplain management responsibilities.
6. Encourage natural nonstructural solutions to reducing flood damages.
7. Improve coordination and partnerships among all levels of government and other parties to facilitate the protection and restoration of floodplains.
8. Evaluate various Federal programs that impact floodplains to ensure that Federal agency implementation of floodplain management objectives are complementary and support State and local initiatives. Ensure that Federal programs that respond to floods are not working at cross-purposes.

While the 2002 report provides a valuable compilation of information on this subject and references current policies and case studies, it repeats a basic message from previous task force reports about the need to protect floodplain functions, without tackling the thornier issues concerning which past task force recommendations have or have not been achieved and why. It did not discuss what steps can be taken to effectively implement the latest task force recommendations in a timely manner. Rosenbaum (2005) noted this in his report for the NFIP Evaluation. If progress is to be made, FEMA needs to assess the progress made on the recommendations presented in the 2002 report and chart a course to help complete any unfinished business. It would also be helpful if FEMA placed the 2002 Task Force report on its website for broader public availability. Distribution of the report via the Internet would help to disseminate the task force recommendations and stimulate further efforts in this regard.

11.3 Policy Framework

Current policies directly and indirectly related to the 1 percent standard both support and undermine protection of the natural and beneficial functions of floodplains. This section discusses how State and Federal policies provide both incentives and disincentives for local entities to protect the natural and beneficial functions of floodplains. Examples are given for how design standards and cost-sharing requirements imposed by one agency, and based in part on the 1 percent standard, may be working at odds with the objectives of other agencies. Finally, examples of variances and exceptions to floodplain management criteria that either support or conflict with protection of floodplain functions are provided.

11.3.1 Design Standards and Funding Requirements

Design standards that are linked to the 1 percent standard and associated cost sharing requirements of funding agencies may also have an effect on how local NFIP communities choose to implement floodplain management standards. An example from King County, Washington, may be typical of changes in design standards and Federal funding incentives experienced by other NFIP communities that conflict with sound floodplain management efforts to protect the natural and beneficial functions of floodplains.

A King County minimum design standard for bridge replacements provided 6 feet of clearance between the low chord elevation of bridges and the 1 percent flood elevation to allow for the safe passage through the bridge structure of large floating debris that typically occurs during flood events in the Pacific Northwest. However, the Federal Highway Administration (FHWA) minimum standard is 3 feet. The lower Federal standard is a blanket *national* standard that does not reflect *regional* riverine characteristics and flood risks. This lower standard is viewed more favorably by local agencies seeking grant funding from FHWA because the reduced clearance, from 6 feet to 3 feet, lowers the required height and length of a bridge and its approaches and, consequently, lowers the cost of a project. The higher King County design standard was changed late in 2004 under pressure from the county roads department because of its issue with costs and leveraging grant support from FHWA.

Federal funding incentives may lead to further design decisions that impact floodplains. For example, since the FHWA/local cost share is 75/25 for the bridge structure itself and 15/85 for the bridge approaches, this creates a disincentive for locals to “do the right thing” in floodplains. In this case, where it is bearing the larger financial burden for the bridge approaches, a local government will opt for the lowest cost alternative, which is typically embankment fill, as opposed to alternatives with less impact on overbank flood hydraulics and floodplain functions, such as elevated road decks, culverts, etc. Governments also will favor the smaller “footprint” for bridge approaches provided by the lower clearance standard.

The NFIP does not prohibit construction of bridge approaches or other development in special flood hazard areas defined by the 1 percent standard, but it does require that construction in flood-prone areas be “reasonably safe from flooding” (44 CFR 60.3 (a)(3)). Accordingly, new construction is required to be “constructed by methods and practices that minimize flood damages.” While the intent of the NFIP is to address economic damages, efforts to minimize environmental damages would only further the ability to achieve flood damage reduction and better protect investments in public infrastructure designed, funded, and built in and near flood-prone areas. FEMA should coordinate with other Federal agencies to promote design standards and funding incentives that minimize environmental damages in floodplains.

11.3.2 Exceptions to Floodplain Management Criteria

Several exceptions exist to the NFIP floodplain management criteria established for flood-prone areas. Provisions in 44 CFR 60.6(b)(1) allow exceptions from the criteria established in 44 CFR 60.3, 60.4, and 60.5 for communities adopting floodplain management regulations. An exception from the minimum standards may be made where “local conditions may render the application of certain standards the cause for severe hardship and gross inequity for a particular community.” This exception may be interpreted as a means for the development of floodplain lands to prevent economic hardships or inequities, as opposed to conservation of the natural and beneficial functions of the floodplain. The subsequent section (44 CFR 60.6(b) (2)) describes the requirement for FEMA to prepare a special environmental clearance to assess the impact the exception request may have on the environment.

It is understood that only a few of these clearances have been granted in the past and an exception that ultimately requires the preparation of an Environmental Impact Statement or other environmental document may not likely be granted (Robinson 2006). However, as the developable land supply for the Nation’s communities continues to shrink over time, the pressure on communities to seek exceptions from the minimum floodplain management criteria, based in large part on the 1 percent standard, may increase with outcomes that may be counterproductive to the protection of natural and beneficial functions of floodplains.

Perhaps some of the most direct impacts to floodplain natural and beneficial functions come from the ability of communities to perform “no-rise” analyses to develop within the regulatory floodway. The regulatory floodway is defined as the stream channel plus a designated portion of the floodplain that must be kept free from encroachment in order to discharge the 1 percent flood without increasing flood levels by more than 1 foot. This is the minimum NFIP standard and some States specify a smaller allowable rise. The intention of the floodway concept is not to preclude development but to assist communities in managing and developing floodplain lands so as to prevent additional damages to other property owners.

Approximately 9,000 square miles of floodway have been established along 40,000 miles of stream and rivers in the Nation (FEMA 2002a) and the use of floodways as a land use management tool has protected the natural and beneficial functions of tens of thousands of acres of riparian floodplain lands (ASFPM 2005). However, the minimum NFIP standards (44 CFR 60.3(d)(3)) allow “fill, new construction, substantial improvements and other development within the regulatory floodway” if it can be demonstrated through engineering analyses that an encroachment will not result in any increase in the base flood elevation. These analyses constitute the “no-rise” analyses that are required by FEMA to demonstrate that any loss of flood flow conveyance and associated potential rise in water level is adequately mitigated by actions to restore the lost conveyance. This mitigation can be accomplished by excavating land and removing vegetation within the floodway to compensate for the obstruction caused by the proposed encroachment, such that the conveyance capacity of the stream remains unchanged. FEMA discouraged development of the floodway but provided guidance for performing “no-rise” analyses to standardize the methods (Schauerte 1990).

Disruption of natural floodplain terrain and vegetation within a floodway adjacent to the stream channel can affect some of the highest-quality habitat and represents a significant impact to the natural and beneficial functions of floodplains. Recommendations were made at the Forum to enhance the existing 1 percent standard by eliminating the 1-foot rise allowed in the floodway and delineating a “resource-based” floodway, with consideration for ecological and geomorphic processes, to better protect floodplain functions (Coulton 2004, and Berginnis 2004).

Due to the endangered status of various salmon species in the Pacific Northwest, FEMA Region 10 published guidance allowing an exception to the “no-rise” standard if the floodway encroachment is related to a fish habitat enhancement project or the recruitment of woody debris (FEMA, 2002d) and an engineering analyses can demonstrate that the rise in water level would be minimized and not adversely affect any insured properties. This is a case where an exception to the minimum NFIP standards is intended to protect the natural and beneficial functions of floodplains.

11.4 Relationships between the 1 Percent Standard and the Natural and Beneficial Functions of Floodplains

Application of a single uniform national standard that has a direct effect on ecosystems such as floodplains ignores the significant regional variation of floodplain ecosystems and their associated physical, biological and ecological processes. Accordingly, an evaluation of the 1 percent standard and its relationship to floodplain functions is complex. To simplify this effort, these relationships are broken down into the following considerations:

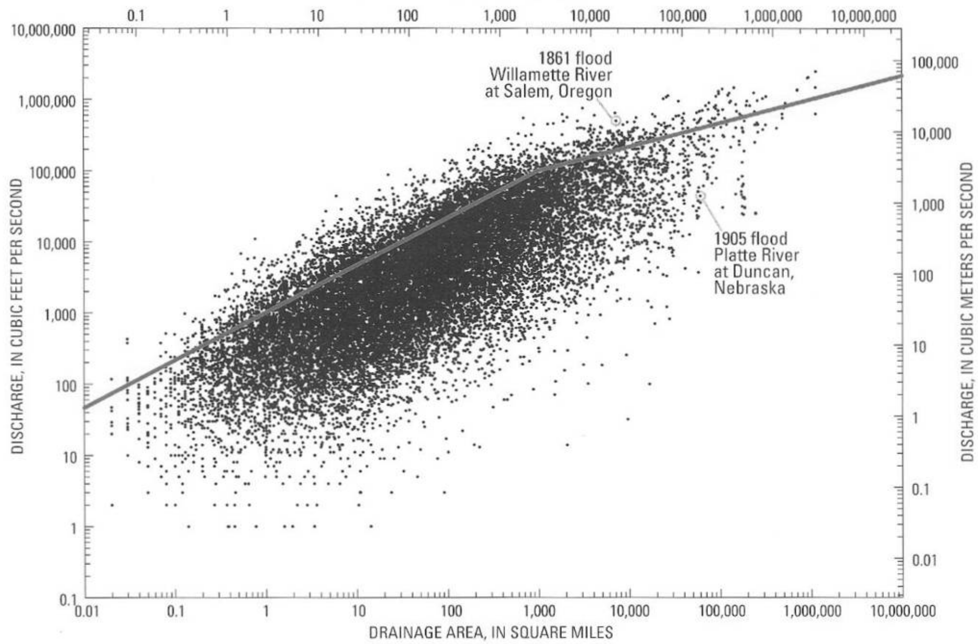
- Climatic and geologic effects on flooding
- Spatial extent of flooding
- Temporal characteristics of flooding
- Natural processes associated with flooding
- Relationships between wetland losses and flood damages
- Economic value of the natural and beneficial functions of floodplains

11.4.1 Considerations for Climatic and Geologic Effects on Flooding

The probability of large floods varies geographically and is not uniformly distributed. While this probability of flooding should be reflected in available stream gage data, additional considerations should be given to the climatic and geographic characteristics of a flood source, should higher standards other than the 1 percent standard be desired.

Nearly all riverine and coastal floods are caused by severe storm systems, which, through the interaction of climatic processes with terrestrial conditions, result in extreme water levels in rivers or along coastlines. Recent research by the USGS indicates that the distribution of large floods in the United States is not random but is a function of climate, topography, and drainage basin size (O’Connor and Costa 2003). Larger floods occur more often over land areas close to sources of oceanic moisture, such as along the Pacific Ocean and Gulf of Mexico, and where large-scale topography features are located perpendicular to the predominant direction of atmospheric moisture movement, such as along the eastern edge of the Rocky Mountains and the Appalachian Mountains. Large floods are more likely to occur from large drainage basins that encompass areas of high precipitation and snowfall and from small basins that experience intense precipitation from convective storms. To illustrate this, the USGS plotted the largest annual flow versus drainage area from 22,063 streamflow stations in the United States and Puerto Rico (Figure 11-1); data points above the line represent stations with the largest relative flows. This subset of stations was then plotted on a map of the Nation and begins to show spatial patterns for where the largest flows in the United States could be expected to occur. For example, concentrations of the largest flows for the smallest drainage areas tend to occur in Hawaii, Puerto Rico, and the panhandle of Alaska, suggesting a higher standard may be suitable where intense maritime precipitation events can occur.

FIGURE 11-1: Relationship of Peak Floods to Drainage Area in the United States

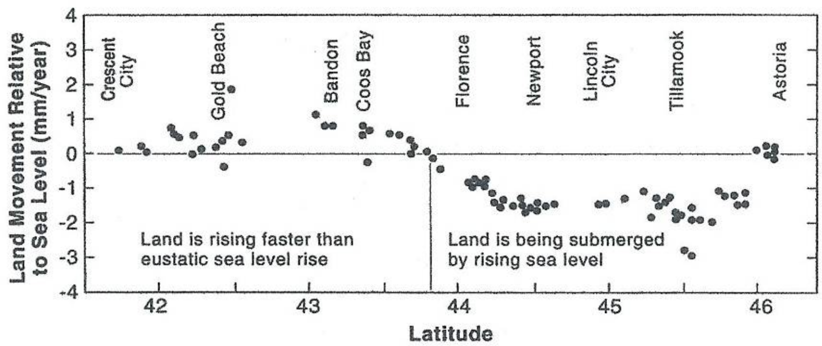


SOURCE: O'Connor and Costa, 2003

Geologic processes are often more dynamic along coastal land margins and can influence the risk of flooding substantially. For example, repetitive geodetic surveys along the coast of Oregon (Figure 11-2) indicate portions of the coast are both "sinking" in the vicinity of Tillamook, Oregon, and "rising" in the vicinity of Gold Beach, Oregon, relative to a changing sea level through tectonic decline and uplift, respectively (Komar 1992). As was also seen in New Orleans following Hurricane Katrina, 1 percent tidal stillwater elevation estimates, measured with reference to land, may lose accuracy over time. Coastal hazards from tsunamis may include earthquakes, as well as flooding.

Tsunamis generated from local earthquakes may be accompanied by co-seismic subsidence of the shoreline landmass. Investigations of soil layers in buried marshes in the Pacific Northwest indicate that rapid subsidence events from 3 to 5 feet have occurred historically (Madin 1992). This magnitude of ground elevation change can dramatically increase flood hazards from stillwater, wave attack, and coastal erosion otherwise not accounted for when establishing 1 percent coastal hazard zones under current FEMA coastal flood study guidelines. If these "nonstationary" processes were to be accounted for in a 1 percent standard, natural and beneficial functions of estuarine floodplains, such as salt marsh sediment accretion, vegetation growth, and subsequent wave attenuation, might be better protected because coastal flood hazard zones might be established farther inland, thus protecting a greater amount of the coastal and estuarine landscape.

FIGURE 11-2: Land Elevation Changes Relative to Sea Level Rise along the Oregon Coast



SOURCE: Komar (1998).

11.4.2 Considerations for the Spatial Extent of Flooding

Floods occur across the three dimensions of space, as well as the fourth dimension of time. FEMA floodplain maps are the most readily accessed flood study products and they provide an emphasis on the two-dimensional floodplain area. Hydraulic model data used to map floodplains are less available to the public but provide a three-dimensional construct of the floodplain. These products are used by many other disciplines, including fisheries biologists and ecologists for environmental investigations, to obtain an understanding for the spatial extent and characteristics of extreme flooding.

The floodplain defined by the 1 percent standard has no scientific connection to the natural, biological, physical, or geomorphologic floodplain (ASFPM 2005). It defines a spatial "footprint" where a theoretical flood can occur. Often the area contained by the 1 percent floodplain encompasses the areas over which most of the natural and beneficial functions of floodplains occur on a seasonal basis.

Within the 1 percent floodplain, natural and beneficial functions are generally more prevalent closer to the stream where overbank flooding is frequent and complex habitat exists along the aquatic-terrestrial boundary. Disturbances to habitat are typically much greater from activities that occur closer to the stream channel than along the outer limits mapped for the 1 percent flood.

Logically, flood damages have the potential to occur more frequently where flooding is more frequent. In Washington State, nearly two-thirds of the flood damages are observed to be within the 10-year floodplain (Steele 2005). Coincidently, preliminary research into the natural flood storage function of floodplains in the Pacific Northwest indicates that floodplains act as storage reservoirs up to the 10-year floodplain stage, then shift to provide more of a conveyance function as floodwaters rise higher (Coulton 2004). These separate observations of flood damage trends and floodplain function lead to a logical conclusion that the 10-year floodplain may provide a unique delineation by which to achieve mutual objectives in the reduction of flood damage and the conservation of floodplain functions.

The definition of a riparian ecosystem in the FEMA CRS manual recognizes that these ecosystems are associated with water bodies and groundwater tables that may in some circumstances “extend beyond the Special Flood Hazard Area” (FEMA, 2002c). Indirect impacts to riparian ecosystems may occur where these ecosystems are sustained by groundwater influence that extends beyond the 1 percent floodplain. Environmental impacts attributed to the NFIP and receiving significant attention have included groundwater degradation (Rosenbaum 2005). The natural functions of floodplains may therefore extend beyond the boundaries of a 1 percent floodplain when considering groundwater conditions.

11.4.3 Considerations for the Temporal Characteristics of Flooding

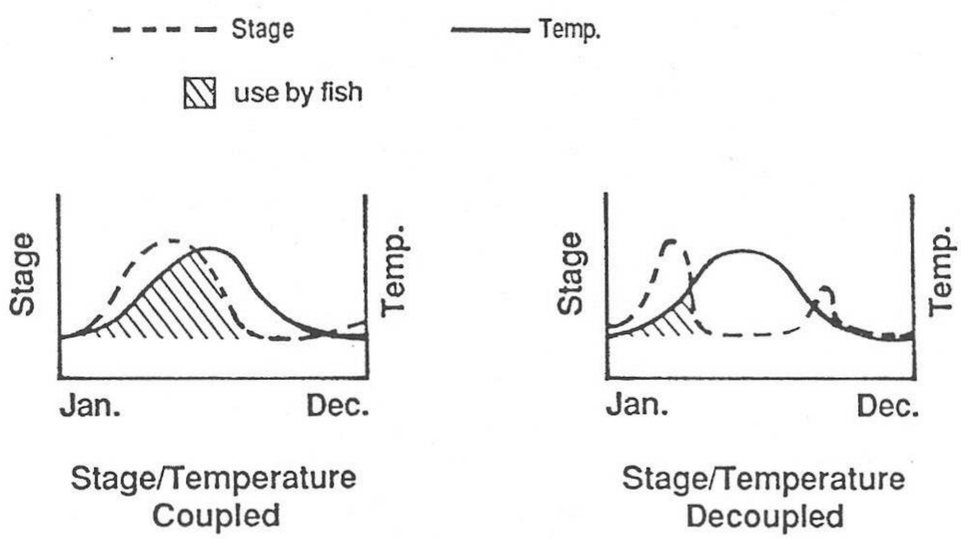
As noted earlier, the 1 percent flood and its associated floodplain are hypothetical constructs, derived from a statistical analysis of infrequent hydrologic events, while the natural and beneficial functions of floodplains are associated with more frequent seasonal hydrologic events. Flood insurance study products document flood characteristics associated with only the peak of the 1 percent flood event, and other return period events, but do not specifically account for the temporal nature of flooding. However, the temporal characteristics of flooding are important to defining the natural and beneficial functions of floodplains.

While periodic inundation of floodplain habitats is generally known to be important for sustaining habitats for plant and animal species, the significance of the seasonal frequency and duration of flooding has become better understood in recent decades and can provide valuable information from which to judge the adequacy of the 1 percent standard for supporting these functions. The temporal characteristics of flooding-and flood-related erosion hazards-occur as different events over varying timescales. Each flood and flood-related erosion event has its own frequency and duration characteristics that may not be adequately addressed by one standard.

Observed riverine flooding is best characterized as a “wave” that proceeds downstream and combines with other flood waves of varying magnitude and duration discharging from tributaries. The flood wave is a function of the discharge, valley slope, floodplain size, and vegetation. Junk et al. (1989) described this wave as the flood pulse concept in river-floodplain systems, and the physical process of flooding was linked to biological and ecological processes.

The flood pulse is the primary “driving force responsible for the existence, productivity, and interactions of the major biota in river-floodplain systems” (Junk et al. 1989). The two main characteristics of the flood pulse that influence nutrient recycling and effects on biota are the downstream seasonal pulsing of river flow and the associated lateral exchange of water between the channel and floodplain. The flood pulse is characterized by its duration, amplitude, frequency, timing, and predictability (Petts 1996). Large floodplain rivers exhibit more regular, predictable, and longer duration flood pulses. A predictable flood pulse of long duration is more amenable to sustaining floodplain biotic processes. This is especially true when the timing of the flood pulse coincides with seasonal water temperature increases (Figure 11-3), which triggers many of the ecological processes described in the next section.

FIGURE 11-3: Schematic Relationship of Seasonal River Flooding to Water Temperature Changes



SOURCE: Junk et al (1989)

Higher floodplain standards might be applied on lowland valley floodplains in semiarid or temperate continental climatic regions where flooding is predictable, of long duration and tends to coincide with the annual seasonal increase in water temperature. An alternative to creating a specific standard may be for FEMA to develop a map product that allows delineation of floodplains associated with more frequent flooding and having a higher ecological value. For example, digital flood insurance rate map (DFIRM) products might include a utility to map the 10-year floodplain, which has been tentatively linked to natural and beneficial floodplain functions (Coulton 2004, FEMA 2002d). Such a FEMA map product would likely define a zone larger than the regulatory floodway, thereby further reducing flood damages while better protecting natural and beneficial functions.

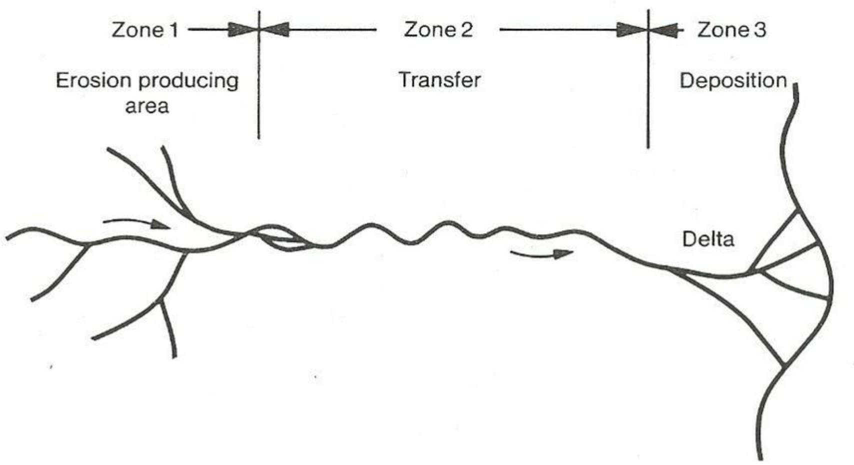
11.4.4 Natural Processes Associated with Flooding

Several reports have defined the natural and beneficial functions of floodplains (Federal Interagency Floodplain Management Task Force 1986, 1994, 1996, FEMA 2002a). These definitions are appropriate and demonstrate general relationships but do not provide quantitative details for how the processes relate to the 1 percent standard or describe the complex interaction of the processes during flood events. Scientific research from the disciplines of geomorphology and aquatic biology can be integrated with the traditional flood study disciplines of hydrology and hydraulics to construct conceptual models of floodplain function from which informed decisions can be made for locally refining the 1 percent standard to better account for the natural and beneficial functions of floodplains.

Natural processes may be better accounted for in setting standards for floodplain management by using a classification system to define the geomorphic context within which floodplain functions can be described based on a location of a flood study site within a particular watershed or a littoral cell. One of the broadest classifications for river systems was defined by

Schumm (1977), where a stream network is broken down into three regions of erosion, transport, and deposition (Figure 11-4).

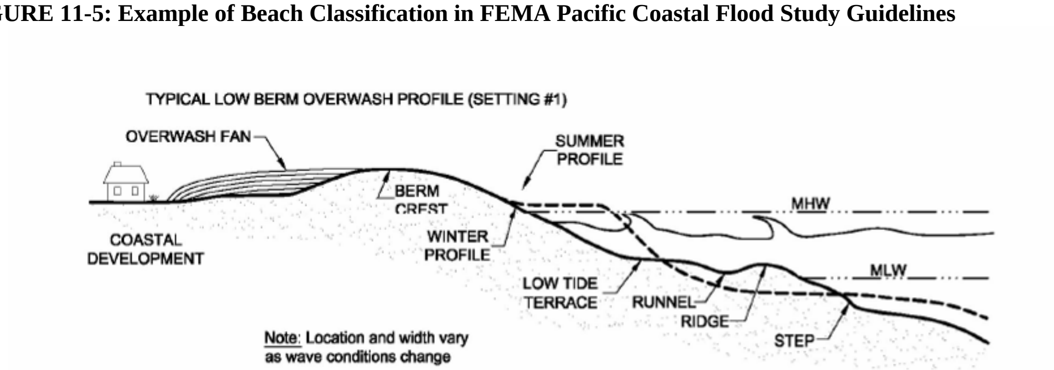
FIGURE 11-4: The Fluvial System



SOURCE: Schumm (1977).

While an explicit riverine floodplain classification scheme is not currently included in the FEMA guidelines for riverine flood studies, draft guidelines for coastal flood studies along the Pacific Ocean (FEMA 2004) include guidance to study contractors for identifying a particular beach setting, with six settings classified (Figure 11-5). The beach settings are identified by sediment type and profile characteristics and, depending on the setting, specify data requirements and specific methods to use to eventually define coastal flood hazards.

FIGURE 11-5: Example of Beach Classification in FEMA Pacific Coastal Flood Study Guidelines



SOURCE: FEMA (2004).

FEMA should consider establishing a classification system for riverine floodplains to guide a decision-making process to assess the adequacy of the 1 percent standard for protecting the natural and beneficial functions of floodplains. A geomorphic classification approach to floodplain management would also help better identify and manage flood-related erosion hazards.

Perhaps one of the most significant omissions in flood studies is the lack of consideration for the natural processes of sediment and debris transport. In this respect flood insurance studies remain somewhat fixed in their historic roots of flood control hydraulics, where simplifying assumptions, such as clear water flow and fixed bed boundaries, and a lack of consideration for geomorphic processes, have led to the delineation of 1 percent floodplains that do not fully consider the natural and beneficial functions of floodplains.

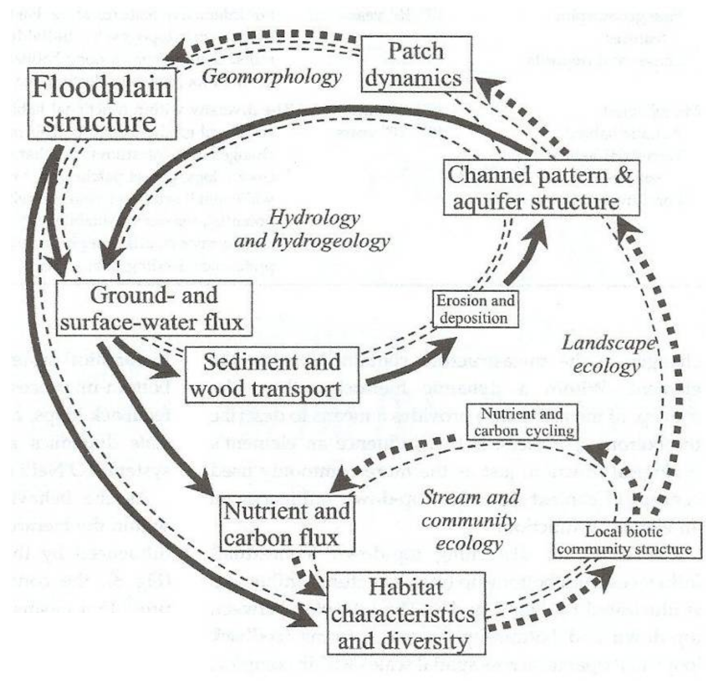
The present allowance in the NFIP to fill in the flood fringe may reduce the ability of floodplains to serve as sediment sinks. Suspended sediments, otherwise deposited on the floodplain, may settle in downstream channel reaches and contribute to increased aggradation and reduction in channel flood capacity. FEMA should consider supporting higher standards on stream reaches where suspended sediment loads are high and where the morphology of the floodplain is conducive to receiving sediment-laden overbank flows. For example, wide floodplain terraces along the outer edge of meander bends might be protected to conserve their potential sediment sink functionality. Investigations of floodplain sedimentation will have the added benefit of estimating the rate of floodplain elevation changes, which can affect the assumed level of protection within a 1 percent floodplain over time by increasing flood elevation where significant sedimentation has occurred.

Research into floodplain processes is increasing and the associated knowledge base is growing. New concepts of biocomplexity and fluvial landscape dynamics (Poole 2002) underscore the recent advancements in linking multiple disciplines together to investigate floodplain processes, including geomorphology, hydrology, hydrogeology, landscape ecology, and stream and community ecology (Figure 11-6). FEMA should encourage the involvement of a variety of scientific disciplines in the establishment of new standards for protecting the natural and beneficial functions of floodplains. While past membership in the Natural and Beneficial Functions of the Floodplain Task Force has been representative of various Federal and State resource management agencies, a reconstituted task force should specifically seek out interdisciplinary experts—representing agencies, academia, or the private sector—who have a deep technical understanding of the subject, recent applicable research, and the ability to work in an interdisciplinary manner.

11.4.5 Relationships between Wetland Losses and Flood Damages

Available data were evaluated during this study to see if a relationship could be drawn between wetland loss and flood damages, as an indicator for how the NFIP and 1 percent standard may be protecting the natural functions of floodplains. Several members of the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) staff were contacted, and the Internet was searched to determine if a national database on wetland losses was available. While many studies and inventories have been done and are ongoing in discrete geographic areas, there has not been a comprehensive national accounting o wetland losses since the landmark report by Dahl (1990). These data were retrieved from the Internet *http://www.npwrc.usgs.gov/resource/othrdata/wetloss/wetloss.htm*), and wetland losses by State from the 1780s to the 1980s were observed.

FIGURE 11-6: Conceptualization of River Floodplain Process and Associated Scientific Disciplines



SOURCE: Poole (2002) © Blackwell Science, Ltd.

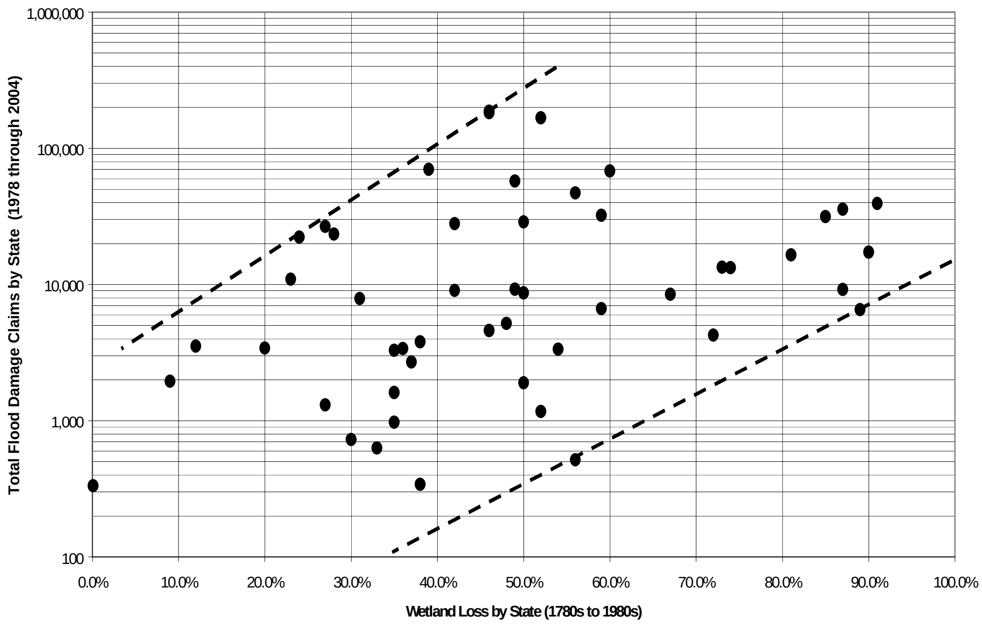
FEMA claims data by State (total losses and total payments) were obtained from the FEMA website (*http://bsa.nfipstat.com/reports/1040_200605.htm*], and correlated to State wetland losses (Figure 11-7). While there is significant scatter in the data, envelope curves were drawn to contain the data points, and a general trend of increasing losses and payments with increasing wetland loss can be discerned.

Rosenbaum (2005) notes that there is an absence of research involving GIS databases and environmental monitoring from which to draw conclusions about the environmental impacts of the NFIP. Direct comparisons of floodplain areas and wetland areas (Berginnis 2004) and other ecosystem features such as riparian areas and surficial aquifers using a GIS may better draw the connections between floodplains and their natural and beneficial functions. As more related data become available, more detailed analyses should be performed to evaluate the relationships between impacts to the natural and beneficial functions of floodplains and flood damages.

11.4.6 Economic Value of the Natural and Beneficial Functions of Floodplains

Several of the 2002 Natural and Beneficial Functions Task Force report recommendations address the need to better quantify the economic value of floodplains and their functions. Recommendation 5 advocates the need to assess the "socioeconomic costs and benefits of floodplain uses," and Recommendation 6 calls for the modification of "current benefit-cost analysis methods to include and reflect the long-term environmental and economic

FIGURE 11-7: Comparison of Wetland Loss to Flood Damage Claims in the United States



SOURCE: Derived from FEMA Data

benefits derived from utilizing nonstructural [floodplain management techniques].” The 1 percent standard is directly related to current FEMA benefit-cost analysis methods. Benefits (avoided future flood damages and losses) are defined based on the relationship of buildings and infrastructure to the elevation and lateral extent of flooding associated with a range of flood frequencies, including the 1 percent exceedance frequency, to determine the extent of flood risk.

Efforts to quantify the economic value of ecological services, such as floodplain functions, are still in early stages of development. One of these first broad efforts by Costanza et al. (1997) estimated the world’s ecosystem services at $33 trillion per year, almost twice the combined gross national products of the countries in the world, with a total value of $19,580 per hectare per year (1994 U.S. dollars) assigned to swamps and floodplains. They also assigned approximately 43 percent of the world ecosystem service value to the coastal zone, even though this area represents only 6.3 percent of the planet’s surface.

The 1 percent standard and many supporting NFIP regulations were designed to strike a balance between promoting economic growth and preventing flood damages in the development of floodplains; however, this perceived balance may be significantly different if the economic value of the natural and beneficial functions of floodplains is to be accounted for. For its mitigation projects, FEMA employs a benefit-cost analysis method to determine the future benefits of a mitigation project versus its cost; however, it does not take into account the short- or long-term economic value of ecosystem services provided by floodplain mitigation activities.

Although the economic valuation of ecosystem services is still in its infancy, studies show that the economic value derived from the sustainable management of ecosystems is often greater than the value obtained from converting the complex natural ecosystem to more simplified systems for human uses. Documentation of the value of ecosystem services protected by sound floodplain management practices may better justify the protection of the natural and beneficial functions of floodplains to NFIP communities and the public in general. FEMA should initiate pilot studies to test the feasibility of incorporating the economic value of floodplains into current benefit-cost analyses to better reflect the benefit of mitigation projects that serve to protect or restore beneficial floodplain functions.

11.5 Influence of the LOMC Process on the Natural and Beneficial Functions of Floodplains

As noted previously, the 1 percent floodplain is generally large enough to encompass the land area where many of the natural and beneficial functions of floodplains occur during more frequent (less severe) seasonal flooding processes that sustain aquatic and riparian ecosystems. However, the 1 percent floodplain is further divided into the regulatory floodway and the surrounding flood fringe, with development, including filling to elevate land and buildings above the base flood elevation, generally unrestricted in the fringe area.
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Based on a review of the literature, commentary from invited participants at the Forum, and interviews conducted as a part of this work, four main aspects of the Letter of Map Change (LOMC) process appear to be detrimental to the goal of protecting the natural and beneficial functions of floodplains:

- The existing LOMC standards and guidance and economic self interest on the part of developers and communities generally results in map revisions to support economic development that result in a smaller floodplain (decrease in BFEs) as opposed to revisions that attempt to map larger floodplains (increase in BFEs) to protect floodplain natural and beneficial functions and reduce future flood damages; these revisions are often times accomplished using channel or levee techniques that in many cases can adversely impact the channel, adjacent riparian and wetland areas, and the geomorphic stability of the natural system.
- The existing LOMC review process is based on uniform national standards and does not incorporate local resource management input that should ultimately guide map changes while protecting the natural and beneficial functions of floodplains.
- The existing Letter of Map Revision Based on Fill (LOMR-F) provisions provide an indirect incentive for filling in the flood fringe with minimal consideration for environmental impacts, plus the decision to submit and obtain an LOMR-F is voluntary.
- The cumulative effects of approved LOMC actions are not adequately tracked nor are LOMC data readily available to determine these effects.

11.5.1 Existing LOMC Standards and Guidance

There is a general awareness at the local level that the LOMC process as it is now facilitates floodplain development. In fact, the current map change process favors efforts to lower the BFEs and shrink floodplains, as opposed to raising BFEs and enlarging floodplains. This is indicated in FEMA guidance to community officials (FEMA 1993) where it is stated that “revisions that result in higher BFEs are generally made through the PMR (Physical Map

Revision) process… [while] revisions that result in lower BFEs...may be made by a LOMR." This is because it is important that when BFEs go up and the floodplain expands, the new data go through the appeals process and get adopted into the community's floodplain management ordinances; it is less critical in this regard when BFEs go down and the floodplain shrinks. The PMR process is more time consuming and expensive to NFIP communities because the FIS report and FIRM map panel are required to be changed, while the LOMR process does not require these changes.

Given the nationwide trend in urbanization and higher peak flows, a true 1 percent floodplain is likely larger than a mapped effective floodplain. The LOMC standards and guidance should acknowledge this condition and at least scrutinize in more detail requests that lower floodplains, while continuing land development leads to increased runoff, higher flood flows, and increased flood damages, as well as loss of floodplain habitat.

11.5.2 Existing LOMC Review Process

In many cases, opportunities are lost at the LOMC review level to ensure that proposed floodplain changes will not impact the natural and beneficial functions of floodplains because the current LOMC review process does not include a consideration of these impacts. Even if this were changed, reviewers from other geographic regions that do not have an understanding of local ecosystems and habitat could not assess these impacts. FEMA does require a Community Acknowledgement Form to accompany floodplain fill requests and this addresses part of this issue; i.e., before FEMA will process an LOMR-F, the community must determine that the development complies with all local floodplain management regulations and that the applicant has obtained or will obtain before beginning construction all necessary Federal, State, and local permits (including ESA and Section 404). Currently, the form requires the signature of one community official. The signatory requirement could be broadened to include the signature of a community natural resource manager, someone familiar with the environmental effects of the floodplain fill request, in order to more directly address the effects of floodplain fill on floodplain functions.

The State NFIP coordinators are not significantly involved in the LOMC process and this may be contributing to a lack of local input for how resulting land use changes may affect the natural and beneficial functions of floodplains. However, the State NFIP coordinators interviewed said they would not have the time or resources to be extensively involved in the LOMC process, but perhaps they could be involved at strategic points along the review process. It is understood that, if required by State law, the NFIP coordinators only need to sign off on LOMR-F requests and not on LOMAs or LOMRs. Also, unlike other Federal permit review processes that pass through several agencies, such as USACE 404 permit program involving the USFWS and State agencies, the FEMA map revision process involves interaction primarily between FEMA, the floodplain administrator of the NFIP community, and the map revision requestor.

Even with these problems, the LOMC process is recognized as a necessary tool to update floodplain maps given the age and inaccuracies inherent in the maps. The LOMC review process simply needs better checks and balances, such as more local involvement and interagency input, especially from resource management agencies familiar with the unique local natural and beneficial functions characteristic of floodplains.

11.5.3 Existing LOMR-F Provisions

One direct impact to the natural and beneficial functions of floodplains through the LOMC process is present in the LOMR-F process. Any owner or lessee of property in the flood fringe is free to fill his property to raise the lot or structure above the 1 percent flood elevation. This ability to fill in the flood fringe is predicated on the methods and assumptions used to define the regulatory floodway at the time of the effective flood insurance study; i.e., under minimum FEMA standards, the fringe area can be entirely filled because the floodway has been reserved to convey the 1 percent discharge without raising flood elevations more than 1 foot. Many NFIP communities have adopted higher standards limiting the floodway rise, with a zero-rise standard effectively prohibiting fill placement in the flood fringe.

Even with the environmental benefits provided by the regulatory floodway, filling in the flood fringe through the LOMR-F provision has been a general issue nationwide. Plaintiffs in a recent lawsuit against FEMA contend that the habitat of the Puget Sound Chinook salmon is being directly impacted by the placement of fill in flood fringe areas (U.S. District Court Western District of Washington at Seattle 2004c). Public officials who were interviewed noted that if the NFIP didn't recognize "fill" as a means of getting a property out of the floodplain, this would reduce the incentive to place fill in floodplains and would help to protect the natural and beneficial functions of floodplains.

Interestingly, the LOMC process includes a provision for a conditional LOMR-F (CLOMR-F). As with an LOMR-F, obtaining a CLOMR-F is voluntary on the part of the property owner, but when requested it does give FEMA the opportunity to review a map revision request based on fill before the fill is placed. Conditional approval is granted if it is determined the fill would remove the insured structure from the SFHA. An LOMR-F is then submitted after the fill is placed. A reasonable modification to the LOMC process would involve a requirement that a CLOMR-F always be submitted via the NFIP community to FEMA in lieu of an LOMR-F. This approach would parallel Federal permit approaches, such as USACE 404 permit program, that requires a review of a proposed waterway action before it occurs.

11.5.4 Cumulative Effects of Approved LOMC Actions

Based on commentary from Forum participants and interviews conducted as a part of this work, there is general agreement that there should be a more comprehensive view of the cumulative effect of map changes made through the LOMC process. Property-by-property decisions to change effective maps are reviewed and approved without proper considerations for their cumulative effects. While it is understood that the regulatory floodway concept is intended to account for the cumulative effects of development in the flood fringe, the floodway designation relies on numerous assumptions, and in many communities the floodplain maps, and associated data used to make floodway determinations, are severely outdated, effectively invalidating the assumptions the mapped floodways are based on.

There are two significant shortcomings to the established approach in determining a floodway to accommodate cumulative effects of future floodplain development including: 1) the inconsistent use of a 1 percent discharge rate based on *existing* land use conditions to guide *future* land use decisions and 2) the traditional use of steady flow modeling to establish floodway boundaries associated with a highly unsteady, dynamic event such as flooding. These shortcomings should be evaluated in detail to determine the appropriateness of the floodway concept for long-term land use management.

The use of one-dimensional steady flow models has not adequately defined the true hydraulic processes at work in the more complicated flow regimes of floodplains. A continued reliance on these simplified models for flood studies and the map revision process will not advance the recognition of natural and beneficial functions in floodplain management efforts. Until recent years, flood insurance studies have relied upon the use of steady flow hydraulic models to determine the floodway necessary to accommodate the cumulative effect of filling the flood fringe. Steady flow models do not account for the natural and beneficial functions of floodplain storage, associated with fluvial flooding, or the ebb and flood of tidal waters. This means that even if a future-conditions 1 percent discharge is used in a steady flow model the floodway analysis may not be representative of actual conditions. Since floodplain storage has the effect of detaining flow and lowering downstream flood elevations, a steady flow model likely underestimates flood elevations where natural storage occurs and this would underestimate the water level from which the minimum 1-foot rise criterion is based, unless it is properly calibrated. This error may be compounded when upstream natural storage areas are filled and peak flows increase.

The purpose of the floodway may be misunderstood and communicated incorrectly to the public. Information on the FEMA website states that "floodplain management through the use of the floodway concept is effective because it allows communities to develop in floodprone areas if they so choose, but limits the future increases of flood hazards to no more than 1.0 foot." However, the definition of the floodway in the NFIP regulations indicates it is intended to "discharge the [existing] base flood without cumulatively increasing the water surface elevation more than a designated height." Given these two statements, interpretation of the floodway definition appears to result in a belief that the floodway will function as designed into the future. This would be true if the flood fringe is filled and the 1 percent discharge remained the same; however, watershed and floodplain development almost always leads to an increase in the 1 percent discharge and this in turn would violate the basic assumption that the floodway concept is based upon.

11.6 Related FEMA Initiatives and Environmental Legislation

Several FEMA initiatives have been implemented in recent years to better support protection of the natural and beneficial functions of floodplains. The CRS provides flood insurance premium reduction incentives for NFIP communities to protect the natural and beneficial functions of floodplains. Related efforts have been made by FEMA regions.

The Endangered Species Act (ESA) and several other Federal acts affect floodplains. A review and an interpretation of this legislation provide observations for how the 1 percent standard might be modified to better accommodate other agency programs and protect the natural and beneficial functions of floodplains.

11.6.1 The Community Rating System (CRS)

The CRS was established in 1990 to encourage activities beyond those required by the NFIP minimum standards. In the National Flood Insurance Reform Act of 1994 Congress codified the CRS and allowed the NFIP to provide credits in "communities that the Director determined to have implemented measures that protect natural and beneficial functions of the floodplain." However, Congress further directed that credits must be based on the estimated reduction in flood and erosion damage risks resulting from the measures adopted by the community." The CRS planning process was revised in 1994 to include additional credits for activities to protect the natural and beneficial functions of floodplains.

The natural and beneficial functions regulation in CRS Activity 430 (Higher Regulatory Standards) provides credits for prohibiting floodplain development that is hazardous to public health or water quality. The natural and beneficial functions specifically addressed by the CRS include physical processes leading to flood reduction and ancillary beneficial functions to improve water quality, recharge of groundwater, and protection of habitat. The CRS natural and beneficial functions regulation recognizes three types of regulations related to protecting the natural and beneficial functions: 1) regulations that protect pubic health or water quality; 2) regulations that protect shorelines, channels, and banks from disruption and erosion; and 3) regulations adopted pursuant to a Habitat Conservation Plan (FEMA 2002c). The ESA requires the preparation of Habitat Conservation Plans (HCPs) where adverse impacts to listed species cannot be avoided. The CRS encourages communities to coordinate their flood loss reduction programs with HCP and other programs, including those offered by environmental nongovernmental organizations such as the Nature Conservancy.

Additional CRS activities that may support protection of the natural and beneficial functions of floodplains include the following:

- Activity 330 Outreach Projects-The natural and beneficial functions of the local floodplain are one of the 10 topics for which points are provided under outreach projects.
- Activity 410 Additional Flood Data-Using future conditions hydrology or adopting a more restrictive floodway.
- Activity 420 Open Space-Keeping floodplain lands open through public ownership, private reserve, or through regulation.
- Activity 430 Higher Regulatory Standards-Protection of floodplain storage capacity through prohibition of fill or requiring compensatory storage.
- Activity 450 Stormwater Management-Stormwater management master plan as a basis for regulation.
- Activity 540 Drainage Systems Maintenance-Stream dumping regulations.
- Activity 510 Floodplain Management Planning-Adopting and implementing a floodplain management plan (natural resources protection is one of the six areas covered by the plan).

- Activity 520 Acquisition and Relocation-Acquiring, relocating, or otherwise clearing buildings from the floodplain.

In some cases CRS activities could work at cross-purposes to each other. For example, the CRS program provides credits for drainage system maintenance that includes periodic inspection and removal of any debris that impedes flood flows. In some instances natural streams are considered part of the community's drainage system. This had the potential to encourage the removal of woody debris out of streams for CRS credits while the resource management trend for ecosystem protection and compliance with ESA requirements is to keep it in—and add it—for in-stream fisheries habitat improvements. FEMA has since revised the NFIP Coordinators manual to address this issue.

11.6.2 FEMA Region X Higher Standards and Model Ordinance

Perhaps one of the more proactive efforts by FEMA to encourage the protection of the natural and beneficial functions of floodplains occurred in Region X in February 2002 with the publication of the report *Higher Regulatory Standards* (FEMA 2002d). The purpose of the document was to "provide local communities with some regulatory land use ideas that seek to better balance the needs between floodplain development and maintaining the natural and beneficial functions of the floodplain."

The report contains three chapters addressing floodplain development, fish habitat protection, and stormwater management. Appendices provide examples of flood ordinance language from communities in the Pacific Northwest and a model ordinance that supports flood hazard prevention and fish habitat protection and a model stormwater management ordinance. This model ordinance has not had much success being adopted by local governments as their flood damage prevention ordinance, because resource management interests in local governments are more amenable to these standards than the planning/development interests; however some provisions have been used by local governments for other programs, such as shoreline management or growth management programs in Washington State.

11.6.3 Endangered Species Act (ESA)

While Federal agencies, including FEMA, have broad mandates that support protection of the natural and beneficial functions of floodplains, they often have established standards that conflict with each other on this matter. A good example is found where protection of the natural and beneficial functions of floodplains, for the conservation of endangered and threatened species of fish, wildlife, and plants in aquatic and riparian ecosystems, may under some circumstances be in conflict with the purposes of the NFIP.

Section 7 of the ESA requires Federal agencies to consult on activities that may constitute a taking of an endangered species or impact its habitat. This requirement is a main point of contention in a lawsuit against FEMA in Washington State. The court recently ruled that FEMA had violated Section 7(a)(2) of the ESA by failing to consult with National Marine and Fisheries Service (NMFS) to ensure that the minimum standards of the NFIP and the mapping of (1 percent) floodplains are not likely to jeopardize the continued existence of the Puget Sound

Chinook salmon (U.S. District Court Western District of Washington at Seattle 2004c). A key issue of the plaintiffs is that FEMA designates the boundaries of floodplains on flood maps and these actions affect the location and patterns of development.

The NFIP must comply with applicable environmental laws but also has the responsibility of acting in the spirit of these acts and policies in areas where it can exercise discretion because there are limits to what FEMA can do. FEMA probably does not have the authority, without authorization from Congress, to adopt regulations that are solely intended to protect natural and beneficial functions or to expend funds that are appropriated for other purposes, but it can take many types of actions to protect natural and beneficial functions that also reduce flood losses.

Some FEMA activities and regulations that are primarily intended to reduce flood damages also provide some level of protection for natural and beneficial floodplain functions even though this is not their primary purpose. The most important are: flood hazard mapping; the provision at 44 CFR 60.1(d) that more restrictive State and local floodplain management regulations take precedence over NFIP minimums; the floodway requirement; the construction requirements that increase the cost of floodplain development; and the requirements at 44 CFR 60.3(b)(2) that communities ensure that permit applicants have obtained any necessary Federal and State permits–most of which are environmental. The provision at 44 CFR 60.3(b)(2) has been interpreted to include ESA compliance. Therefore, implementing the minimum NFIP standards, and especially higher standards, is one route local communities might take to align floodplain management actions to achieve compliance with other Federal environmental regulations.

11.6.4 Coastal Barrier Resources Act

The Coastal Barrier Resources Act (CBRA) was established by Congress in 1982 to help direct construction away from the undeveloped portions of barrier islands, landforms that are inherently exposed to high flood risk and are environmentally sensitive. The Act promotes the concept of free-market natural resource conservation; i.e., it does not regulate development but transfers the full cost of insurance and rebuilding to the property owner, primarily through the prohibition of Federal flood insurance in these designated areas.

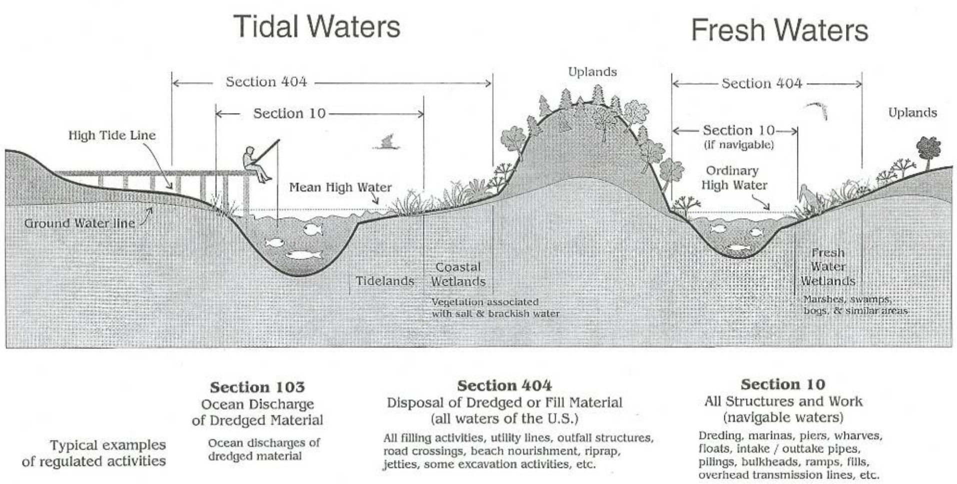
The CRBA can be characterized as a classic example of how the Federal government can encourage conservation simply by getting out of the way (U.S. Fish and Wildlife Service 2002). Since people cannot be told what to do with their property, the withholding of Federal funds (e.g., flood insurance) can be a significant disincentive to development and protection of natural functions. A market-based approach might be taken in other high-risk areas such as earthquake fault zones to the 50-year floodplains on rivers (U.S. Fish and Wildlife Service 2002). A similar recommendation came from the Gilbert White National Flood Policy Forum (ASFPM 2005) where an incentive-based approach was proposed as an option to the current 1 percent standard. Under this approach the standard would be abolished and market forces would be relied upon to shift floodplain uses away from development.

11.6.5 Other Federal Acts

The FEMA 1 percent floodplain delineates a boundary based on streamflow statistics that is not changed until the floodplain is restudied; however, other Federal legislation regulates more naturally defined boundaries. For example, the Clean Water Act (CWA) applies to waters of the United States defined as: waters that are, were, or could be used for interstate or foreign commerce; waters subject to the ebb and flow of the tide; tributaries of these waters; and wetlands adjacent to these waters. The Coastal Zone Management Act (CZMA) regulates "shorelines and land extending inward to the extent necessary to control shorelines." The Coastal Barrier Resources Act (CBRA) prohibits Federal funding for development on "ecologically, sensitive, geologically vulnerable, and the scenic and recreational values of barrier islands along the East Coast, Gulf of Mexico, and Great Lakes of the United States."

Figure 11-8 illustrates how USACE's regulatory jurisdiction in tidal and fresh waters is based on naturally defined hydrologic or ecological boundaries. It is acknowledged that the natural boundary issues related to Section 404 may be more contentious than those of a flood insurance study, and in many ways, there are significant advantages to having an arbitrary standard such as the 1 percent chance flood rather than having to determine jurisdiction on a case-by-case basis. However, delineations within the 1 percent floodplain based on the use of local geomorphic and hydrologic conditions, such as the channel bankfull width or the ordinary high water level, will result in boundaries that are better aligned with natural processes actually occurring at a location in a riverine or coastal setting. This, in turn, can lead to more effective management of the natural and beneficial functions of a floodplain.

FIGURE 11-8: USACE Regulatory Jurisdiction in Tidal and Fresh Waters



SOURCE: United States Army Corps of Engineers (2006).

11.7 Observations

Based on a review of the impact of the 1 percent standard and the NFIP on natural and beneficial functions, the WPC team offers the following observations:

The 2002 report by the Task Force on Natural and Beneficial Functions of Floodplains provided important recommendations with a goal of reducing flood losses while protecting and restoring the natural resources and functions of floodplains. FEMA should assess the progress made on the recommendations presented in the report and chart a course to help complete any unfinished business. FEMA should also anticipate new efforts that may be needed in the near future.

While the intent of the NFIP is to address economic damages, efforts to minimize environmental damages would only further the ability to achieve flood damage reduction and better protect investments in public infrastructure designed, funded, and built in and near flood-prone areas. FEMA should coordinate with other Federal agencies to promote design standards and funding incentives that minimize environmental damages in floodplains.

The definition of the 1 percent flood and associated floodplain is a hypothetical construct derived from a statistical analysis of infrequent hydrologic events, while the natural and beneficial functions of floodplains are associated with more frequent seasonal hydrologic events. FEMA should work with other environmental agencies to identify higher NFIP standards or map products and associated guidelines to protect natural and beneficial functions in floodplain ecosystems.

An alternative to creating a new standard specific to the natural and beneficial functions of floodplains may be for FEMA to develop a map product that allows delineation of floodplains associated with more frequent flooding and having a higher ecological value. For example, digital flood insurance rate map (DFIRM) products might include a utility to map the 10-year floodplain, which has been tentatively linked to natural and beneficial floodplain functions.

Research into floodplain processes is increasing and recent advancements have been made in linking multiple disciplines together to investigate floodplain processes, including geomorphology, hydrology, hydrogeology, landscape ecology, and stream and community ecology. FEMA should reconvene the Natural and Beneficial Functions of the Floodplain Task Force to examine new concepts in floodplain ecology.

Much of the data prepared in the process of defining the 1 percent floodplain remain unused and could be “mined”—and flood study methods could be refined—to better characterize the natural and beneficial functions of floodplains. The 1 percent floodplain has no known connection to a natural floodplain; however, the “footprint” it creates typically encompasses a land area within which many of the natural and beneficial functions of floodplains occur during more frequent flood events. The hydrologic regime within the 1 percent floodplain is therefore as important to defining ecological processes as it is to estimating flood hazards. Hydrologic data compiled by FEMA could be useful to other scientific disciplines. Conversely, hydrologic data observed by other scientific disciplines (such as data recently derived from large-scale managed flooding experiments below dams) could be used by FEMA to refine flood study methods to better achieve the goal of protecting the natural and beneficial functions of floodplains.

There is a consensus at the scientific and policy levels that wetlands best characterize the diverse and important natural and beneficial functions provided by floodplains, and wetland loss can exacerbate flood hazards. Yet there has been little study of the implementation of actions to prevent such losses, and a comprehensive nationwide database on wetlands, their losses, and relationship to FEMA 1 percent floodplains and flood damages is lacking. A visual representation of these data, through the application of terrain mapping and GIS, can guide decision makers and inform the public as to the spatial extent and importance of wetlands in floodplain management.

Although the economic valuation of ecosystem services is still in its infancy, studies show that the economic value derived from the sustainable management of ecosystems is often greater than the value obtained from converting the complex natural ecosystem to more simplified systems for human uses. Documentation of the value of ecosystem services protected by sound floodplain management practices may better justify the protection of natural and beneficial functions of floodplains to NFIP communities and the public in general. FEMA should initiate pilot studies to test the feasibility of incorporating the economic value of floodplains into current benefit-cost analyses to better reflect the benefit of mitigation projects that serve to protect or restore beneficial floodplain functions.

Even with the environmental benefits provided by the regulatory floodway, filling in the flood fringe facilitated through the LOMR-F provision has been a general issue nationwide and has recently been under scrutiny in the Pacific Northwest through an ESA lawsuit. A reasonable modification to the LOMC process would involve a requirement that a CLOMR-F always be submitted via the NFIP community to FEMA prior to issuance of a LOMR-F and that some form of environmental review take place.. This approach would parallel other Federal permit approaches, such as the USACE 404 permit program, that requires a review of a proposed waterway action before it occurs.

There are two significant shortcomings to the established approach in determining a floodway to accommodate cumulative effects of future floodplain development, including: 1) the inconsistent use of a 1 percent discharge rate based on existing land use conditions to guide future land use decisions and 2) the traditional use of steady flow modeling to establish floodway boundaries associated with a highly unsteady, dynamic event such as flooding. FEMA should evaluate these shortcomings in detail to determine the appropriateness of the floodway concept for long-term land use management.

The FEMA 1 percent floodplain delineates a hypothetical boundary, based on streamflow statistics, that is unchanged over time until the floodplain is restudied; however, other Federal legislation regulates more naturally defined boundaries. Delineations within the 1 percent floodplain based on the use of local geomorphic and hydrologic conditions, such as the channel bankfull width or the ordinary high water level, will result in boundaries better aligned with natural processes actually occurring at a location in a riverine or coastal setting. This, in turn, can lead to more effective management of the natural and beneficial functions of a floodplain.

In sum, the 1 percent floodplain identifies areas containing much of the Nation's important riverine habitat and the ecosystems that depend on that habitat. Influencing the wise use of that land through NFIP actions provides strong support to the NFIP goal of restoring and preserving the natural and beneficial values of floodplains. The WPC team believes that NFIP lags behind other Federal and State programs in supporting effective and innovative management of floodplain ecosystems. The NFIP goal of supporting the protection of the natural and beneficial functions of floodplains has not been realized and is far from being a success. The NFIP goal of supporting protection of the natural and beneficial functions of floodplains is closely tied to the 1 percent floodplains but is not being effectively pursued.

FEMA should ensure that consideration of the natural and beneficial functions of floodplains is fully integrated into all aspects of FEMA and NFIP actions influencing floodplain activity. The 1 percent standard delineates a critical segment of the riverine natural environment. Within this zone are areas that do or could provide to society the natural and beneficial functions of the floodplain. FEMA has actively studied those actions that it could take under the NFIP to enhance the quality of these functions but has had limited success in implementing these measures. As it moves to the future, it must move from planning to implementation and see the realization of what has long been recommended to it.

12. IMPROVED USE OF THE 1 PERCENT STANDARD

Clearly, there are many practical reasons to maintain the 1 percent annual chance flood standard and improve the ways it can be used to support the NFIP and associated goals for flood hazard reduction. Over 20,000 communities currently participate in the NFIP, approximately 4.5 million flood insurance policies in place, and with annual premiums of over $1.8 billion for approximately $750 billion in coverage, and are regulating their land use and development based on this standard. As indicated in Chapter 8, any change to the basic standard would involve a difficult and lengthy political and regulatory process to change the NFIP regulations and impose the new standard on local and State administrators of the NFIP, the insurance industry, and other entities involved in the various aspects of the NFIP. This chapter discusses what actions could be taken to improve implementation of the existing standard should it be retained or modified.

12.1 Potential Means of Improved Use of the 1 Percent Standard

Floodplain management activities, while practiced in some locations since the 1930s, were only widely implemented with the advent of the NFIP and continue to be tied formally and informally to the NFIP. The floodplain management programs in place today are designed primarily to regulate for flood events up to and including the existing condition 1 percent flood stage and are linked, in most cases, to NFIP regulatory minimums.

As part of this study, the WPC team examined the relationship between floodplain management activities and flood damages (see Appendix 4) and determined that stronger State-level floodplain management programs may result in decreased damages per capita. (See also Mittler et al. 2006.)

While continued support of floodplain management activities will be required under all circumstances, as they provide fabric to the implementation of the NFIP, there are several areas where improved implementation of the 1 percent standard could make it more effective. Use of future-conditions hydrology was discussed in Chapter 5. Four other means of improved use of the 1 percent standard were investigated and are addressed in this chapter:

1. Improve public understanding of the minimum standard.
2. Improve hazard definitions within the one-percent annual chance floodplain.
3. Improve the definition of the floodway.
4. Improve the utilization of existing NFIP provisions and new initiatives.

12.1.1 Improve Public Understanding

Past evaluations of the 1 percent standard have indicated that this intended minimum standard of the NFIP has often become the sole standard for many communities. While FEMA has embarked on successful marketing campaigns to encourage the purchase of flood insurance by individual homeowners and has published promotional materials articulating the objectives of the NFIP and the 1 percent standard, a renewed and concerted effort targeting public officials and politicians may be appropriate to again inform decision makers of the implications of relying on the minimum standard. A challenge with technical and statistically based topics is purely that of communicating the risk.

This evaluation is based on whether efforts have been put forth that, rather than attempting to explain what a 1 percent flood is, have focused on communicating that building in a floodplain is inherently more risky than building out of the floodplain. There seems to be a tendency in society to assume that “someone” has looked at the risk and the presumption is that if the risk were severe they would not be allowed to build. Development in flood-prone areas can be driven by the community’s desire to increase its tax base, reluctance to say no to development requests, or lack of recognition of the risk of building within the floodplain. Findings from this proposed NFIP review should provide the facts for this type of a targeted public awareness effort.

Improved public understanding can be quite challenging to accomplish and can consist of several different types of measures, because of the many different segments of the “public.” The following are the categories of the public that improved public understanding may apply to:

- Lay persons, who might be affected landowners, any other landowner, or any interested party
- Members of the insurance industry
- Members of the banking/lending industry
- Members of the real estate community
- Surveyors
- Engineers, architects, builders, developers, and others involved in land development
- Engineers involved in floodplain studies and mapping
- Local administrators of a flood damage reduction ordinance
- Local elected or appointed officials
- State agency staff responsible for NFIP coordination

Since there are so many categories of the “public,” improving the public’s understanding of the 1 percent standard is indeed a challenge. There has already been a great deal of effort directed toward this issue at the Federal, State, and local levels. These efforts have come from several sources, including FEMA headquarters and regional offices, the ASFPM, State coordinating agencies of the NFIP, and local governments.

Of all the different segments of the public that have a need for a good understanding of the 1 percent standard, probably the key group is the local administrators of a flood damage reduction ordinance. This ordinance, and the administration of this ordinance through a local floodplain management program, is required to be maintained in good standing by meeting all of FEMA’s minimum requirements for their community’s continued participation in the NFIP. Most of the training/educational effort at the State and Federal levels related to continued and improved the understanding of the NFIP and the 1 percent standard has historically been directed toward these local administrators. This training is accomplished through publications, technical manuals, brochures, conferences, workshops, and media presentations by FEMA and NFIP State coordinating agencies.

It is very important that training of local administrators be an ongoing program, because of the number of local administrators in each State and the normal expected turnover of local government employees in these positions. With over 20,000 local communities participating in the NFIP for the 50 States, this amounts to an average of 400 local communities/local administrators in each State. From this it can be seen that it is extremely difficult for the State NFIP coordinators to maintain a high level of training for all the local administrators in their States.

In addition to the more formal training of local administrators by FEMA and State agencies, FEMA and the States respond to individual inquiries from local officials, insurance agents, lenders, property owners, and the general public and publish information tailored to the particular legal, administrative, and geographic situations of each State. Numerous nonprofit and professional organizations with concern for floodplain management have been formed in the last two decades. These organizations conduct research, produce publications, hold conferences and workshops, and provide a network through which professionals can exchange information.

From the interviews conducted, it was generally agreed that the local administrators of floodplain management programs are much more knowledgeable of the provisions of the NFIP as they relate to the 1 percent standard than are members of the general public.

Part 8 of the ASFPM publication *Effective State Floodplain Management Programs* (2003) describes the following types of activities that have proven to be successful in improving public understanding, particularly for local floodplain management administrators:

- State Floodplain Management Manuals for Administering Local Programs
- Workshops and Training, by FEMA and State and local agencies
- State agency newsletters and web pages
- Technical assistance by State agencies for local officials on a one-on-one basis
- State agency support for local governments in the Community Rating System
- Certified Floodplain Manager (CFM) Program
- State or regional floodplain management associations/chapters

As noted in Chapter 3, there was agreement from the interviews that even though the term “1 percent chance” is being used more frequently than in the past, the term “100-year flood” still has the most widespread usage. This is primarily due to the fact that there is such a broad-based group that has used this term for so many years, and there has not been any concentrated effort to educate everyone who has used this term in the past that the more accurate terminology is the “1 percent chance flood.”

As was expressed by one State coordinator, it really does not matter whether you call it the “1 percent chance” or the “100-year” flood. What is more important is that the public, who needs to know about this, understands what this flood is and what it would look like on the ground.

There was concern, however, that even though there is getting to be more widespread understanding, a great deal of effort is still needed to ensure that all those who need to know are made aware that the "100-year flood" really is not a flood that could be expected to occur every 100-years, but instead is a flood that has a 1 percent chance of occurring in any given year.

Another means that has been used effectively in communicating the risk of the 1 percent chance flood to the lay person is that during the period of a typical 30-year mortgage for a house, the house is more likely to suffer damages from a flood than a fire.

12.1.2 Improve Hazard Definitions

The 1 percent annual chance floodplain that is shown on the existing FIRMs contains only the most basic information on the spatial extent and depth of one potential flood scenario. There is a three-step process that is used in defining the areal extent of the floodplain shown on the FIRMs: (1) calculating a discharge (2) translating the discharge into a height for the water surface, and (3) combining the water surface elevations with topographic information to produce a map for the expected flood. The accuracy of the location of the limits of the floodplain can be highly variable, due to the source of the data used in determining the discharge, the 1 percent flood elevation. and the elevation of the original ground.

As noted in Chapter 3, the initial step in delineation of the extent of the mapped floodplain is calculation of the discharge for a 1 percent annual chance flood. There are multiple methods of performing this calculation, each of which is highly dependent upon the accuracy of the data used in the calculation. Since many of the existing detailed flood insurance studies were conducted during the 1970s, there are approximately 30 additional years of hydrologic and flow data that are not being utilized in these existing studies that were conducted shortly after initiation of the NFIP in 1968. Even if there were excellent data available when the initial study was done and all the calculations were correct, these data can be woefully out of date and there could be a much different calculated flood discharge if this calculation were done today.

In locations where detailed studies have been conducted, the flood elevation is a calculated elevation, with the designation on the FIRM being a numbered A, V, or other zone. In many instances, however, there is no elevation shown on the FIRM and the floodplain area shown on the FIRM is an unnumbered A or other zone.

The third factor in determining the areal extent of the floodplain, which is the original ground elevation, can be highly variable in the accuracy of the data used in preparing the FIRMs. In limited instances, the ground elevations may have been determined by actual surveys, which of course is the most accurate data that could be available. The more common practice is that the ground elevations used in the preparation of the FIRMs are based on existing topographic data, which can be highly variable in accuracy. Some areas may be based on existing detailed topographic maps with 1- or 2-foot contours, while some areas may have only large-scale topographic maps available with the most detailed topographic information only being 50- to 100-foot contours.

Simulation of the physical process of flooding and delineation of the 1 percent annual chance floodplain for detailed riverine flood studies have traditionally been performed using steady flow computer models. Only a fraction of the output data available from these models has typically been utilized to establish the water surface profile and floodplain width, and ultimately used to map flood hazard zones. This section will examine if additional available output data, such as flow velocity and shear stress—as an indicator of erosion and sediment transport—could be utilized to refine hazards within floodplains. In coastal settings, flood damages to insured structures have often resulted from wave-cast debris and gravel from severe wave runup conditions. Efforts are currently underway to prepare guidance for delineating the 1 percent annual chance hazard zone with consideration for these processes.

The evolution in modeling technology can be cost effectively used to obtain additional data on the various physical processes of flooding. For example, FEMA's approval of unsteady flow and two-dimensional models in recent years can now provide information on the duration of flood stages, variation of flow direction and velocity within the floodplain, the effect of in-channel and floodplain storage, and the implications of cumulative effects of floodplain development over time. The shift to incorporating these newer models into GIS-based analyses under the Map Modernization program further increases the cost-effectiveness of their application; i.e., more definition of physical processes at work within the 1 percent annual chance floodplain can be obtained for a reasonable cost of performing the individual flood study.

Efforts have been made by many States and local governments in dealing with the inaccuracies of FIRMs that were initially prepared as communities entered the NFIP.
There are two primary categories that the majority of these efforts fall into: (1) updating of flood insurance studies and FIRMs and (2) utilization of additional requirements above the NFIP minimum requirements.

The most effective means of improving the hazards definition is to make the FIRMs as accurate as possible. In most instances this requires a complete restudy by using current, accurate hydrologic data and detailed accurate topography so the areal extent and elevations of the 1 percent chance flood are accurately depicted on updated FIRMs.

In *Floodplain Management 2003—State and Local Programs,* based on a survey conducted by the ASFPM in 2003, it was found that 25 States conduct the engineering studies needed for floodplain mapping, with 15 of these States producing floodplain maps either with their own staff or by contracting out with private firms to produce updated maps. Most States have the capability to produce maps in a GIS format, which can include multiple layers besides floodplain information, and with many of the States having orthophoto maps on GIS, which provides better data for locating land features than the standard FIRMs.

In addition to providing the basic information required for FIRMs, many States incorporate additional flood-related hazards on their State-generated floodplain maps. *Floodplain Management 2003—State and Local Programs* indicates that State-generated floodplain maps also show hazards such as ice jams, erosion, dam failure, alluvial fans, closed basin lakes, coastal erosion, riverine erosion, levee residual risk, mud flows, and barrier islands.

One specific way in which hazards within the 1 percent floodplain could be better defined is to associate risk to flood vulnerability. Flood vulnerability is defined as the effect of floods on the population at risk from varying return periods and other flood characteristics and variables

(Penning-Roswell and Tunstall 1996). Considerations for flood characteristics may include the following (Penning-Roswell and Fordham 1994):

1. Depth of flooding
2. Duration of flooding
3. Sediment concentration
4. Sediment size
5. Wave/wind action
6. Water flow velocity
7. Pollution load of floodwaters, and
8. Rate of water rise at the onset of flooding

Many variables (social/economic, property and infrastructure) contribute to flood vulnerability in addition to flood characteristics alone. Spatial interpretations of these variables with GIS may identify locations of relatively higher flood vulnerability, where increasing number of variables intersect, and guide decisions for where higher (or lower) standards may be appropriate.

The flood characteristics of flow depth and velocity have been used in combination to define flood severity. Flood severity can improve hazard definitions by identifying areas within the 1 percent floodplain that have relatively higher risk. Pierce County, Washington, regulates areas of "deep and/or fast flowing water" as a floodway, in addition to the regulatory floodway defined by FEMA (Pierce County Code 2005). The origins of this higher standard floodway appear to be linked to earlier work by the Bureau of Reclamation that established depth-velocity risk relationships for pedestrians that might be moving through the flow from a dam failure (Trieste 1988).

Flood hazard severity has been used in Australia since 1984 to guide floodplain development by relating flood risk to ease of evacuation (Government of New South Wales 1984). This site-specific flood parameter, together with flood-proofing and evacuation and other considerations, replaced a uniform 100-year flood standard previously used to assign risk (Penning-Roswell and Tunstall 1996).

The concept of flood severity has also recently been applied to coastal flood hazards through incorporation in the draft final FEMA guidelines for the Pacific Coast (FEMA 2005). In this case, the inland extent of the coastal high velocity zone (VE Zone) associated with wave overtopping is established where overflow depth times velocity squared equals or exceeds a threshold value of 200 cubic feet per second.

The Flood Map Modernization program initiated by FEMA in 1997 is intended to modernize the existing flood hazard maps, by digitizing the maps and increasing the accuracy wherever possible. Funding has been provided by Congress for the program for fiscal years 2003-2007, including funds to support State efforts under the Cooperating Technical Partners Program. It is expected that the total cost of the Map Modernization Program will exceed $1 billion by the time it is finished.

Some of the larger local governments that have a special interest in floodplain management also have developed updated floodplain maps for their area of jurisdiction. Many local governments also have GIS capability which would allow them to incorporate digitized FIRMs produced under the Flood Map Modernization program, as a layer into their local GIS.

The other primary method of improving the hazards definition is the incorporation of additional requirements at either the State or local level that exceed the NFIP minimum requirements. The most effective means of doing this is either through State law or regulations that would be applicable to all local governments participating in the NFIP. It should be noted that most communities that establish standards that exceed NFIP minimum requirements receive credit under the NFIP CRS.

In Appendix D of the ASFPM publication *Effective State Floodplain Management Programs 2003*, the following are some of the higher regulatory standards that have been adopted by either State or local governments in efforts to ensure a higher degree of protection than that provided by adopting the minimum NFIP standards:

- Freeboard of 1, 2, or 3 feet above the base flood elevation
- Foundation protection by required engineered designs
- Lower substantial improvement/damage threshold than the 50 percent per the NFIP
- Mapping all waterways, instead of only those shown on FIRMs
- Coastal A Zone requirements similar to V Zone requirements
- No rise (or less than 1-foot rise) floodway
- Compensatory storage to require removal of equivalent volume of fills
- Dry land access to ensure that buildings in floodplains have access
- Prohibition of all development/ residential structures in floodways
- Critical facilities limitation based on 500-year floodplain
- Setback requirements from mapped floodplains
- Cumulative substantial improvements that do not exceed the 50 percent threshold
- Minimum height above grade for areas not mapped as floodplains

12.1.3 Improve the Definition of the Floodway

The regulatory floodway is the portion of the 1 percent annual chance floodplain restricted from encroachment and typically encompasses the stream channel and adjacent floodplain areas where higher velocity flows occur. Many communities have augmented the regulatory floodway concept with other more restrictive hazard zones.

The existing standard definition of the term "floodway" as used in the NFIP regulations is "the channel of a river or other watercourse and the overbank areas adjacent to the channel that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot."

The floodway is the portion of the floodplain that carries the bulk of the floodwater downstream and is usually the area where water velocities and depths are the greatest and most destructive. Floodplain regulations typically require that the floodway be kept open so that flood flows are not obstructed or diverted onto other properties.

The typical cross-section of a floodplain shows a floodway which includes the normal channel and some overbank area, with a flood fringe area on either side of the floodway, which extends to the limits of the floodplain.

The outer limits of the floodway are determined during the Flood Insurance Study by modeling the streamflow for the base flood, by selecting multiple cross-section locations and encroaching on the outer limits of both sides of the floodplain to the point where the base flood elevation does not increase by more the 1 foot. A smooth curve is then drawn between these locations to delineate the floodway limits. This is for the FEMA minimum requirement of a maximum 1-foot rise floodway.

This typical method of establishing a floodway makes it allowable for levees to be constructed along the entire reach of the river at the outer limits of the floodway, for the entire flood fringe area of the floodplain to be filled, or for the entire flood fringe area to be developed for any type of residential or nonresidential development as long as minimum floor elevations and/or floodproofing requirements were met. Even though this method of establishing a floodway can result in increased flood levels, the current floodway does limit increases in flood stage that could increase damages to adjoining and upstream properties, in most instances keeps development out of the most hazardous parts of the floodplain and away from the river channel, and provides substantial protection to natural and beneficial floodplain values in that most floodways are left open. More restrictive floodway standards could provide a higher level of protection as well as providing the additional benefits of establishing a floodway

Much has been written about this FEMA minimum requirement which allows for as much as a 1-foot rise in the elevation of the base flood. Critics have two primary areas of concern with the FEMA minimum floodway requirements:

- Development is allowed within the floodplain instead of discouraged.
- Fills and/or other types of development that could be destructive of the natural and beneficial functions of floodplains are allowed.

In addition to these two primary areas of concern, which are more typically expressed by those who are not floodplain managers, concerns expressed by floodplain managers include:

- The allowable 1-foot rise above the base flood elevation results in buildings being constructed in accordance with the minimum elevation requirements that could have their floor levels be as much as 1 foot lower than the base flood elevation when the floodplain is fully developed.
- In some instances the deeper and faster flowing water is some distance away from the stream channel and outside the limits of the typical floodway.

Some States have been amenable to accepting other definitions of the term “floodway” by local governments that may have unique flooding characteristics for certain river systems in their jurisdictions. Any definitions of the term “floodway” that are different from the standard definition must result in regulation of development in floodplains which is at least as restrictive as the regulation of development would be using the standard definition to be approved by the State and FEMA.

An example of a required higher standard relating to floodways is in the State of Wisconsin, which has a zero-rise floodway requirement, instead of the FEMA minimum 1-foot rise requirement. Wisconsin has a program to remap all floodplains by showing a floodway that results in a zero rise in the level of the base flood if the entire fringe area is filled or levees are constructed at the location of the boundary line between the floodway and the fringe area for the entire length of the mapped floodplain. Only the portion of the floodplain that has no effective flow-carrying capacity is mapped as a fringe area. A zero-rise floodway results in a much larger floodway and less development in floodplains.

Some examples of other definitions for floodways that have been used are as follows:

- Something between a zero-rise and a 1-foot-rise floodway.
- Zero-rise analysis for individual projects proposed for construction in the floodplain.
- Deep and/or fast-flowing water areas, where the potential flood damage is high.
- Channel migration zones that include land that is higher in elevation than the base flood but subject to the natural erosion process.
- The “natural floodway” concept that conserves the portion of the floodplain most effective for flood flows.
- The “density floodway” concept that allows limited development throughout the less hazardous areas of the entire floodplain but limited to the amount that would not increase the base flood level by more than 1 foot.

12.1.4 Improve the Utilization of Existing NFIP Provisions

The NFIP currently provides numerous flood hazard zone designations to communicate flood hazards and assign risk premium rates for insurance purposes. Some of the zones, such as the flood-related erosion “E Zone” and the coastal shallow water “VO Zone,” have found little use to date in hazard mapping. Given the NFIP definition of flooding to include the collapse or subsidence of land from erosion, it would seem to be appropriate to evaluate if clarifying areas of erosion within the 1 percent annual chance floodplain using the E Zone can provide an increased level of protection. New guidelines underway for coastal flood studies may better define the use and application of the VO Zone in coastal settings.

Hazard zones define flood risk and associated actuarial premium rates for insurance. Accordingly, FEMA’s general counsel has advised that these risks must be based on existing conditions.

New FEMA initiatives now allow NFIP communities to exceed the minimum 1 percent annual chance standard by defining and mapping an overlay to the traditional flood map that accounts for more speculative risks from future land use hydrology and future riverine erosion. Similarly, future flood risks from relative sea level rise are being considered in coastal flood insurance studies. The use of a GIS environment for DFIRM production will enable NFIP communities to develop and use these land use planning maps together with the more traditional insurance products in creative ways to further improve the interpretation and use of the 1 percent annual chance standard.

Accurate and updated mapping of the risk associated with flooding is paramount to conveying the true hazard associated with occupying floodplain areas. With updated techniques available for determining the hydrology and hydraulics associated with the 1 percent chance flood event, more accurate techniques for determining existing ground elevations, and more sophisticated modeling and mapping technologies than when the initial FEMA Flood Insurance Rate Maps (FIRMs) were developed, updates of FIRMs are essential for local communities.

In addition to using updated information for revising FIRMs, State and local governments are incorporating other technologies to more accurately depict the potential flood hazard. One of the more common means is the mapping of an erosion hazard zone for riverine or coastal hazard areas. *Floodplain Management 2003—State and Local Programs* indicates that seven States have maps that include high-risk erosion areas. In the State of Washington, several counties have mapped erosion hazards for certain reaches of rivers subject to potential erosion. Pierce County, Washington for example, has adopted into its local ordinance a provision that includes channel migration zones as designated regulatory floodways, meaning that these erosion hazard areas have the same restrictions as the typical regulatory floodway.

Many State and local governments have adopted more restrictive standards and/or improved definitions that exceed the FEMA minimum requirements by conducting their own State floodplain mapping program. The following information about State floodplain mapping is taken from the ASFPM publication *Floodplain Management 2003—State and Local Programs*:

- 24 States have floodplain mapping included in a Statewide mapping effort
- State budgets for floodplain mapping range from zero to $32 million in North Carolina
- 25 States conduct the engineering studies required for floodplain mapping
- 15 of these 25 States produce their own floodplain maps
- 34 States have their floodplain maps in a Geographic Information System (GIS), with 25 States sharing their GIS data with communities that have GIS capability
- 3 States have their floodplain maps on a website
- 1 State has floodplain maps showing ice jams
- 7 States have floodplain maps showing high-risk erosion areas
- 8 States have floodplain maps showing dam failures
- 3 States have floodplain maps showing alluvial fans
- 6 States have floodplain maps showing coastal erosion

12.1.5 Other Approaches

No Adverse Impact

In 2001, due to continued increases in flood damages despite the best efforts of many agencies and individuals, including those involved with the administration of the NFIP, the ASFPM initiated discussions of a concept described as No Adverse Impact (NAI) floodplain management. In essence, NAI floodplain management is an approach that ensures the action of any community or property owner, public or private, does not adversely impact the property or rights of others. This can be measured by no increases in flood peaks, flood stage, flood velocity, or erosion and sedimentation. NAI floodplain management extends beyond the limits of the floodplain to include managing development in the watersheds where the floodwaters originate.

The ASFPM has developed several publications relating to NAI that are shown on the ASFPM website. Some of the key publications are:

- *No Adverse Impact: A New Direction in Floodplain Management Policy*, Larson and Plasencia, June 18, 2001
- *A Common Sense Strategy to Protect Your Property,* June 2001
- *No Adverse Impact Status Report: Helping Communities Implement NAI*, June 2002
- *NO ADVERSE IMPACT: A Toolkit for Common Sense Floodplain Management*, 2003
- *Community Liability and Property Rights,* May 2003
- *NAI White Paper—No Adverse Impact Floodplain Management*, April 29, 2004

The ASFPM continues to promote the concept and principles associated with NAI, including additional publications, as well as having NAI as one of the tracks for papers presented each year at the ASFPM annual conference.

The principles of NAI are directed toward local governments that are responsible for administration of local floodplain management programs. The Toolkit, published by ASFPM in 2003, offers examples of means of implementing NAI for local communities. These tools are organized under the following seven "building blocks":

- Hazard identification and floodplain mapping
- Education and outreach
- Planning
- Regulations and development standards
- Mitigation
- Infrastructure
- Emergency services

For each of the identified building blocks, the Toolkit contains a description of three levels of implementation: Basic, which is the NFIP minimum requirements; Better, which is a higher level of additional requirements for reducing flood damages; and NAI, which is considered to be the highest level of implementation, which results in No Adverse Impact to others.

Implementing the provisions of NAI by local governments is an entirely voluntary program and is not associated in any way with the minimum requirements of the NFIP but is a means of building off of the NFIP minimum requirements to reduce flooding and the damages to life and property associated with flooding.

Community Rating System

The Community Rating System (CRS) and NAI go hand in hand in that additional efforts to reduce flood damages to implement NAI floodplain management are generally eligible for credit under the CRS program.

As indicated in the previous chapter, the CRS provides credits to local governments for implementing activities that can result in a reduction in flood damages. It is designed to encourage communities to implement floodplain management programs above and beyond the minimum NFIP criteria. This is done by scoring the community's activities according to formulas that measure their impact on flood losses and insurance rating. The higher the amount of eligible activities that a local community is participating in, the greater the amount of reduction in flood insurance premium rates that can be achieved. A reduction in flood insurance premiums from 5 to 45 percent, for a CRS Class 9 to a CRS Class 1, respectively, can be achieved depending on the CRS activities that a local community is participating in.

The four general categories of the 18 CRS activities that are eligible for receiving credit points are as follows:

- Public information activities
- Mapping and regulatory activities
- Flood damage reduction activities
- Flood preparedness activities

In addition to reducing flooding damages in their community, local governments that are participating in the NFIP and elect to participate in the CRS program and implement many of the CRS-eligible activities receive the added benefit for the NFIP policyholders in their community of making them eligible for reduced flood insurance premiums.

Of the approximately 20,000 local communities participating in the NFIP, there only about 1,000 have elected to participate in the CRS. There is a great deal of opportunity for additional communities to join the program. Additionally, many of the communities that are participating in the CRS Program have implemented only enough activities to place them at the lower levels, such as a Class 7, 8, or 9, so there is a potential for these communities to improve their CRS class level.

Within the context of the NFIP and the 1 percent standard there is recognition on the part of FEMA that encouraging State and local actions to exceed the one-percent standard or other program minimums is in the interest of the program and is an underlying premise of the CRS program. The direct beneficiaries of the CRS program are the individual policy holders who receive a premium reduction, and the flood fund that should experience fewer payout demands due to the programs and initiatives of State and local government. Indirectly the Nation as well as State and local governments benefit because these actions reduce the need to respond to disasters.

12.2 Observations

Improved use of the current 1 percent standard is certainly feasible, and several actions can be taken to carry out these improvements.

Improving public understanding:

- Examine closely the use of the terms “100-year flood” “1 percent annual chance flood,” and other descriptors to determine which would be the most effective.
- Focus on training for local officials. This training has received most of the focus to date by FEMA and State NFIP coordinating agencies. Local officials continue to be the most important segment of the “public” in improving public understanding.

Improving hazard definitions:

- Utilize existing available hydrologic and topographic data and updated technology in revising flood insurance studies and firms under the Map Mod Program.
- Incorporate additional standards beyond the FEMA minimum requirements at State and local levels, such as freeboard, zero-rise floodways, compensatory storage for fills in fringe areas, etc., to offset inaccuracies in existing FIRMs.
- Improve the definition of the floodway.
    - Use a floodway definition of less than 1-foot rise.
    - Include deep and fast-flowing areas in the floodway definition.
    - Include channel migration zones in the floodway definition.
    - Use a “density floodway” where appropriate.

Improving CRS

- Conduct a benefit-cost analysis of every activity in CRS to determine if the standards should be revised. The CRS may prove to be a good "laboratory" to examine actions that benefit the goals of the NFIP as well as the goals of the Nation that could lead FEMA and other agencies to develop incentives that would accrue to local or State governments as part of future cost sharing for disaster programs or for programs of flood mitigation.
- Examine the potential reduction in disaster costs that might take place by incentivizing communities through use of the CRS standards.

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13. ADEQUACY OF THE 1 PERCENT STANDARD

This chapter summarizes the material reviewed in the earlier chapters, identifies the most salient information and its influence on determination of the adequacy of the 1 percent standard, and provides the conclusions and recommendations of the WPC team. As indicated in Chapter 1, the assessment of the adequacy of the current standard is based on how well the standard assists the NFIP in meeting the goals established for it through relevant legislation and derived missions: decreasing the risk of flood losses; reducing the costs and adverse consequences of flooding; reducing demands and expectations for Federal disaster assistance after floods; and restoring and preserving the natural and beneficial values of floodplains. Since successful implementation of the NFIP relies on the cooperation of States and communities, the assessment also considers the balance between Federal administration and State and local needs and responsibilities for some control over the implementation of the NFIP.

13.1 Getting to a Standard

13.1.1 Background

Nearly 40 years experience has clearly demonstrated that the NFIP cannot satisfy concurrently all of the interests of the many stakeholders that live and work within the floodplain. Many States and communities use the NFIP as a starting point for their floodplain management, imposing higher standards where they feel such actions are needed to deal with local conditions. There are variations in the manner in which states manage their floodplains and support the NFIP (Mittler et al. 2006). These modifications to the Federal requirements deal with flood elevations, including such items as freeboard for levees, higher first-floor elevations for structures, and myriad other special requirements reflecting the particular needs of the State or community. California is considering raising the use of the 1 percent standard to a 0.5 percent standard and requiring insurance behind levees with protection less than 0.5 percent. At the Gilbert White Forum, Dr. White indicated that the proposal for a 1 percent national standard was made with the understanding that the regulations would provide for deviations from the standard to meet local conditions.

It is also clear that conditions in floodplains differ from one location to another across the expanse of this Nation. Some floodplains are subject to flash floods or fast-rising floodwaters. Others face floods that arrive slowly and can be forecast days or even weeks in advance. Floods in West Virginia are not the same as floods in Arizona. In some areas the difference between the 1 percent flood and the 0.2 percent flood is a matter of inches and the areal extent of the 0.2 percent floodplain is only slightly larger than the 1 percent floodplain. In other cases, the vertical difference may be a matter of feet and the difference in areal extent may be measured in hundreds of acres. NFIP claims and losses are concentrated in a few States. Over the full history of the NFIP, losses due to both riverine floods and hurricane events have been concentrated in Texas, Florida, and Louisiana, whereas nonhurricane losses have been concentrated in Texas and Louisiana. Repetitive losses are also concentrated in a few States, with Louisiana, Texas, Missouri, and New Jersey at the top.

Over the history of the NFIP, the 1 percent standard has applied equally to the regulation of land use in floodplains, the requirements for insurance, and recognition of levees for inclusion in the program. But is this necessary? Regulation, insurance, and recognition of levees contribute in different ways to achievement of the goals of the NFIP.

13.1.2 Meeting the Goals of the NFIP

Meeting the goals of the NFIP will require the development of a new mindset with respect to the 1 percent national standard. As previously discussed, the 1 percent standard is an "elegant abstract concept." It represents an agreement by decision makers and their professional staffs to employ, in regulation of floodplain activity and establishment of insurance risk levels under the NFIP, an arbitrarily selected recurrence interval and carefully derived methodologies for determining the resulting elevations for floods that may take place across the Nation. As the program got underway, it was useful to have a single national standard for administrative and political reasons. Over time, this single standard has been accepted in this country and in many other countries. The current use of this single standard does not mean that one standard should govern all floodplain management activities. Given topographic, meteorological, and land use differences across the country, variations in the standard would seem logical. Because the Federal government operates the insurance program and provides the majority of the assistance following a flood disaster, it has both an obligation and a right to establish minimum standards and to expect, in return, that States and communities will take actions to raise the standards where they believe higher standards are needed.

13.2 Factors to Be Considered

This report and the work of the Forum identified many factors that should be considered in assessment of the adequacy of the current 1 percent standard.

13.2.1 The 1 Percent Standard

- In the initial implementation of the NFIP, the 1 percent standard set a baseline for land use regulation and insurance. As pointed out at the Forum, the 1 percent standard was never seen as the optimal standard; rather, it was one that could be agreed to by decision makers and the people who would be affected by its implementation. The 1 percent standard was to provide a point of departure for adjustments that could reflect the differences that might exist in floodplains across the country and in the objectives of the States and localities that would implement the standard.

- The 1 percent standard has become an accepted standard and a departure point for land use regulation in floodplains. It has also been accepted as a reasonable level for imposition of mandatory insurance requirements.

- Because of uncertainties in hydrology and hydraulics, the elevation of the 1 percent flood is a statistical construct that identifies one elevation from among many possible elevations within a statistical distribution. The "real" elevation may be higher or lower than the elevation selected. Determination of the elevation of the 1 percent flood is made more difficult by limited historical records in the United States, the age of the weather documents, and changing hydrological conditions within river basins or along shorelines. These factors reduce the utility of the standard as an accurate measure of risk. The myriad factors involved in flood frequency determination and topographic measurement also make it difficult to ascribe to a flood map the accuracy that is frequently presumed by floodplain residents who see the 1 percent line as a commitment to a given elevation and to a line on the map. Someone above that elevation or outside that line cannot be guaranteed to be safe from the 1 percent flood.

- Statistically, there is a 26 percent chance of a 1 percent flood occurring during the lifetime of a 30 year mortgage. There is a 6 percent chance of a 0.2 percent flood during the same period.

13.2.2 The 1 Percent Standard in Practice

- A 1 percent threshold focuses attention on one level of risk and ignores higher risks. Over time, the Nation has moved from an approach that emphasized careful evaluation of risk and provision of appropriate mitigation for that risk to an approach that fosters achievement of the minimum requirements of the NFIP in order to minimize local costs and avoid mandatory insurance requirements and eliminate floodplain land use management requirements.

- NFIP claims data through 2004 suggest that, in flood-prone areas, the Nation is building to near a 1 percent standard. Since initiation of the NFIP and the issuance of flood maps, the rate of claims per policy on new construction (post-FIRM) and dollar losses per insured value are lower than 1 percent for those who are insured within the 1 percent flood zone, indicating the relative effectiveness of some land use regulation and building codes in the SFHA.

- Although there is a paucity of data to either support or reject the assertion, floodplain managers indicated that having a regulated floodplain has slowed development in the 1 percent floodplain and improved management.

- The technology of high-resolution remote sensors and the power of 21st century computing platforms are enabling the rapid and inexpensive determination of the near precise, three-dimensional coordinates of floodplain structures. This in turn will permit structure-by-structure rating of the flood risk faced by structures in floodplains.

- Having any reasonable standard assists in the reduction of risks from flood damage. Unfortunately, the absolute nature of a strict standard, the 1 percent standard, when combined with the NED objective of Federal *Principles and Guidelines* creates the potential for significant damages to occur when this standard is exceeded.

13.2.3 Implementation of the 1 Percent Standard

- Implementation of the 1 percent standard across the Nation varies considerably by State and community, and as a result the effectiveness of the NFIP varies. The CRS has moved many communities to improve their implementation in order to reduce insurance rates for their citizens. The floodplain management programs in place today are designed primarily to regulate for flood events up to and including the existing condition 1 percent flood stage and are linked, in most cases, to NFIP regulatory minimums. Stronger State-level floodplain management programs may result in decreased damages per capita.

- Improvements to the implementation of the 1 percent standard could make that standard more effective. These improvements could include

    - Use of future-conditions hydrology.
    - Improvement of public understanding of the minimum standard.
    - Improvement of hazard definitions within the 1 percent annual chance floodplain.
    - Improvement of the definitions of the floodway.
    - Improvement in the utilization of existing NFIP provisions and new initiatives.

13.2.4 Development in the 0.2 Percent Floodplain

- Insured properties outside the 1 percent floodplain today tend to represent an adverse selection of those at risk. They are few in number compared to the total at risk outside the 1 percent floodplain and are more at risk than average. Thus, the premiums for these policies may not be actuarially priced.

- Delineation of the 1 percent floodplain has led to an apparent development of the area just outside the 1 percent floodplain (to avoid falling under floodplain regulation), as well as to a class of structures that are elevated to the 1 percent flood levels creating a significant exposure for floods in the 1 percent to 0.2 percent zone.

- The potential damage to property in the 0.2 percent floodplain may be more than twice as much as in the 1 percent floodplain. Since the majority of these structures are not insured, the potential costs of uncompensated losses and Federal assistance costs are extremely large.

    - According to information developed from USACE reports, the damages that can occur in the riverine 1 percent to 0.2 percent zone average 2.24 times the damages that occur within the 1 percent zone. Damages in the 1 to 0.5 percent zone are 1.48 times as large as in the 1 percent zone.

    - FEMA claims data also suggests that there is considerable property at risk outside the 1 percent zone, since about one-third of claims and losses accrue from properties other than those in the 1 percent zone.

  - FEMA’s HAZUS model runs indicate that the risk to property outside the 1 percent zone is substantial. Damages in the zone between the 1 percent and 0.2 percent flood lines are estimated to be 1.5 times larger than those within the 1 percent zone.

- Analysis of data collected by the University Corporation for Atmospheric Research (UCAR) indicates that approximately 33 percent of flood damages occur as a result of floods larger than the 1 percent event. While some of these damages can be attributed to losses in the 1 percent zone as a result of the increased flood height, the bulk likely occurs in the zone between the 1 and 0.2 percent flood lines.

13.2.5 Recognition of Levees

- Studies within the Federal government and by outside agencies over the past 30 years have indicated that urbanized areas should be protected by levees and other structures to levels higher than 1 percent, with most recommending 0.2 percent, Standard Project Flood protection, or higher. They also have indicated that the 1 percent standard is too low for removing an area from mandatory insurance requirements. Standards applied in many foreign countries provide for a higher level of levee protection for urban areas, with the Dutch and Japanese providing 0.001 percent (10,000-year) protection against coastal attacks and between 0.5 percent (200-year) and 0.0.05 percent (2,000-year) for river protection.

- The residual risks to those protected by a levee are not understood by those at risk and the public at large. The residual risk behind levees creates a large disaster assistance and recovery exposure for the Federal government. The Federal government pays for the protection and when it is compromised supports the recovery of individuals who were at risk yet did not purchase insurance to mitigate this risk.

- As illustrated by Hurricane Katrina’s impact on New Orleans, the consequences of levee overtopping or failure on the land side can be catastrophic. The residual risk that exists for those who are protected by levees and the binary nature of the protection that levees provide create a major challenge for the NFIP. If a levee is properly designed, constructed, and maintained, it should provide protection to the design height. When a flood exceeds the design height, the levee is overtopped by the flowing waters and may begin to erode and fail.

13.2.6 Impacts of Changes in Standards

- The costs of affecting any change in the current standard would be significant and would cut across the public and private sectors, but the costs are likely far less than the potential costs of additional disasters such as New Orleans. The impacts of change can be mitigated through phased implementation.

- Changes in the standard that tightens control over the floodplain and that concurrently heightens awareness of the residual risk to those in floodplains should result, *eventually,* in a reduction in individual flood losses, payouts from the NFIP, and disaster assistance expenses through gradual decrease in floodplain occupance and increased participation in the insurance program.

13.2.7 Critical Facilities

- Executive Order 11988 requires Federal agencies to, at a minimum, use the 1 percent floodplain in evaluation of the efficacy of government actions. For construction of critical facilities to include access routes to and from the critical facilities, agencies must use the 0.2 percent flood. States vary in their treatment of critical facilities, which generally include emergency operations centers, disaster shelters, schools, fire and emergency medical stations, hospitals, water and wastewater treatment plants, power facilities, and community buildings that are occupied by important public services.

13.2.8 Natural and Beneficial Functions

- A derived goal of the NFIP is to support the conservation and management of natural and beneficial functions within the floodplain. Action toward meeting the goal has been limited. The intent of the goal appears to have become lost as well-intended efforts by State and local NFIP entities and FEMA staff have been hindered by the conflicts inherent in implementing the NFIP.

- The floodplain defined by the 1 percent standard has no scientific connection to the natural and beneficial functions of floodplains. However, the area contained within the 1 percent floodplain typically encompasses the land within which most of these functions occur and thus merits attention.

- The 1 percent standard and many supporting NFIP regulations were designed to strike a balance between promoting economic growth and preventing flood damages in the development of floodplains; however, this perceived balance may be significantly different if the economic value of the natural and beneficial functions of floodplains is considered.

- Within the 1 percent floodplain, current regulations allow development in the outer flood fringe area and restrict development in the regulatory floodway that encompasses the stream channel. These allowable activities in the flood fringe and floodway are governed by methods and assumptions that have inherent flaws and have become outdated over time. This is resulting in continued disruption of natural terrain and vegetation, often impacting some of the highest-quality natural and beneficial functions of floodplains.

13.3 Conclusions

The 1 percent standard was developed to define an area in the floodplain where the Federal government believed it was necessary to control development. It also was to identify the zone in which a substantial number of individuals were at risk and should be required to purchase flood insurance. Both of these actions were focused on mitigating the impact of floods on floodplain residents, reducing the need for post-flood Federal assistance, and reducing future flood damages by limiting unwise development in floodplains. History has shown that implementation of the standard has varied considerably by location and local support, and this implementation is not as effective as it could be. The net result is that the risk to those in floodplains now extends far beyond the 1 percent floodplain, and the exposure of individuals and the government to significant losses has grown as a result.

The 1 percent standard, as currently applied, is inadequate, and as a result it is not contributing effectively to accomplishment of the goals of the NFIP. The standard is not being effectively implemented for land use regulation and, for insurance purposes, is too low to properly address the significant flood risk exposure faced by the Nation.

A properly implemented 1 percent standard would provide a reasonable baseline for NFIP-based regulation of land use in the SFHA across the Nation.

States and their communities have a responsibility to implement higher standards where local conditions threaten the health and safety of floodplain residents.

Several officials active in floodplain management at the Federal and State levels, expressed concern that some of the actions of the Federal government seemingly reward States that do not have effective programs governing the floodplains in their jurisdictions. A State or a community that has taken action to keep people out of the floodplain is given far less support by the Federal government than communities that seek funds to provide flood protection structures for those who want to remain in floodplains and subject to residual risk. For many years, reports have highlighted the challenge of dealing with repetitive losses. States and communities that do not closely regulate activity in floodplains and subsequently are hard hit by floods are given large sums by the Federal government to recover from those losses. States and communities that establish setback lines, limit riverine actions that cause flood heights to rise, or restrict coastal occupancy suffer far less and yet receive little reward from the Federal government for their avoidance of the disasters. Pro-active states and communities suggest that FEMA, as recommended in Chapter 12, should closely examine the entire structure of payments and incentives to see that these incentives properly support those who are taking action and, if not, penalize or limit the support to those who do not.

The NFIP seeks to provide insurance for those at risk in floodplains and to reduce the amount of Federal disaster assistance required following a major flood. Given the exposure that exists in the 1 to 0.2 percent zone, leaving the standard at the 1 percent level would not permit

NFIP to meet its goals of insuring those at most risk and reducing the potential impacts of major floods on the Federal government.

Requiring insurance to the 1 percent standard does not provide for coverage of the significant amount of property at risk in the area outside the 1 percent but within the 0.2 percent (500-year) floodplain.

Levees do not provide full protection to those behind them. They reduce but do not eliminate the risk. Levees can and are frequently overtopped and may be subject to failure as illustrated in New Orleans. The residual risk of failure creates a safety and property loss hazard for those in the area and a significant exposure for the government in terms of the required assistance in the event of a levee failure. Those living behind levees do not seek flood insurance because they do not recognize the risk and, should a levee fail, they will have contributed nothing to the mitigation of the resultant damage.

The 1 percent standard is too low for removal of NFIP land use and insurance requirements for population centers behind levees. A 1 percent standard does not adequately take into account the residual risk behind levees.

While Federal agencies are required to locate critical facilities outside the 0.2 percent floodplain when such an action is feasible, many State and local agencies, businesses, and other private organizations protect their critical facilities to only the 1 percent level, placing them at considerable risk during major flood events.

The 1 percent standard is not an appropriate standard for siting critical facilities.

Technical reports have not been updated, and stream gaging data collection has been reduced. Levee designs and flood risk determinations may not reflect current conditions and, as a result, could increase the risk to those behind levees and in the floodplain. Collection of flood data by NOAA is not adequately supported, and information in the FEMA claims and policy databases is incomplete.

Much of the baseline information, on which current determinations of the height of the 1 percent flood (and all other floods) are made, is out of date and data collected about flood events is inadequate to support analysis of loss reduction strategies.

The 1 percent floodplain identifies areas containing much of the Nation's important riverine habitat and the ecosystems that depend on that habitat. Influencing the wise use of that land through NFIP actions provides strong support for the NFIP goal of restoring and preserving the natural and beneficial values of floodplains. The NFIP lags behind other Federal and State programs in supporting effective and innovative management of floodplain ecosystems. The NFIP goal of supporting the protection of the natural and beneficial functions of floodplains has not been realized and is far from being a success.

The NFIP goal of supporting the protection of the natural and beneficial functions of floodplains is closely tied to the 1 percent floodplains but is not being effectively pursued.

13.4 Recommendations

The NFIP is an important tool in the battle against flood losses and disruption of the lives of those who live and work in floodplains. The standards established for regulation of land use and for mandatory purchase of flood insurance help define the effectiveness of the NFIP. As indicated earlier, there are problems with the use of the 1 percent standard to control land use, designate areas where insurance should be required, establish an accreditation level for levee protection, define safe areas for critical facilities, and assist in the protection and enhancement of the natural and beneficial functions of floodplains. The WPC recommends that:

- *Recommendation 1 (R1). If it can be more effectively implemented, FEMA should retain the 1 percent annual chance flood as the Federal standard for regulation of activity in the SFHA.* The Nation needs to have a common standard for Federally imposed land use restrictions. The 1 percent standard has changed the nature and, to a degree, the occupancy of the 1 percent floodplain.

- *R2. FEMA should take action to improve implementation of the 1 percent standard for regulation of land use***.** Such actions as enhancement of public understanding of hazards, use of future-conditions hydrology to account for urbanization and climate change, reduction of floodway infringements, and greater attention to enforcement of existing NFIP provisions would greatly improve the effectiveness of NFIP-related land use decisions.

- *R3. States and their communities should exercise their responsibility to impose higher standards, where the health and safety of the population merit a higher standard for land use regulation. Concurrently, FEMA should examine the use of incentives, possibly through use of the Community Rating System***,** *to reward States that exercise these responsibilities.* Imposition of higher standards is well within the purview of the States and the communities that lie within the States and that receive their land use authorities from the States.

- *R4. FEMA should seek legislative authority to require mandatory purchase of flood insurance by those living in the 0.2 percent floodplain* if they hold a Federally insured mortgage or if they are to receive any disaster assistance from the Federal government in the case of a flood. The cost of this insurance should be determined actuarially, based on the reduced risk of living at a specific elevation within the 0.2 percent floodplain.

- *R5. FEMA should not recognize levees under the NFIP unless they provide protection to the 0.2 percent (500-year flood) level.* Levees in nonurban areas should protect against the 1 percent or larger flood, depending on the economic costs and benefits of the levee. Levees are subject to failure and overtopping and, when such compromises occur, the results are disastrous. For nearly 30 years, program officials have urged that levees be required to provide more protection than offered by a 1 percent levee. Communities with levees providing less than 0.2 percent protection should be given a reasonable period to bring their levees to the new standard. The NFIP recognition of 1 percent rural levees should be suspended when development that will create new population centers is initiated behind these levees. In the face of development, recognition should be suspended until these levees are improved to meet the 0.2 percent standard.

- *R6. FEMA should seek legislative authority to require mandatory purchase of flood insurance by those living behind accredited levees to address the residual risks they face and to ensure they are aware of this risk.* Structures behind levees are subject to residual risks and should be insured against that risk. The Federal government is exposed to the possibility of dealing with catastrophic damages that would arise from a 0.2 percent flood. Those at risk bear some responsibility for covering the potential costs of flooding. Technology now permits higher resolution identification of the specific risks faced by structures in floodplains, and rates in this new zone could be set accordingly. Expanding insurance coverage to the 0.2 percent floodplain would also increase the awareness of those in that zone of the risks that they face.

- *R7. FEMA should ensure that NFIP guidance and program activities clearly indicate that critical facilities should be located outside the 0.2 percent floodplain.*

- *R8. FEMA should improve the collection of policy and claims data to assist in ongoing evaluation efforts, and should actively support Federal funding of NOAA efforts to upgrade precipitation frequency estimates and flood data collection and USGS efforts to upgrade its stream gaging program. The accuracy of the Federal flood data is no better than the baseline information from which the data are derived.*

- *R9. FEMA should ensure that consideration of the natural and beneficial functions of floodplains is fully integrated into all aspects of FEMA and NFIP actions influencing floodplain activity.* The 1 percent standard delineates a critical segment of the riverine natural environment. Within this zone are areas that do or could provide to society the natural and beneficial functions of the floodplain. FEMA has actively studied those actions that it could take under the NFIP to enhance the quality of these functions but has limited success in implementing these measures. As it moves to the future, it must move from planning to implementation and see the realization of what has long been recommended to it.

13.5 A Final Comment—Communicating the Risk

As discussed in Chapter 3, use of the 1 percent terminology to describe the national standard appears to be of marginal utility. The 1 percent terminology is understood but not necessarily supported by the floodplain management community. It is certainly not in more common use by government officials, the media, or the public, and nearly two decades of work to enshrine the terminology has had little success. If the risk is going to be communicated more effectively, something needs to be done. The WPC team believes that FEMA should undertake a thorough analysis of the use of the percentage chance of occurrence as the basis for expressing the national standard for the NFIP to determine if a more effective approach can be developed. Until such time that a risk communication strategy is developed and accepted, FEMA should consider returning to the 100-year terminology for public communications.

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15. ACRONYMS

BFE	Base Flood Elevation (1-percent-annual-chance) flood
CBRA	Coastal Barrier Resources Act
CFM	Certified Floodplain Manager
CFR	Code of Federal Regulations
CID	CIS community identification number
CIF	Contracts in Force
CRA	California Resources Agency
CRS	Community Rating System
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DOC	Department of Commerce
DOI	Department of Interior
FEAT	Flood Emergency Action Team
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration
FICO	Flood Insurance Claims Office
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
44 CFR 65.10	Title 44, Section 65.10, Code of Federal Regulations
GIS	Geographic Information System
GPS	Global positioning system
IFMRC	Interagency Floodplain Management Review Committee
LOMC	Letter of Map Change
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision based on Fill
NAI	No Adverse Impact
NEMIS	National Emergency Management Information System
NFIP	National Flood Insurance Program
NGS	National Geodetic Survey
NMFS	National Marine and Fisheries Service
NOAA	National Oceanic and Atmospheric Association
NWI	National Wetland Inventory
SFH	Single Family Home
SFHA	Special Flood Hazard Area
SLG	State and Local Guide (FEMA)
SPF	Standard Project Flood
UMES	University of Maryland, Eastern Shore
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

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APPENDICES

Appendix 1. Executive Summary, National Flood Policy Forum

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Report of the 2004 Assembly of the Gilbert F. White National Flood Policy Forum
Executive Summary

The 1% annual chance flood standard has been used for nearly a century as the basis for many structural and nonstructural floodplain management approaches. It is widely supported and thoroughly institutionalized as the foundation for these efforts throughout Federal, State, and local government in the United States, and is also used extensively abroad.

However, the effectiveness of the standard in helping to bring about sensible use of floodprone lands, minimize losses, and protect resources has never been thoroughly evaluated. This is so in spite of regularly expressed concerns about the adequacy and appropriateness of the 1% chance flood standard, and in the face of indicators that there may be a better approach:

- Floods appear to be getting bigger and causing more damage than anticipated. Nationwide flood losses continue to rise.
- The expected flood depths and the extent of flood reach as depicted on maps are regularly demonstrated to be inadequate in specific situations.
- Numerous localities use a higher level of protection than the 1% chance standard, add margins of error, and apply tighter land use restrictions in order to reduce their flood losses.
- Advanced technology, modeling, and computing capabilities call into question the wisdom of clinging to a standard designed in an earlier era.

To examine the usefulness of the 1% standard, therefore, the ASFPM Foundation convened a group of about 75 experts in floodplain management at the first Assembly of the Gilbert F. White National Flood Policy Forum in September 2004. They considered the standard's applicability in increasingly complex situations, whether today's science can provide a better approach, and what counterproductive impacts may have ensued during the years of the standard's implementation.

The Forum concluded that the 1% chance flood standard, although in hindsight perhaps not a perfect choice, has nevertheless stood the test of many decades of use in a varied and changing Nation. Determined efforts have been made at all levels and sectors to implement the standard and associated practices and, not surprisingly, these have met with varying degrees of success, depending on the circumstances. There are areas in which specific scientific and technical knowledge are still lacking, and filling those gaps could help improve implementation. Forum participants also observed that the Nation has changed and grown rapidly and that in some ways it has not been possible for the policies and practices associated with the 1% standard to keep pace.

The Forum noted positive results from use of the 1% chance standard; some apparent shortcomings in the standard and its use; and some broad approaches and specific actions that could be taken to help address deficiencies in floodplain management.

Encouraging Outcomes from Use of the 1% Standard and Associated Practices

- The single, prescriptive standard has satisfied our social needs for uniformity, administrative ease, and a baseline for equity.
- In 20,000 communities, flood hazards are being managed. There are 4.5 million flood insurance policies in force (covering an estimated 40–55% of floodprone structures nationwide).
- Within the mapped 1% annual chance flood area, homes and other buildings constructed since regulations began are safer and in post-disaster surveys have been found to sustain less damage.
- As an unanticipated benefit of the decision to manage development in the 1% chance floodplain (and restrict development in the floodway), tens of thousands of acres of riparian land have been protected and their resources thereby preserved.
- The 1% annual chance standard is well institutionalized, supported by a body of case law, and integrated into Federal, State, and local floodplain management initiatives. While there is support to reduce annual flood losses (currently about $6 billion), there is no overwhelming cry for reform of the 1% annual chance flood standard itself or the framework that has been established around it.
- Technological advances made in communications, cartography, computing, modeling, and other fields have enhanced and simplified many aspects of floodplain management, especially mapping and information dissemination.
- Costs for flood protection, flood damage, and flood disasters are being spread more widely among States, localities, individuals, and the Federal government.
- About 1,000 communities, representing about 2/3 of the flood policy base nationwide, are going beyond the minimum requirements of the NFIP, as evidenced by their participation in the Community Rating System. Many of them are exceeding the 1% standard in some way.

Shortfalls in the 1% Standard Approach

- As noted above, flood losses are rising, perhaps for reasons related to the 1% annual chance standard.
- Because of the standard, in many parts of the country development has tended to cluster just outside of the 1% floodplain boundary, an area not free from flood risk and possibly subject to considerable risk now that watersheds have been urbanized and runoff thereby increased.
- Natural floodplain resources and functions are ignored in the delineation of the 1% chance floodplain, so their protection is a hit-or-miss proposition within the

existing framework.
• There is a "gray area" of uncertainty surrounding the calculation and the mapped floodprone zone, resulting from inadequate data, lack of consideration of changing and future conditions within watersheds, and oversimplified assumptions. Because of this uncertainty, there is considerable doubt whether management practices are actually being applied to the entire 1% floodplain.
• The 1% annual chance standard has not lent itself to ready integration with water related programs based on other types of standards, such as those for water quality or resource management.
• As a means of communicating flood risk, the 1% chance floodplain has been problematic. Both the concept and terminology are confusing and inaccuracies have undermined the credibility of the maps and the program operations.
• The "in or out" nature of the prescriptive standard too often triggers misunderstanding, denial of the flood risk, or attempts to have a property "removed" from the 1% floodplain.
• The 1% annual chance standard is inadequate when applied to levees, considering the potentially disastrous impacts associated with failure of those structures.

Action Needed

Options

Forum participants discussed an array of approaches to remedy noted deficiencies in floodplain management related to the 1% standard. Those approaches centered on the six options listed below. The Forum did not recommend any one option, although it was noted that nothing should stand in the way of improving the existing approach (the second option, below) even if more dramatic changes are made later. The options are listed from least amount of change to most.

1. Bring the 1% Standard Approach up to the 1% Standard. This would require an investigation of the level of protection that is actually being used on the ground (many experts suspect it is often actually much lower than the 1% standard). Based on those findings, a decision would be made whether to adopt that standard or make appropriate corrections in calculations and implementation to make sure the 1% annual chance standard is being met.

2. Enhance the Existing 1% Standard Approach. Improvements could be made in the policies, regulations, and implementation of the 1% annual chance standard to make it more accurate and effective at achieving its goals. The most badly needed are integrating the protection of natural resources and functions; eliminating the 1-foot rise allowed in the floodway; using future-conditions hydrology; and establishing a new levee standard.

3. Adopt a Two-Tiered Standard. This would keep the 1% annual chance standard for the bulk of activities to which it is now applied, but would add another, higher level of protection for certain important uses and facilities.

4. Use A Vertical Standard. Under this approach, flood insurance would become mandatory for every building in the country. The elevation of each building (or lot) would be compared to the flood elevation at the site. Insurance rates would be based on the flood level, the size of the building, and the amount of coverage. Protective measures (as used in the NFIP today) would be imposed for buildings within a certain vertical distance of the flood elevation.

5. Apply a Benefit/Cost Model. Each proposed activity in a floodprone area would be analyzed for the probability of flooding at that site, the consequences of flooding to that activity, and the uncertainties associated with those estimates. Whether or not to proceed, and what protective measures would be needed, would be based on that analysis.

6. Take an Incentive-based Approach. Standards would be abandoned and market incentives would be used. This would involve re-delineating the floodplain from the current 1% annual chance area to something larger. Development of the area would have to bear the costs of flooding by itself, leading to more sensible uses such as agriculture, sequestering carbon, filtering pollutants, providing wildlife habitat, and conveying and storing normal and extreme flows.

Data, Policy, and Research Needs

Whether or not a fundamental shift is made in use of the 1% annual chance standard, Forum participants agreed that a number of issues need further attention now if progress is to be made in managing floodplains. The highest priorities for enhancing the amount and quality of data available, improving existing policies and programs, and obtaining further fundamental knowledge are listed below.

- Obtain more and better stream gage data, both in terms of geographic areas covered and time periods.
- Establish a uniform method and associated management techniques for using future conditions within a watershed, e.g., ultimate build-out vs. a number of years into the future, or how to quantify the benefits of flood protection.
- Use management techniques and develop maps based on future-conditions hydrology at the local level. At the State and Federal levels, encourage or require localities to base their maps, engineering, and planning on future conditions.
- Examine the role of levees in floodplain management, and particularly with regard to the 1% standard. Evaluate existing levees and develop uniform procedures for certifying levees as being capable of providing a specified level of protection.
- Establish an appropriate policy for coastal A-zone designations and associated development standards.
- Quantify both the accuracy and effectiveness of the 1% annual chance standard in specific riverine and coastal situations, such as the hurricanes of 2004.
- Investigate techniques for better communication of the probability of flooding, flood risk, expected damage, impacts of changing conditions in watersheds, and other issues.
- Determine how residual risk could be incorporated into floodplain management programs and policies.
- Determine what effect the 1% standard and associated practices have had on the protection of natural functions and resources of floodplains.
- Conduct hydrologic research (1) to improve algorithms and methods for

rainfall/runoff modeling for traditional and special hazards applications; (2) to determine the applicability of the Bulletin 17B guidelines for flood flow frequencies ; and (3) to estimate flood frequencies for watersheds that are urbanizing and/or have flood control works in place.

- Quantify the economic costs and benefits of application of the 1% annual chance standard, including public and private property damaged and protected, loss of life, cost of repair and reconstruction, insurance coverage, lost opportunity, environmental costs and benefits, disaster relief, and other factors.

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Appendix 2. History of The 1 Percent Chance Flood Standard

Michael F. Robinson
DHS/FEMA

The following discussion is based on information obtained from publications and documents in Department of Homeland Security/Federal Emergency Management Agency files. Only limited information is available in those files on the history of the 1 percent chance flood prior to the establishment of the National Flood Insurance Program (NFIP). I used the term "100-year flood standard" in place of "1 percent chance flood standard" where appropriate to reflect the terminology that was in use at the time.

Evolution of the 100-year Flood Standard

Prior to the 1950's and 1960's the primary governmental response to floods was structural flood control and the only flood standards in use were the design standards for those projects. The Tennessee Valley Authority (TVA) used the "maximum probable flood" and USACE used the "standard project flood" as their design standards. As these agencies began moving toward nonstructural floodplain management, there was a recognized need for a different standard that conveyed a level of flood risk that was more appropriate for land use planning and regulation by communities and more meaningful for individuals.

Flood information was initially provided to communities and individuals based on the historical flood of record. However, it was generally recognized that this flood was more a matter of chance and did not adequately reflect the risk of flooding for an area. When TVA began its nonstructural community flood damage prevention program in 1953 it adopted as its standard a "regional flood" which was estimated to be on the order of a 50-year flood or greater. As USACE began to provide floodplain management assistance to communities under the Flood Control Act of 1960 it adopted an intermediate regional flood that approximated the 100-year flood as its standard for nonstructural activities. By the early 1960's, both USACE and TVA recognized the need for a uniform standard and agreed on the 100-year standard. The few State floodplain management programs that had been established by the late 1960's generally also adopted the 100-year standard.

Several other standards were also in use during this period. The Connecticut Resources Commission began to use 5-7 times the mean annual flood as a standard. This equated to between a 35- and 150 year level of protection, depending on the watershed. Their reason for adopting this standard instead of the 100-year flood or some other frequency-based standard was that there was no uniform method for determining flood frequencies. Other standards that were in use at this time include the Soil Conservation Services (SCS) watershed protection program that used the 25-year flood in rural areas and the 100-year flood in urban areas and the U.S. Geological Survey that provided flood data based on the 50-year flood. USGS was initially reluctant to provide information on the 100-year flood because it required extrapolating data beyond experience. By the late 1960's government agencies seemed to be coalescing around the 100-year standard as the standard for floodplain management. However, other standards were still in use and there was still no national standard that was agreed to by all agencies.

Executive Order 11296

In August 1966, the President issued Executive Order 11296 on *Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities and Disposing of Federal Lands and Properties*. E.O. 11296 directs Federal agencies to take flooding into account when making decisions, but contains no standard level of protection. Federal agencies were to develop joint implementing procedures and regulations. This was a several year process and U.S. Water Resources Council did not issue final guidelines for evaluating flood hazards until May of 1972. These guidelines recommended that agencies use the 100-year flood as the "basic flood" to identify and evaluate flood hazards, but provided for the use of smaller and larger floods as appropriate.

Adoption of the 100-year Standard by the National Flood Insurance Program

The National Flood Insurance Act of 1968 that established the National Flood Insurance Program (NFIP) directed U.S. Department of Housing and Urban Development (HUD) to establish floodplain management criteria and to designate flood hazard areas, but was silent on the standard that was to be used. HUD contracted with the University of Chicago's Center for Urban Studies to conduct a seminar to make recommendations on the floodplain management criteria that HUD was to develop. This meeting, chaired by Gilbert White, was held from December 16-18, 1968 and is commonly referred to as the Chicago Seminar. The report recommends that the regulations apply in "that portion of the flood plain subject to inundation by the 100-year flood".

One of the work groups at the seminar had the responsibility of developing hydrologic standards for the identification of floodprone areas and for regulations. Nick Lally included his recollections of this group's deliberations in a paper prepared for FEMA in 1982.
"The group deliberated about 1 ½ days and finally recommended that the 100-year flood would be a reasonable level to use in identifying flood-prone areas. ...The recommended level was a compromise that all of those present were comfortable with and could support. There was no attempt to make any economic analysis due to the constraints of time."

One member of the group supported the 100-year standard, but felt that local deviations should be allowed. The consensus of the group was that, since the NFIP was a new program that was badly needed, it should not be made more complicated by allowing deviations from the 100-year standard.

On February 27, 1969, HUD's Federal Insurance Administration (FIA) published a proposed rule that contains the first floodplain management criteria developed for the NFIP. This proposed rule does not mention the 100-year flood or any other standard (it may have been too soon after the Chicago meeting for a decision on a standard to be made). The June 18, 1969 Final Rule defines "Floodplain having special flood hazards" as the 100-year floodplain for mapping purposes, but only requires that communities "should take into account the relation between first floor elevations and the anticipated level of the 100-year flood" in developing their floodplain management measures. It was not until the June 9, 1971 proposed rule and September 10,1971 final rule that the NFIP specifically tied the regulatory requirements of the program to the 100-year flood standard.

With its adoption and use by the NFIP, the 100-year flood standard became the de facto national standard for floodplain management. Since most floodplain mapping was now being done in support of the NFIP and communities had to meet NFIP minimum requirements to be eligible for flood insurance, the 100-year flood standard soon replaced any other standards that were still in use.

Senate Hearings on the Flood Disaster Protection Act of 1973

The key issue at the U.S. Senate Committee on Banking, Housing, and Urban Affairs hearing on the Flood Disaster Protection Act of 1973 was the NFIP's adoption of the 100-year standard and not the imposition of the prohibitions on Federal assistance in designated floodplains or the mandatory flood insurance purchase requirement. Much of the opposition to the standard came from communities. Most cited the perceived devastating economic impacts on communities of using this large of a flood to designate floodplains and as a basis for mandatory purchase and floodplain management regulations. For example the City of Savannah testified that they had only sustained $10 million in damages since 1900, yet it would cost $100 million to $700 million to meet floodplain management requirements based on the 100-year standard.

Alternatives that were discussed at the hearing include the 50-year standard, the historical flood of record, and a flexible standard that would recognize the differences in damages that would occur under a variety of flooding condition. FIA and USACE both prepared papers supporting of the 100-year standard that were submitted for the record. These papers both argued that the 100-year standard was a reasonable standard that provided the proper balance between the competing needs for economic development and flood protection and that there was a need for a uniform standard to administer the NFIP. Gilbert White, Jon Kusler and James Wright testified on a panel in support of the standard with Jon Kusler raising the additional concern that the 100-year standard may not be restrictive enough.

In the Committee Report, the Committee "agreed that the 100-year standard or the flood that has a one percent chance of occurrence is reasonable and consistent with Nationwide standards for flood protection". In retrospect this endorsement by the Senate Committee settled the issue of the 100-year standard even though there continued to be challenges to its use. For example, the issue was again raised in hearings on amendments to the National Flood Insurance Act in 1974. The 1974 amendments also are the first time the 100-year flood is specifically mentioned in NFIP legislation although only in the context of limiting flood insurance premiums where adequate progress had been made on constructing Federal flood control projects.

Base Flood

During this period concerns were raised that the term 100-year flood was misleading and that other terminology should be used. In an October 15, 1976 letter the Water Resources Council's Hydrology Committee recommended that Federal agencies use descriptive terminology for future flood events that would convey to the public their probabilistic character. In keeping with the discussion that preceded this recommendation, HUD/FIA's March 26, 1975 proposed rule and October 26, 1976 final rule introduced the terms "base flood" and "base flood elevation" and began to phase out the use of the term "100-year flood". Base flood was defined was defined as "the flood having a one percent chance of being equaled or exceeded in any given year." The term 100-year flood is still used in the NFIP as a colloquial term and is still used on flood hazard maps, but does not appear in the floodplain management regulations.

In the national hearings and comment period held during the development of the October 26, 1976 final rule, there was again discussion on the NFIP's use of the 100-year standard. Comments were divided, some wanting a less restrictive standard, others advocating elevating structures to a height exceeding the base flood elevation, and still others wanting to allow no new construction in floodplains. In the final rule the FIA Administrator stated that he continued to believe that elevating to above the base flood elevation was reasonable and no changes were made to the standard.

Executive Order 11988, Floodplain Management

On May 24, 1977, President Carter issued Executive Order 11988, *Floodplain Management.* The Executive Order directs Federal agencies to use HUD (now FEMA) maps to determine if an action will occur in floodplains and to adopt regulations and procedures consistent with those promulgated under the National Flood Insurance Program. This in effect established the 100-year standard as the minimum for evaluation of all Federal actions. The U.S. Water resources Council *Floodplain Management Guidelines for Implementing E.O. 11988* introduced the concept of providing 500-year protection to "critical actions". "Critical actions" include those actions for which even a slight chance of flooding would be too great. Examples include hazardous materials, hospitals, and emergency services.

The Presidents Commission on Housing, the Vice Presidents Task Force on Regulatory Relief, and FEMA's Report on the 100-year Base Flood Standard

The Presidents Commission on Housing was established in June of 1981 and charged with reviewing all existing Federal housing policy and programs and assessing factors that contribute to the cost of housing. Much of the focus of the commission was on removing regulatory barriers and not on issues such as providing adequate flood protection to housing. The Commission provided a forum for HUD and others to again raise issues associated with the 100-year standard. The Commission recommended reevaluating and revising the 100-year standard to "take into account water height, velocity of flow, frequency of flooding, quality of floodwater (sediment and debris), historical flood-loss experience, socioeconomic costs (both in terms of damage and of removal of land from development), and maximum average annual damages…" They suggested substituting a risk-based approach based on an acceptable level of flood damage to structures for the 100-year standard.

Based on the recommendations of the Presidents Commission on Housing, the Vice Presidents Task Force on Regulatory Relief included the 100-year standard and Executive Order 11988, *Floodplain Management* on its list of Federal regulations and policies that might impose severe hardships on States, local entities, and citizens.

The Office of Management and Budget (OMB) then directed FEMA to undertake a review of the 100-year base flood standard and Executive Order 11988. FEMA reviewed the history and usage of the standard and conducted a formal solicitation of comments from Federal agencies, the Governors and others. Again, no effort was made to analyze the standard in terms of costs and benefits. Federal and State agencies, communities, and individuals submitted 105 comments on the 100-year Base Flood Standard. The responses were overwhelmingly in support of retaining the 100-year base flood standard. FEMA submitted its report to OMB in September of 1983. Findings and conclusions were:

- The 100-year base flood standard was strongly supported and being applied successfully by all levels of government.
- No alternatives were identified that were superior to it, and there was no evidence to justify the expenditure of funds that would be necessary to convert to another standard.
- Improvements or refinements in application of the 100-year base flood standard to unique flooding situations could further effect flood loss reduction.

FEMA recommended to OMB that the base flood standard be retained. In a January 6, 1984 letter, OMB agreed with FEMA's conclusions and concluded that "the 100-year base flood standard appears to be working well and, given its widespread use, it does not appear to be in the public interest to adopt another methodology."

Discussions on the 1 Percent Chance Flood Standard Since 1983

Since 1983, there has been very little discussion on changing the 1 percent chance flood standard to an alternative standard. The standard has been incorporated into policies and programs at all levels of government and any change would be exceedingly costly and disruptive. The need to provide protection to at least the 1 percent chance flood has become almost universally accepted. Communities seldom argue that implementation of floodplain management regulations that use the 1 percent chance flood standard will cause severe economic harm.

Most of the discussion has instead focused on how the standard is applied and, in particular, whether current NFIP minimum requirements are achieving a 1 percent chance flood level of protection. A major concern has been how that the level of protection can deteriorate over time due to factors such as urbanization, coastal erosion, and floodplain encroachment that tend to increase flood risk. The Association of State Floodplain Managers' (ASFPM) "No Adverse Impact" initiative in part is intended to address many of these issues.

Examples of actions that can be taken beyond NFIP minimum requirements to prevent future increases in flood damages include:

- Use of future conditions hydrology, particularly in rapidly urbanizing areas,
- Stormwater management and regulation to reduce increases in run-off,
- Preservation of floodplain storage,
- Designation of zero rise floodways, and
- Use of Freeboard

In addition, there are special hazards that are not adequately addressed by current NFIP mapping and minimum floodplain management standards, such as:
• Areas subject to coastal erosion.
• Coastal AE zones. These are areas outside of the Coastal High Hazard Area (V Zone)
that are subject to wave impacts.
• Alluvial fans and similar arid regions flooding. These issues are not related to adequacy of 1 percent chance flood standard, but instead relate to how the standard is applied.
Finally, there are two situations where there is general agreement that protection to the 1 percent chance flood may not provide an adequate level of flood protection:
• Recognition of levees providing protection to urban development.
• Protection of critical facilities.

These issues were addressed in *Sharing the Challenge: Floodplain Management into the 21st Century* (IFMRC 1994a) written in response to the 1993 Midwest Floods. That report expressed concerns over the residual risk behind levees credited with providing 100-year protection. It recommended that the Standard Project Flood be used as the minimum level of protection for urban development and that flood insurance be required behind all levees that provide less than that level of protection. The report also recommended providing a similar level of protection to critical facilities. Residual risk behind levees was also a major issue in the on-going controversy related to the American River levee system in Sacramento, California. This resulted in the report *Flood Risk Management and the American River Basin: An Evaluation* published in 1995 by the National Academy of Science.

NFIP Community Rating System (CRS)

FEMA's strategy to address many of the issues identified in the previous section has been to provide incentives through the National Flood Insurance Program's Community Rating System (CRS) for communities that voluntarily map or regulate to a higher standard than NFIP minimum requirements. Many of the approaches recommended in ASFPM's *No Adverse Impact: A Toolkit for Common Sense Floodplain Management* (2003) are already credited under CRS. In addition, most FEMA guidance that has been issued in recent years not only explains minimum requirements, but also recommends that communities consider adopting more restrictive requirements where appropriate.

NFIP Evaluation

In 1999 FEMA began a comprehensive evaluation of the National Flood Insurance Program (NFIP). The evaluation is being coordinated for FEMA by the American Institutes for Research (AIR). Proposals are currently being solicited for a subcontractor to conduct a study on the 1-Percent Chance Flood Standard. This study will build on the results of the ASFPM Forum and provide an opportunity to follow-up on any issues that are identified. Other studies already underway that may provide information on the adequacy of the 1 percent chance flood standard include studies on:
• Mapping Anticipated Development
• Minimum Building standards
• Environmental and Developmental Impacts of the NFIP
• Actuarial Soundness

• Risk Perception
• Costs and Consequences of Flooding.

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Appendix 3. Extract from NFIP Program Description

Section 1315 of the 1968 Act prohibits FEMA from providing flood insurance to property owners unless the community adopts and enforces floodplain management criteria established under the authority of Section 1361(c) of the Act. These criteria are established in the NFIP regulations at 44 CFR §60.3. The community must adopt a floodplain management ordinance that meets or exceeds the minimum NFIP criteria. Under the NFIP, "community" is defined as:

"any State, or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction."

The Program has served as an important impetus for the establishment of floodplain management programs nationwide in the approximately 19,700 participating communities and most States and territories. Community participation in the NFIP is voluntary. Prior to the creation of the NFIP, floodplain management as a practice was not well established – only a few States and several hundred communities actually regulated floodplain development. For many communities, the NFIP was the community's initial exposure to land use planning and community regulations. The power to regulate development in floodplains, including requiring and approving permits, inspecting property, and citing violations, is granted to communities under a State's police powers. FEMA has no direct involvement in the administration of local floodplain management ordinances. Since the Federal Government does not have land use authority, the NFIP is based on the Federal government's power to spend under the Constitution rather than any Federal authority to regulate land use.

Minimum NFIP Floodplain Management Requirements

Under the NFIP, the minimum floodplain management requirements that a community must adopt depends on the type of flood risk data (detailed FIS and FIRMs with BFEs or approximate A Zones and V Zones without BFEs) that the community has been provided by FEMA. Under the NFIP regulations, participating NFIP communities are required to regulate all development in SFHAs. "Development" is defined as:

"any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials."

Before a property owner can undertake any development in the SFHA, a permit must be obtained from the community. The community is responsible for reviewing the proposed development to ensure that it complies with the community's floodplain management ordinance. Communities are also required to review proposed development in SFHAs to ensure that all necessary permits have been received from those governmental agencies from which approval is required by Federal or State law, such as 404 wetland permits from the Army Corps of Engineers or permits under the Endangered Species Act.

Under the NFIP, communities must review subdivision proposals and other proposed new development, including manufactured home parks or subdivisions to ensure that these development proposals are reasonably safe from flooding and that utilities and facilities servicing these subdivisions or other development are constructed to minimize or eliminate flood damage.

In general, the NFIP minimum floodplain management regulations require that new construction or substantially improved or substantially damaged existing buildings in A Zones must have their lowest floor (including basement) elevated to or above the Base Flood Elevation (BFE). Non-residential structures in A Zones can be either elevated or dry-floodproofed. In V Zones, the building must be elevated on piles and columns and the bottom of the lowest horizontal structural member of the lowest floor of all new construction or substantially improved existing buildings must be elevated to or above the BFE. The minimum floodplain management requirements are further described below:

For all new and substantially improved buildings in A Zones:

All new construction and substantial improvements of residential buildings must have the lowest floor (including basement) elevated to or above the BFE.
All new construction and substantial improvements of non-residential buildings must either have the lowest floor (including basement) elevated to or above the BFE or dry-floodproofed to the BFE. Dry floodproofing means that the building must be designed and constructed to be watertight, substantially impermeable to floodwaters.
Buildings can be elevated to or above the BFE using fill, or they can be elevated on extended foundation walls or other enclosure walls, on piles, or on columns.
Because extended foundation or other enclosure walls will be exposed to flood forces, they must be designed and constructed to withstand hydrostatic pressure otherwise the walls can fail and the building can be damaged. The NFIP regulations require that foundation and enclosure walls that are subject to the 100-year flood be constructed with flood-resistant materials and contain openings that will permit the automatic entry and exit of floodwaters. These openings allow floodwaters to reach equal levels on both sides of the walls and thereby lessen the potential for damage. Any enclosed area below the BFE can only be used for the parking of vehicles, building access, or storage.

In addition, to the above requirements, communities are required to select and adopt a regulatory floodway in riverine A Zones. The area chosen for the regulatory floodway must be designed to carry the waters of the 1 percent-annual-chance flood without increasing the water surface elevation of that flood more than one foot at any point. Once the floodway is designated, the community must prohibit development within that floodway which would cause any increase in flood heights. The floodway generally includes the river channel and adjacent floodplain areas that often contain forests and wetlands, an area estimated at 5.8 million acres (or over 9,000 square miles) on the FIRMs. This requirement has the effect of limiting development in the most hazardous and environmentally sensitive part of the floodplain.

For all new and substantially improved buildings in V Zones:

All new construction and substantial improvements of buildings must be elevated on piles and columns so that the bottom of the lowest horizontal structural member of the lowest floor is elevated to or above the BFE. No fill can be used for structural support.

All new construction and substantial improvements of buildings must be properly anchored to resist flotation, collapse, and lateral movement.

In V Zones, the velocity water and wave action associated with coastal flooding can exert strong hydrodynamic forces on any obstruction to the flow of water. Standard foundations such as solid masonry walls or wood-frame walls will obstruct flow and be at risk to damage from high-velocity flood forces. In addition, solid foundation walls can direct coastal floodwaters into the elevated portion of the building or into adjacent buildings. The result can be structural failure of the building. For these reasons, the area below the lowest floor of the elevated building in V Zones must either be free of obstruction, or any enclosure must be constructed with open wood lattice-panels or insect screening or, be constructed with non-supporting/non-load bearing breakaway walls which meet applicable NFIP criteria. Any enclosed area below the BFE can only be used for the parking of vehicles, building access, or storage.

In order to further protect structures from damaging wave impacts, structures must be located landward of the reach of mean high tide. Furthermore, man-made alteration of sand dunes and mangrove stands, which would increase potential flood damage, are prohibited within V Zones

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Appendix 4. Floodplain Management Practices

Floodplain management activities, while practiced in some locations since the 1930s, were only widely implemented with the advent of the NFIP and continue to be tied formally and informally to the NFIP. The floodplain management programs in place today:

- Tend to focus on building construction and generally ignore agriculture and infrastructure.
- Are designed primarily to regulate for flood events up to and including the existing condition 1 percent flood stage and are linked, in most cases, to NFIP regulatory minimums.
- Generally ignore flood-related hazards such as erosion.

A significant factor to consider in the effectiveness of the NFIP is whether flood damages are affected by floodplain management. Factors that influence this could include—but are not limited to—the development of State and local programs, evidence of enhanced professional capability as quantified by the CFM program, growth within the State or community, and the degree to which the Community Rating System is implemented within each State.

Floodplain management as practiced is locally implemented and predominantly focused on managing land use and how one builds within a flood-prone environment. In most cases agricultural uses are exempt from floodplain management ordinances, and with the exception of some limited structural flood control, there are few if any nonstructural practices being applied to agricultural lands that would protect crops from flooding. At best there are some limited conservation easement programs that are focused on wetlands and floodplains which remove flood-prone agricultural lands from production on a temporary basis.

Conventional wisdom is that flood damages should decrease as floodplain management programs and standards become stronger. A stronger program is one that is doing a better job of communicating risk, educating professionals who make building and land use decisions, and encouraging standards and practices that provide a level of flood protection that meets or exceeds the base standards of the NFIP.

However, at the same time, even with the advent of State and local floodplain management programs, total flood damages in the Nation continue to escalate. This escalation of damages could be attributed to various factors, including floods larger than 1 percent generating more flood damages, more damages being attributed to improvements that are not regulated as part of the floodplain management program (agricultural and infrastructure), improved capture of flood damages due to better communication and documentation techniques or a general failure of floodplain management practices.

Data provided in Chapter 6 indicate that agricultural losses appear to contribute significantly to total flood damages in the Nation (e.g. In the 1993 Midwest flood event, FEMA attributed more than 50 percent of all damages to agricultural losses, and the States of Missouri, Iowa, and North Dakota are among the 10 States with the highest average flood damages summed over the period of record.)

On the other hand, floodplain management practices are predominantly focused on construction of buildings within floodplains with little or no emphasis on agricultural practices.

Quantitative data that evaluated the impacts of floodplain management practices on flood damages were not found. As such, in order to evaluate floodplain management practices on damages it was necessary to pull together various data sources to evaluate whether a trend might be discerned.

First, data were obtained from two sources in order to evaluate the floodplain management factors. The first was *Floodplain Management 2003- State and Local Programs.* The second source was CRS activities by State, provided by FEMA via its contractor, ISO.

Table 1 captures by State various factors that would influence the overall effectiveness of a State's floodplain management program. These factors are:

- CFM—the number of certified floodplain managers in a State. While the CFM credential is relatively recent, becoming a CFM requires passing a rigorous exam with continuing education requirements. The more CFMs there are in a State should translate into improved implementation of the floodplain management program.
- State staff—the number of full-time floodplain managers in a State. This demonstrates both capacity and in most cases the degree of commitment to flood protection strategies at the State level.
- State association—State or regional floodplain management association indicates a sense of professionalism and continuing education for practitioners in this area.
- Five floodplain management practices
    - Disclosure—mandatory disclosure of flood risk with real estate transaction
    - Detention—storage of stormwater
    - Setbacks—setting development away from wetlands, riparian zones, or floodplains some fixed distance
    - Floodway Standards—more restrictive than NFIP
    - Freeboard—more restrictive than NFIP (1 means 1 foot, 2 means 2 feet)

It was hypothesized that proactive floodplain management practices should translate into fewer flood damages. As the data were assembled, it became apparent that floodplain management practices currently are primarily focused on flood events up to and including the 1 percent flood event and that the practices were primarily focused on the built environment. On the other hand, total damage data for the Nation was all inclusive and included agricultural, infrastructure, and recovery costs that are not currently impacted by floodplain management practices. To compare State and local floodplain management practices, it was necessary to normalize between States to account for size and population. "Damages per capita" was used for this purpose. This statistic also allows the impact of growth on damages. Census data by State were obtained for 1960, 1970, 1990, and 2000 to approximately match the four time periods used to accumulate damage data. Damages per capita were estimated for both the total damage data set and the data set where the extremes were removed.

Table 1. Damages to Infrastructure

Home-State	CFM's	State Staff	State Assoc	Disclosure	Detention	Setbacks	Floodway Standard	Freeboard	SUM
AK	3	1.25	0.5	1					1
AL	31	4.5					1	1	2
AR	72	3	1						0
AZ	178	0.5	1	1				1	2
CA	63	10	0.5	1			1		2
CO	105	5	1	1	1			1	3
CT	4	3	0.5		1				1
DC	22	1.85		1	1	1	1	1.5	5.5
DE	1	3		1	1		1		3
FL	208	7	1	1	1	1	1		4
GA	66	3		1	1	1	1	1	5
HI	6	1.5	0.5	1	1			1	3
IA	2	0.00001							0
ID	4	1	0.5		1				1
IL	198	2	1	1					1
IN	39	5	1	1	1			2	4
KS	32	3	1	1	1		1	1	4
KY	10	11			1	1			2
LA	39	4	1	1					1
MA	25	3	0.5						0
MD	141	2	1	1	1			1	3
ME	4	3	0.5		1	1	1	1	4
MI	42	11	1		1		1	1	3
MN	17	9	1		1	1	1	1	4
MO	73	6	1						0
MS	41	1	1		1		1		2
MT	21	2	1	1			1	0.5	2.5
NC	135	4.5	1		1	1	1		3
ND	4	2						1	1
NE	19	6.5						1	1
NH	2	0.75	0.5	1	1				2
NJ	10	6	1		1		1		2
NM	109	1	1	1		1			2
NV	35	1.3	0.5	1				1	2
NY	20	4.75	1	1	1		1		3
OH	40	11	1	1	1		1	2	5
OK	175	1.5	1	1	1				2
OR	22	1	0.5	1		1	1	1	4
PA	13	2		1	1			1.5	3.5
PR	3	2		1	1	1		1	4
RI	1	1	0.5	1	1	1	1		4
SC	137	3	1		1				1
SD	4	1							0
TN	4	1							0
TX	459	2.5	1	1	1				2
UT	2	1	1		1				1
VA	168	3	1		1	1			2
VT	0	1	0.5	1					1
WA	24	7.5	0.5	1	1		1		3
WI	11	9	1		1	1		2	4
WV	7	1							0
WY	5	1.5			1				1

SOURCE: ASFPM and ISO.

Analysis of the data indicated:

- Weak to moderate correlation, suggesting that damages per capita are lower when there is a stronger State floodplain management program.
- When evaluating damages for events less than the 1 percent event, there was weak correlation between population growth and higher flood damages per capita.
- In contrast, when evaluating all flood events, there was moderate correlation between population growth and flood damages per capita.
- When evaluating professional accreditation and education about floodplain management (as measured by the number of CFMs by State, there was weak negative correlation to flood damages per capita.

Table 2 Regression Results, Flood Damages as a Function of State Flood Plain Management Metrics

Description	R	Rsquare	X statistic	Discussion
Regression of Base Damage per capita with hi-lo extreme removed- Vs. State Program Points	0.45	0.20	-2.94	Weak to moderate regression that suggests that as a state program has stronger floodplain management elements damages per capita decrease
Regression of Base Damage per Capita with mean damages per capita vs. State Program Points	0.33	0.11	-6.71	Weak to moderate regression that suggests that as a state program has stronger floodplain management elements damages per capita decrease
Regression of Base Damage per Capita with Extremes Removed vs State Program Points	0.24	0.06	-3.01	Weak to moderate regression that suggests that as a state program has stronger floodplain management elements damages per capita decrease
Regression of Base Damage (hi-lo extreme removed) vs growth	0.13	0.02	1.30	weak regression that suggests as growth increases damages per capita increases
Regression of Base Damage (extremes removed) vs Growth	0.13	0.02	2.38	weak regression that suggests as growth increases damages per capita increases
Regression of Base Data (mean values) vs Growth	0.56	0.32	17.05	Moderate regression that shows that the increase in total flood damages at the state level is related to growth
Regression of Base Data(mean values) vs number of CFMS	0.17	0.03	-0.06	Weak regression that suggests that increasing number of CFMs relates in decreasing damages pre capita
Regression of Base Data (hi-lo removed) vs CFMs	0.14	0.02	-0.03	Weak regression that suggests that increasing number of CFMs relates in decreasing damages pre capita
Regression of Base Data (extremes removed) vs CFMs	0.08	0.01	-0.01	Weak regression that suggests that increasing number of CFMs relates in decreasing damages pre capita
NATIONAL DAMAGES 55-2003	All	Extremes out		
($ 1000K)	$163,193,100	$109,665,244	0.33	33% increase in damages due to extreme events

Observations

The following summary observations result from a review of flood damages compiled by NOAA, UCAR, and others since 1955. All of these are qualitative in a statistical sense, since the data record does not allow for greater specificity.

- Current floodplain management practices have little or no impact on controlling flood losses for agricultural uses and most likely have limited impact on controlling damages for events larger than the 1 percent event.

- Stronger State-level floodplain management programs may result in decreased damages per capita.

- Until such time that we improve our data collection procedures for capturing flood damages, at best we will have only anecdotal evidence related to total damages` and whether our current management practices are making a difference.

Water Policy Collaborative
University of Maryland
1173 Glenn L. Martin Hall
College Park, Maryland 20742
Tel: 301-405-1341

AMERICAN INSTITUTES FOR RESEARCH®

American Institutes for Research
1000 Thomas Jefferson Street, N.W.
Washington, D.C. 20007-3541
Tel: 202-403-5000
www.air.org