

ENGINEERING PERSPECTIVES FOR A NATIONAL LEVEE SAFETY PROGRAM

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Abstract:

The catastrophic destruction and loss of life induced by the 2005 flooding of New Orleans by Hurricane Katrina was a wakeup call to the nation. This terrible tragedy demonstrated yet again the fragility of levees and the significant flood risks that many of our communities now share. On January 15, 2009, the National Committee on Levee Safety submitted a draft report to the Office of Management and Budget prior to submitting the final version to Congress. The report contains recommendations for a National Levee Safety Program and a strategic plan for implementation. Among the 20 recommendations in the report are ones calling for the establishment of a National Levee Safety Commission, the development and adoption of National Levee Safety Standards, the creation of State Levee Safety Programs, completion of a National Levee Database, implementation of mandatory risk-based flood insurance, swift action by Congress to address growing liability concerns, and the establishment of a National Levee Rehabilitation, Improvement, and Flood Mitigation Fund by the federal government. The authors of this paper are members of the Committee and worked together in a work group to develop many of the engineering-related recommendations, including the use of national levee standards, levee hazard classifications, use of tolerable risk guidelines, technical assistance and training, and liability. This paper will summarize the Committee's 20 recommendations, and provide an engineering perspective on the reasoning and rationales for developing them.

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Introduction

The National Committee on Levee Safety was established by the United States Army Corps of Engineers as part of a congressional mandate contained in the National Levee Safety Act of 2007, part of the Water Resources Development Act of 2007. As required by the Act, the 16-member Committee is composed of a diverse group of professionals from federal, state, local/regional governments and the private sector. The Committee's mission was to develop recommendations for a national levee safety program, including a strategic plan for implementation of the program. The Committee worked assiduously from October 2008 to January 2009 to evaluate current practices, examine alternative policies, and develop its vision. The Committee then produced twenty recommendations for a National Levee Safety Program and submitted them in a draft report on January 15, 2009. The recommendations are contained in three major categories:

- Providing Comprehensive and Consistent National Leadership
- Building and Sustaining Strong Levee Safety Programs in All States
- Aligning Existing Federal Programs

The Committee concluded that we are at a critical juncture in our nation's history – a burgeoning growth of flood risk to people and infrastructure as a result of more than 100 years of inattention to our levee systems. The stark reality of our nation's levee systems, both federal and non-federal, is that many are inadequate and deteriorating, and that we lack sufficient information to predict their level of performance. These levee systems not only serve as protection from flooding for a great portion of our population and ecosystems, but also for much of our country's critical infrastructure. As recent events have shown, the impacts caused by inadequate levees that are unable to withstand ever-increasing severe weather events can have catastrophic long term impact on the public and the economy. The recommended National Levee Safety Program, potentially as part of a broader national flood risk management approach responding to the impacts from climate change (including rising water levels), must be a critical component to protecting the public and other infrastructure investments and preserving our economic welfare.

What We Have Learned About the Nation's Levees

As the nation's population spread across the continent in the mid-1800's, communities were established along river systems because rivers were the principal transportation system and because water was needed for both agricultural and domestic use. Over time, farmers and communities began constructing long earth embankments to prevent flood waters from inundating their lands. Many of these embankments, or levees, were crudely constructed long piles of dirt without any benefit from modern engineering or construction techniques. These initial embankments still form the core of many of the levee systems currently relied upon to protect the nation's critical infrastructure and the public in both urban and rural areas.



Figure 1. Construction of a Levee by Clamshell Dredging in California around 1910
(from Sacramento Archives & Museum Collection Center)

The current levee safety reality for the United States is stark:

- ✓ We do not know where all the levee systems are, what they protect or what level of performance we can expect from them. It is estimated that there are over 14,000 miles of federal levees and over 100,000 miles of non-federal levees across the nation, but we cannot be certain.
- ✓ We do know that levees are abundant in many areas of the country and are integral to our citizens' lives, economic prosperity, and physical security. Cities such as New Orleans, Dallas, St. Louis, Sacramento, Portland, Washington, D.C., Des Moines, and Kansas City are all protected by levees. Levees protect other critical infrastructure such as schools, hospitals, wastewater treatment plants, oil refineries, power plants and transportation systems.
- ✓ The consequences of levee failures and overtopping can be devastating: the loss of homes, businesses, infrastructure, cherished possessions, and sometimes, tragically, loved ones. Some recent examples include:
 - 1993 Midwest floods – Losses totaled \$16 billion. 50,000 private homes were destroyed and approximately 40,000 commercial structures were damaged.



Figure 2. Photograph of Floodwaters During 1993 Midwest Flood (from Interagency Floodplain Management Review Committee, 1994)

- 2005 Hurricanes Katrina and Rita – 771 people died and losses totaled \$200 billion due to levee/floodwall failures or overtopping.

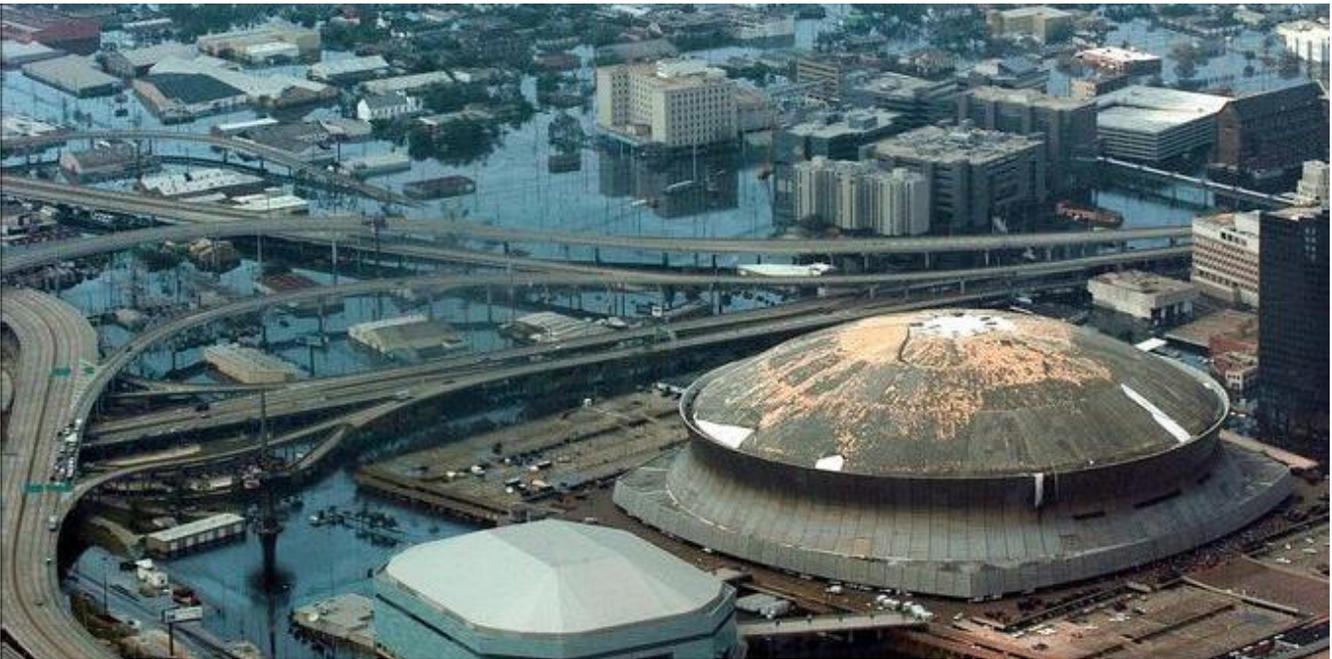


Figure 3. Photograph of Flooded New Orleans Following Hurricane Katrina in 2005 (from Interagency Performance Evaluation Task Force, 2007)

- 2008 Midwest floods – Currently \$2.7 billion in federal flood relief approved to aid 2008 victims, not including the value of low interest loans and small business assistance as well as the value of crop insurance and private insurance.



Figure 4. Overtopping of Mississippi River Levee in Eastern Missouri During Spring 2008 Midwest Flood (from Kelley et al., 2009)

Levees only reduce the risk of flooding – they do not eliminate the risk. In addition, many public policies have actually led to unintended and detrimental consequences:

- In many areas, levees have often inadvertently increased flood risks by attracting residential and commercial development into the floodplain.
- The National Flood Insurance Program established the one percent annual chance (100-year) flood for actuarial insurance purposes, but this level of flood protection mistakenly is perceived as a levee safety standard, *which it is not*. Consequently, many officials and the general public believe that they don't live in a flood plain and are not at risk if they are mapped as having a 100-year level of flood protection.
- The 1986 Water Resources Development Act established new requirements for local cost-sharing of flood control projects constructed by the United States Army Corps of Engineers (hereafter, the Corps). Local communities with limited finances were unwilling to fund levels of protection beyond the minimum certification requirements, which in turn became associated with the 100-year level of protection.

Government officials and the general public often have only a limited understanding of levees and the risks associated with them. For example, some believe that a 100-year level of flood protection means that a flood won't occur for another 100 years. In fact, over the life of a typical 30-year mortgage, the chance of flooding with a 100-year level of flood protection is actually 26 percent, a dangerously high risk. A 200-year level of flood protection corresponds to a 14 percent chance of flooding over a 30-year period.

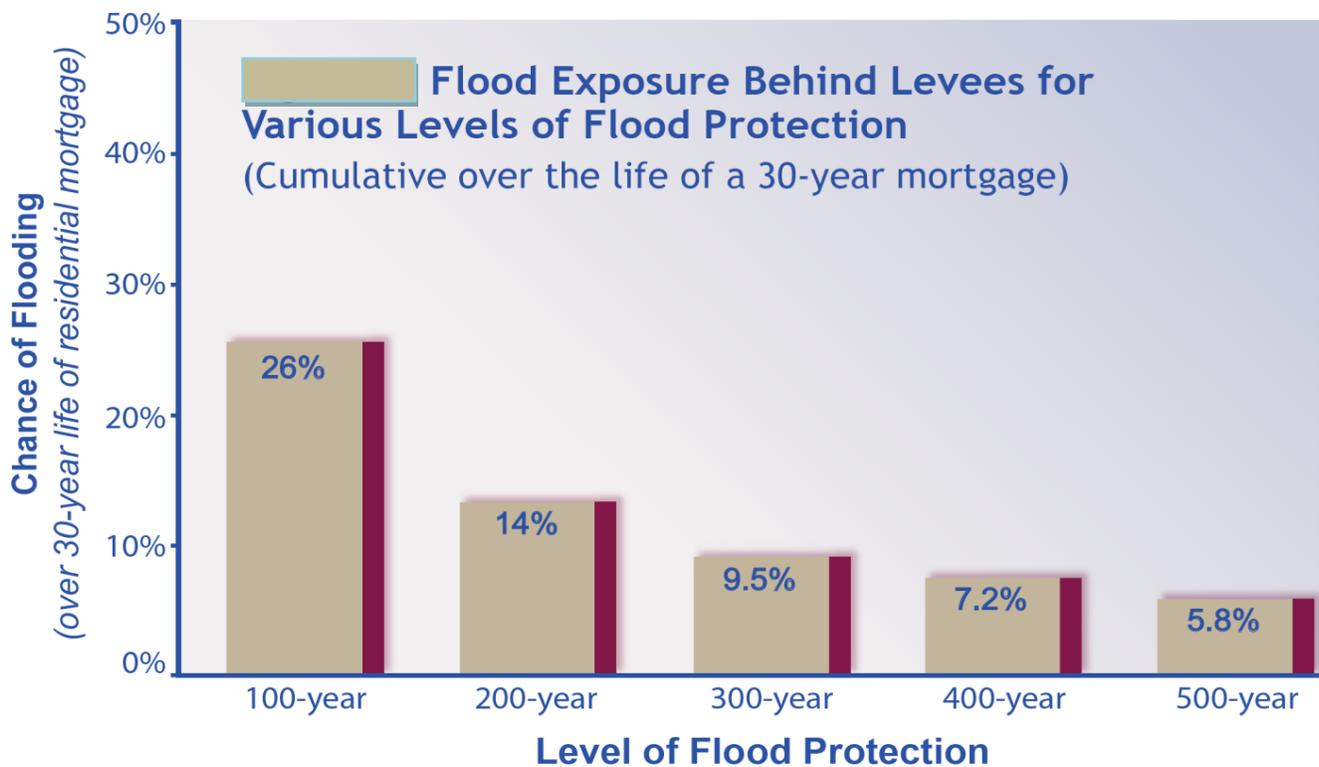


Figure 5. Chance of Flooding During the 30-year Life of a Typical Mortgage (from National Committee on Levee Safety, 2009)

It is not until we reach a 500-year level of flood protection that the chance of flooding starts diminishing to a relatively small chance (i.e., approximately six percent over a 30-year period). For comparison, the standard for flood protection along rivers in the Netherlands is a 1200-year level of flood protection, and for coastal flooding from the North Sea, it is a 10,000-year level of flood protection. If we carefully examined the capacities of our levee systems, we would probably find that many, if not most of the U.S. levee systems do not actually provide a 100-year level of flood protection.

Our levee systems are also deteriorating over time as a result of long-term settlement, flood damage, and rodent burrowing. In addition, climate change is expected to lead to more frequent and larger storm events, and this will exacerbate our current flood risks.

In recent years, liability issues have placed a terrible burden on both public entities and private engineering firms. Under current law, liability can be incurred by state and local government agencies and engineering firms that provide services for levees and other flood control structures and systems. Unlike most types of infrastructure, the reliability/capacity of levee systems is so low that many levee systems have the likelihood to fail during their design lives. As a result, many public agencies are very reluctant to take on new flood control responsibilities, and engineering firms are reluctant to provide evaluation, design, or construction services. Over time, the situation will only worsen, putting the public further at risk.

Recommendations of the National Levee Safety Committee

The National Committee on Levee Safety developed twenty recommendations for a National Levee Safety Program and submitted them to Congress (by way of the Office of Management and Budget) in a draft report on January 15, 2009. The recommendations are contained in three major categories:

- Providing Comprehensive and Consistent National Leadership
- Building and Sustaining Strong Levee Safety Programs in All States
- Aligning Existing Federal Programs (Incentives and Disincentives)

Under the category of **Providing Comprehensive and Consistent National Leadership**, the recommendations are:

1. Establish a National Levee Safety Commission
2. Expand and Maintain the National Levee Database
3. Adopt a Hazard Potential Classification System
4. Develop and Adopt National Levee Safety Standards
5. Develop Tolerable Risk Guidelines
6. Change “Levee Certification” to “Compliance Determination”
7. Subject Levee Compliance Determinations (Certifications) to Peer Review
8. Swiftly Address Growing Concerns Regarding Liability
9. Develop Comprehensive National Public Involvement and Education/Awareness Campaign
10. Provide Comprehensive Technical Materials and Direct Technical Assistance
11. Develop a National Levee Safety Training Program
12. Develop and Implement Measures to Harmonize Levee Safety Activities with Environmental Protection
13. Conduct a Research and Development Program

Under the category of **Building and Sustaining Strong Levee Safety Programs in All States**, the following recommendations are:

14. Design and Delegate Program Responsibilities to States
15. Establish a Levee Safety Grant Program
16. Establish the National Levee Rehabilitation, Improvement, and Flood Mitigation Fund

Under the category of **Aligning Existing Federal Programs (Incentives and Disincentives)**, the recommendations are:

17. Explore Potential Incentives and Disincentives
18. Mandate Purchase of Risk-Base Flood Insurance in Leveed Areas
19. Augment FEMA’s Mapping Program to improve risk identification and communication
20. Align FEMA’s Community Rating System (CRS) to Reward Development of State Levee Safety Programs

The recommended program builds upon a shared responsibility. While the development of the national program is important for consistency of standards and practices, major elements are best performed at the state and local levels.



Figure 6. Recommended Governance Structure for National Levee Safety Commission (from National Committee on Levee Safety, 2009)

The Committee firmly believes in all twenty recommendations and that they work together to form a coherent strategy for a national levee safety program. However, for the purposes of this paper, eight of the twenty recommendations were selected for further discussion.

Develop and Adopt National Levee Safety Standards

While federal and state agencies have varying policies and criteria concerning many aspects of levee design, construction, operation, and maintenance, there are no comprehensive national levee safety policies, standards, or best practices that can be adopted broadly by government at all levels. Consequently, the level of protection and robustness associated with levee design and construction projects vary considerably across the country, despite the fact that floodplains often cross multiple states. The lack of national standards for levees also results in a situation in which licensed professional engineers, levee owners, and governments cannot rely on an accepted standard of care when performing critical services in the design, construction, and evaluation of levees. As a result, this increases the potential for liability for all parties involved. The nation is left in a predicament, with a wide-ranging profile of risk exposure, risk understanding, and public safety.

The Committee recommended that within one year following the creation of the National Levee Safety Program, the International Code Council (ICC) be contracted to develop **Interim National Levee Engineering Guidelines** (including policies, procedures, standards, and

criteria) for levees, canal structures, and related facilities and features. It is anticipated that these interim guidelines would be based in part on existing Corps' policies, procedures, and criteria for levees and on U.S. Department of the Interior, Bureau of Reclamation policies, procedures and criteria for canal structures, as modified through the ICC code development process. These interim guidelines would be in place for about 4 years until a **National Levee Safety Code** is established. Federal legislation should be enacted requiring that all federal agencies and all state levee safety programs adopt the National Levee Safety Code once it becomes available.

Adopt a Hazard Potential Classification System

The Committee concluded that levee safety programs will need to classify levees by potential hazard, and later by risk, in order to set priorities, criteria, and requirements. Such classifications will also be needed for the communication of risk to both public officials and to the general public. While these classifications should ideally be based upon the risk of failure (probability x consequences), too little is known about the integrity of our levees at this time to make such categorizations. Accordingly, for the interim, the Committee recommended that classifications be based solely on consequences of levee failure. Consequences of levee failure include the number of people at risk, ability to evacuate (depth of flooding), and property values at risk.

The Committee developed the three-tiered hazard potential classification system shown in Table 1. It is intended to be simple and easily implemented. It is also intentionally set up to parallel the definitions established for the National Dam Safety Program. They were also intended, to the extent practicable, to use parameters and definitions consistent with those in use by other agencies (e.g. State of California, FEMA).

Table 1. Recommended Interim Hazard Potential Classification
(from National Committee on Levee Safety, 2009)

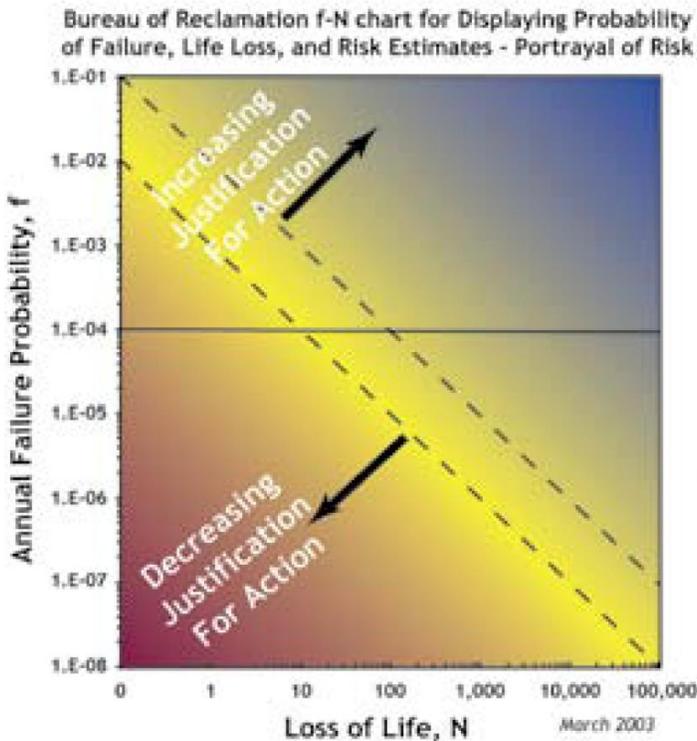
Hazard Potential Classification	Number of People Potentially Inundated	Number of People Potentially Inundated to Depths \geq 3 feet	Additional Considerations
High	\geq 10,000	\geq 10,000	Includes areas of consequence where critical life safety infrastructure is at risk (e.g. major hospitals, regional water treatment plants, and major power plants)
Significant	\geq 1,000	< 10,000	Includes areas of consequence where the number of people potentially inundated is relatively low, but there may be significant potential for large economic impacts or losses
Low	< 1,000	0	

The recommended classifications are intended to be in place over the next 5 years. After that time, it is expected that significant information will have been gathered regarding the integrity of our levee systems to allow for improved hazard potential classifications that would be based on risk.

Develop Tolerable Risk Guidelines

In order for the nation to better understand the risks associated with living in an area protected by levees and then prioritize limited resources, more sophisticated approaches are needed. Not every area or community needs the same level of flood protection. Tolerable risk guidelines can be developed to 1) better enable us to prioritize our public investment for areas where there is both a possibility for damaging consequences and a high probability of levee failure; 2) improve citizen and government knowledge and understanding regarding the benefits of flood risk reduction activities; and 3) enhance the public debate regarding the true benefits and costs of flood risk reduction alternatives. Tolerable risk approaches would also include concepts of equity and efficiency (see Figure 7). A tolerable risk approach to levees would be as follows:

- ✓ Identify levees that pose the greatest risk
- ✓ To what extent do they need to be modified or risks mitigated (tolerability)?
- ✓ Which actions should be taken first (priority/sequence)?
- ✓ How do we balance the desire to reduce risk with the availability of resources (urgency)?



- **Equity** -The principle, which holds: that the interests of all are to be treated with fairness and that individuals and society have the right to be protected (ICOLD); and
- **Efficiency** -In relation to society’s use of resources, that principle, which seeks to gain greatest benefit from the available resources.
- This leads to the notion that tolerable risk should consider both **societal** and **individual** risks as an integral part of the framework for managing risks.

Figure 7. Concepts of Equity and Efficiency with Tolerable Risk Approaches (from USBR, 2003 and National Committee on Levee Safety, 2009)

The Committee recommended the following process for developing tolerable risk guidelines for use by the nation:

- Assembling a panel of internationally renowned experts in risk management to develop ***National Tolerable Risk Guidelines for Levees and Structures Along Canals***.
- Conducting a peer review of the panel's recommendations
- Enacting new federal legislation requiring states to incorporate the guidelines

Mandate Purchase of Risk-Based Flood Insurance in Areas Protected by Levees

Flood insurance is one of the most effective ways to limit financial damages in the case of flooding and to speed recovery of flood damaged communities. It is also a mechanism that can reduce the liability exposure of public and private entities. Currently, many people who live in areas served by levees do not purchase flood insurance because they believe they are protected. Mandatory flood insurance requires individuals living within a floodplain to take individual responsibility and become part of the overall solution.

Even in areas served by well-engineered levees, mandatory flood insurance will increase the risk awareness and emergency preparedness of the public. Because premiums would be risk-based (the higher the flood protection available the lower the rates), communities would be motivated to help improve their levees beyond the current one percent annual chance (100-year) level of flood protection. A similar proposal was contained in legislation proposed in the previous Congress (H.R. 3121).

Design and Delegate Program Responsibilities to States

The National Levee Safety Act of 2007 clearly indicated Congress' intent that state levee safety programs be established and implemented to better manage the critical life safety infrastructure associated with non-federal levees. Because states already have the lead role in overseeing, coordinating, and regulating other elements of infrastructure and the environment, they are uniquely positioned to perform the same role for local and regional levee systems. The requirements of a state levee safety program should include three primary elements:

- Legislating statutory authorities
- Implementing rules, regulations and procedures
- Securing resources for these activities.

Some of the specific activities of a state levee safety program should include:

- ✓ Coordinating levee safety activities among local or regional entities within the state
- ✓ Receiving and reviewing application packages from entities within the state for grants from the National Levee Safety Program

- ✓ Requesting the Corps of Engineers to oversee the inspection of all levees within the State's jurisdiction
- ✓ Inspecting or requiring the annual inspection of levees within the state's jurisdiction, as well as inspections after all significant high water events
- ✓ Providing information to the national levee database for the levees within the state and providing updates at least annually
- ✓ Implementing a levee risk communication and public outreach/education program
- ✓ Adopting the ***Interim National Levee Engineering Guidelines***, and when available, the ***National Levee Safety Code***
- ✓ Requiring that communities develop emergency action and evacuation plans
- ✓ Adopting measures as needed to require consideration of non-structural measures associated with any levee related activities
- ✓ Obtaining a FEMA-approved Hazard Mitigation Plan
- ✓ Providing liaison and coordination on environmental permitting actions

Some of the costs associated with creating and maintaining state levee safety programs should be offset with federally-funded grants. The Committee also recommended that the states be afforded a start-up period to establish state levee safety programs. If at the end of the start-up period, states have not developed a levee safety program, increasingly stringent disincentives (e.g. lower priority for flood control funds) should be applied. At the same time, additional grants and funds should be available if the states develop levee programs that exceed minimum requirements.

Establish the National Levee Rehabilitation, Improvement, and Flood Mitigation Fund

The National Levee Safety Program (NLSP) establishes the minimum effective management program elements for the nation's levees and related infrastructure. By itself, the NLSP does not provide funding to address the many levee deficiencies that are expected to be discovered and documented in the inventory, inspection, and evaluation processes. States will need financial incentives to manage and maintain their own levee safety programs. The Committee recommended that a ***National Levee Rehabilitation, Improvement, and Flood Mitigation Fund*** be developed and cost-shared for non-federal publicly-owned levees. Funds would be available to address both structural and non-structural measures so long as the combination of measures maximizes overall risk reduction. A percentage of the non-federal cost share could be met through implementation of non-structural measures. Such federal assistance should initially be limited only to levee systems that protect existing urban areas with a high damage potential. To begin the program, the fund should be established at a minimum of one to \$1.5 billion annually. While this amount was what the Committee suggested, the need is actually much greater.

Change "Levee Certification" to "Compliance Determination"

Federal agencies should change the term "certification," which is used with FEMA's National Flood Insurance Program, to another term such as "compliance determination." The purpose of this change would be to better communicate to policy makers and the public that the determination does not imply a guarantee or warrantee of safety from flooding.

Swiftly Address Growing Concerns Regarding Liability

Congress should address the growing potential for public and private liability for future damages resulting from levee failures. It should explore a range of measures aimed at reducing the potential liability of engineering firms' and government agencies that provide engineering services for levee systems. Without swift action by Congress, there will be increasingly fewer entities willing to take on the responsibilities and work needed to reduce current and future flood risks. Many municipalities have received no responses to requests for qualifications for levee work. A recent survey of engineering firms traditionally performing such work showed no respondents willing to do so in the future without some form of liability mitigation. Liability reforms would help ensure state and local interest in developing state levee safety programs, and prevent much-needed levee repairs, rehabilitation and compliance determination (certifications) from coming to a halt.

Some of the liability reform measures that were considered by the Committee were as follows:

- Limitations on third-party liability for engineering firms and public agencies providing engineering services for a levee system. Such limitations should:
 - Establish that liability following a flood event would be affirmatively indicated only if the flood event was equal to or less than the design or rated level of flood protection provided by the levee system.
 - Establish that the engineering firm would not be liable for decisions (e.g., level of flood protection provided) made by other parties, such as the levee owner or maintaining agencies; and
 - Apply liability to an engineering firm only for damages caused by gross negligence, recklessness or willful misconduct by the firm.
- Limitations on liability for state and local agencies that sponsor, and then accept, federal flood control projects due to design and construction deficiencies. Since the federal government is responsible for the design and construction work, this would extend the current immunity enjoyed by the federal government to state and local agencies sponsoring the same project.
- Limitation on liability for state and local agencies that, by implementing levee safety programs, provide oversight, funding, or other services for non-federal levees.

Comprehensive National Public Involvement and Education/Awareness Campaign

Full public cooperation for a comprehensive National Levee Safety Program cannot be achieved until all parties who live or work in a flood plain understand the current risks they are bearing, what can be done to mitigate those risks, and what risks they will continue to assume. Through the establishment of technical and communications committees and resulting awareness campaign, a realistic understanding could be imparted. Such educational efforts would help to inform the public of the impact of their day-to-day land use decisions, understanding that those decisions must incorporate a tolerance and responsibility for risk. Proper awareness would influence many areas of civic behavior, including a willingness to

adequately fund levee improvements and maintenance as well as refraining from seeking legal redress for damage caused by foreseeable weather and hydrological events.

Conclusions

Inadequate programs and funding for national flood risk management have led to information lapses, deterioration of structures, excessive maintenance and repair needs, and catastrophic events. Preservation of human life is the most compelling reason for levee safety and we must do more to insure the safety of our citizens. However, we must also consider the costs of continuing to neglect this critical safety infrastructure. We saw both the human and financial costs of a single flood event on the Gulf Coast in 2005 following Hurricane Katrina. But there are also countless other floods across the nation that have had devastating impacts on our economy. While no definitive costs are available, the Committee has estimated that the nation's direct current flood damage losses may be on the order of \$5 to \$10 billion per year, with indirect costs orders of magnitude higher. These costs will continue to rise in the future. We must not persist in putting lives at risk or diminish our global competitiveness by failing to maintain and improve our nation's levee systems.

Much can and should be done beyond individual short-term fixes to address specific levee shortcomings. Without an overall National Levee Safety Program, actions and investments will remain inefficient and ineffective. The full requirements of comprehensive flood risk management are certainly not going to be met in one piece of legislation; however, an effective National Levee Safety Program will get us closer. Considering all of the ongoing expenditures for infrastructure and other activities that are dependent on the continued functioning of levee systems, it is both prudent and imperative to provide for reasonable attention to these systems.

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