The National Levee Challenge

Levees and the FEMA Flood Map Modernization Initiative

Report of the
Interagency Levee Policy Review Committee
Washington, DC

September 2006

This report was prepared for the Federal Emergency Management Agency by an Interagency Levee Policy Review Committee with support from Michael Baker Corporation under contract HSFEHQ-04-D0025, Task Order No. HSFEHQ-05-J-0008. The recommendations of this report are those of the committee and do not necessarily reflect the views of the participating agencies.

Interagency Levee Policy Review Committee
Washington, DC

September 1, 2006

Matthew B. Miller, P.E.
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Dear Mr. Miller:

Attached is the report of the Interagency Levee Policy Review Committee, which was prepared in accordance with Federal Emergency Management Agency (FEMA) Contract No. HSFEHQ-04-D-0025, Task Order No. HSFEHQ-05-J-0008, Michael Baker Jr., Inc.

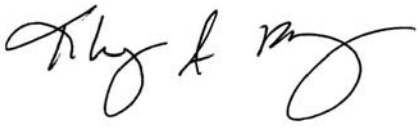
This report:

- Examines current FEMA levee policies, as stated in 44 CFR 65.10 and FEMA guidance documents, and recommends, as appropriate, changes to these policies
- Identifies public awareness and outreach challenges in the conduct of levee remapping and proposes approaches to be taken to deal with these challenges
- Proposes cooperative development by FEMA and the U.S. Army Corps of Engineers of a Geographic Information System-based levee inventory

The report has been coordinated with Federal agencies represented on the Interagency Committee.

We are prepared, at your convenience, to brief you or your staff on the details of the report.

Gerald E. Galloway, Ph.D., P.E.
Consultant, Michael Baker Corp.
Committee Chair



Kelly A. Bronowicz, CFM
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Report of the
INTERAGENCY LEVEE POLICY REVIEW COMMITTEE

Executive Summary

1. Levees, the National Flood Insurance Program, and Flood Map Modernization

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures designed for urban areas where there is insufficient room for levees. Both levees and floodwall are important components of the flood risk reduction systems of many flood-prone communities across the Nation and, over the years, have prevented billions of dollars in damages to property and protected millions of people from the threat of floods.

However, some levees and floodwalls and their appurtenant structures, when stressed beyond their capabilities to withstand floods, have failed with catastrophic results, as seen during Hurricane Katrina. The Department of Homeland Security's Federal Emergency Management Agency (FEMA) currently estimates that levees are found in approximately 22 percent of the Nation's 3,147 counties. Forty-three percent of the U.S. population lives in counties with levees.[1]

Dealing with areas "protected" by levees has been a critical issue for the National Flood Insurance Program (NFIP) since it was established by the National Flood Insurance Act of 1968. When the NFIP was established, thousands of individual levees existed across the United States, ranging from flood control projects with known levels of damage/risk reduction and well-documented engineering to small agricultural levees constructed by individual farmers. If FEMA determines that a levee can be accredited as providing protection from the 100-year flood[2], those living behind the levee no longer must comply with NFIP requirements for regulation of floodplain activity and mandatory purchase of flood insurance.[3] The challenge has been how to determine which levees should be recognized as providing protection from the 100-year flood and, once accredited, how to ensure that those accredited levees continue to provide 100-year protection and that the residual risk is effectively managed.

In 2004, as it initiated work under the Flood Map Modernization initiative (Map Mod), FEMA determined that analysis of the role of levees in flood risk reduction would be an important part of the efforts of Map Mod and directed the conduct of a scoping study to analyze the challenges to Map Mod and the NFIP that would be encountered as the Map Mod program progressed. The study group's report, issued in spring 2005, noted that the status of the Nation's levees was not well understood and the condition of many levees and floodwalls had not been assessed since their original inclusion in the NFIP.

[1] Figures are not available on the percentage actually protected by levees.
[2] The 100-year flood is equivalent to the terms 1-percent-annual-chance flood, FEMA base flood, and base flood.
[3] Communities must provide interior drainage of areas behind levees. When the drainage system will not provide adequate removal of storm waters, the community must identify areas that may flood as a result of inadequate drainage. These areas may be designated as Special Flood Hazard Areas (SFHAs) and require application of land use regulations within the interior SFHAs.

As it began work on the Map Mod initiative, FEMA determined that information developed for remapping of some levees revealed that those levees might no longer be in compliance with FEMA regulations, and that this would lead to the decertification (removal of accreditation) of these levees.[4] FEMA also determined that, in other cases, insufficient information was available on which to base an immediate determination of certifiability. If a levee was decertified, the residential structures behind that levee would be subject to mandatory flood insurance purchase requirements and additional floodplain regulation. FEMA determined that it needed to better assess the current status of its regulations and guidance and to examine the potential impacts of levee mapping on the Map Mod program.

2. The Interagency Levee Policy Review Committee

In September 2005, FEMA established the Interagency Levee Policy Review Committee to review current levee policy as articulated in Title 44 of the Code of Federal Regulations Section 65.10, *Mapping of Areas Protected by Levees* (44 CFR 65.10). The committee was asked to recommend changes to that policy, including outlining the rationale to support those changes and identifying any required revisions to FEMA regulatory or guidance documents and insurance rating practices. The committee was also charged with proposing a public awareness strategy to inform stakeholders of any changes in policy and the public's role in its implementation, and with overseeing development of a draft Geographic Information System framework for a national inventory of levees that would contain or provide access to pertinent data.

The committee first met in November 2005. Committee membership included representatives of the principal Federal agencies that deal with the flood damage reduction activities. Representatives of appropriate State and nongovernmental organizations were asked to participate in discussions of topics relevant to their expertise and interests. The committee met in person (with some members participating by telephone) eight times and coordinated preparation of its report through electronic mail and additional conference calls. During its deliberations, the committee was briefed by Federal agencies and State and other organizations on activities related to levee issues. Members of the committee conducted research into specific topics as needed.

This committee report addresses the current criteria for evaluating levees under the NFIP, the procedures for applying these criteria to certain situations, and the impact those actions have on the local community, Map Mod, and the NFIP. The report also recommends actions to be taken when it was found that current criteria and procedures need to be revised.

3. Conclusions and Recommendations

Based on its review, the committee developed conclusions and recommendations concerning the treatment of levees in the NFIP and in execution of the Map Mod initiative and the need for modifications to current approaches. These conclusions and recommendations are summarized in the following paragraphs

[4] On approval of levee certification documentation prepared by a professional engineer or an appropriate federal agency, FEMA will recognize the levee as providing protection against the base flood. When the levee no longer provides the specified protection, it is considered to be decertified and the recognition is withdrawn.

Identification of the Risk behind Levees

Levees only *reduce* the risk to individuals and structures behind them; they do not *eliminate* the risk. In fact, in many cases, they can create significant and potentially catastrophic residual risk that may increase if conditions in the region change, if the levees are affected by natural events, or if the levees are not properly maintained. Levees should be considered as *flood risk reduction* structures, not *flood protection* structures, and should be treated accordingly. A structure that is elevated to the 100-year Base Flood Elevation (BFE) faces significantly less risk than an unelevated structure built behind a 100-year levee.[5]

To ensure that the public and public officials are aware of the risk to the areas behind levees, **FEMA should define a new flood insurance zone (Zone XL) for areas behind levees that provide 100-year protection and meet other requirements for inclusion in the NFIP and, in coordination with other agencies, identify the level of risk to those structures behind those levees.**

The XL zone would include those areas behind the levee that are subject to inundation by the 100-year flood in the without-levee condition. The area between the 100- and 500-year floodplain lines would be shown as a shaded X zone.[6]

Levees would also be identified under a scientifically based levee risk classification system (e.g., high, medium, or low). This classification system would be based on several factors, including the following:

- Potential depth of flooding in the event of failure or overtopping
- Type and density of development in protected areas behind the levee
- Steps taken to ensure that levee failure does not occur during levee capacity exceedance (overtopping)
- Warning times
- The number and types of egress so that people who may be inundated may move out of harm's way

This levee risk classification would be designated on the Flood Insurance Rate Map (FIRM) and in the Flood Insurance Study report.[7]

[5] Flood risk is the product of the probability of occurrence of a flood and the consequences of that flood. Residual risk is the portion of risk that remains after a flood damage reduction structure has been built. Risk remains because of the possibility that the capacity design level of protection for the structure is exceeded by a flood event that the structure fails and/or there are problems with the interior drainage.

[6] An explanation of zone definitions is provided in Appendix E.

[7] The U.S. Army Corps of Engineers is currently developing a risk assessment system that will be coordinated among Federal agencies.

Improvement of Regulations Governing Levees in the NFIP

Current regulations and other guidance for recognition and mapping of levees in the NFIP are not adequate for making the initial determination that a levee meets minimum design, operation, and maintenance standards, and ensuring that it continues to meet standards.[8]

The regulations and guidance do not provide adequate oversight of a levee's continued conformance with NFIP criteria. Therefore, the regulations may permit inclusion and/or retention in the NFIP of levees that do not provide the required level of protection.

To ensure that levee systems maintain the conditions that qualified them for NFIP accreditation, FEMA should require as a condition of retaining FEMA recognition of levee status that sponsors:

- Conduct annual inspections of the levee system
- Submit to FEMA biennially the results of the annual inspections, levee system operation and maintenance records, and an assessment of the levee system during any flood events that occurred within the reporting period
- Submit to FEMA every 10 years a report, prepared by a registered Professional Engineer or Federal agency responsible for levee design, that recertifies the engineering and geotechnical conditions of the levee system
- Certify levees as systems that include not only levees and floodwalls, but also the pumps, interior drainage systems, closures, penetrations, and transitions that provide systems integrity, and ensure that operation and maintenance plans cover all elements of the system

To ensure that all components of a levee system meet required standards, FEMA should exclude embankments, such as roads and railroads, from inclusion in accredited levee systems unless those embankments meet the engineering criteria required of levees and are maintained and operated in accordance with the provisions of 44 CFR 65.10.

FEMA should revise 44 CFR 65.10 to incorporate the above recommendations and to deal with other needed changes in the administrative requirements of 44 CFR 65.10 as noted in the appendices to this report.

Development of a Levee Inventory

Information about the location and condition of levees across the Nation is spotty and is not in a form that supports effective management and decision making.

Various levee databases have been developed, but for the most part they are not geospatially referenced, are incomplete, and lack usable information concerning the condition of the levees and attendant supporting structures. Current efforts by the U.S. Army Corps of Engineers (USACE) and FEMA to coordinate and develop a multi-agency, Federal-State approach to inventory and assessment promise to provide significant benefits.

[8] As noted earlier, levee owners or sponsors ***certify*** that levees meet FEMA standards (44 CFR 65.10). If the certification information is acceptable, FEMA ***recognizes*** (or accredits) on NFIP maps that a levee system provides protection from the base flood.

FEMA and USACE should continue their efforts to develop a joint database structure that will meet the needs of both agencies and other Federal and State organizations to maintain an inventory and assessment of flood damage reduction structures, including levees.

While agency-specific components of such a database will be needed, the management and fiscal benefits that accrue from a common core and adherence to the national spatial data infrastructure (NSDI) will be significant.

Improving Public Understanding of Levee Risks

The public at large and public officials generally do not understand the residual risk to those living behind levees. The public also does not understand that FIRMs provide information only about levees that have been recognized by the NFIP and not information about the existing risk to structures located behind those recognized levees.

Working with its Federal, State, and local partners and with levee sponsors, FEMA should develop and implement a public awareness and outreach strategy that will improve public awareness and understanding of the hazards and risks associated with levees. This audience includes the Administration and Congress, other public officials, and private citizens.

As part of this public outreach effort, levee sponsors should be required to notify annually property owners in areas behind a levee about the residual risk that exists and the risk classification of the levee.

Enhancing Institutional Relationships

The relationships among institutions and organizations dealing with levees are not clearly defined and vary by agency and region.

The Federal Government's role in flood damage reduction through USACE, the Natural Resources Conservation Service (NRCS), the Bureau of Reclamation, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS) is generally understood. FEMA's role in floodplain management is evolving and is less understood by the public. Similarly, the role of State and local organizations in carrying out floodplain-related activities is evolving.

Success in Map Mod as well as flood damage reduction will depend on the development of close working relationships among representatives of the agencies involved.

Efforts should be made to closely coordinate the activities of relevant Federal agencies in floodplain management and related mapping programs.

Assisting Communities following Levee Decertification

The process of conducting certification activities and, if required, restoration of decertified levees will place a heavy burden on local communities.

These communities are already turning to the Federal Government for support, and the Federal Government should expect these requests to increase. These requests will place heavy burdens on related FEMA and USACE programs that are already fiscally stretched thin.

FEMA and USACE should review existing authorities and funding available to assist communities in performing certification analysis and make recommendations to the Office of Management and Budget (OMB) if the funding and authorities are not available.

FEMA and USACE also should develop expedited processes to assist communities in remediation of publicly owned levees and seek OMB and Congressional approval of these processes and the need for resource commitments to support them.

FEMA should consider seeking legislative action to permit use of A99 designation and procedures by communities that are able to self-fund levee upgrades.

Ensuring 21st Century Levee Design

Much of the baseline information that is used in determination of the height of the 100-year flood is out of date. The engineering community is replacing the current levee-height determination methodology required by 44 CFR 65.10 with new approaches. As a result, levee designs and flood risk determinations may not reflect current conditions; this could increase the flood hazard risks to those behind levees and in the floodplain.

To ensure that the base data used to support the hydraulics and hydrology (H&H) analysis are up to date and reflect 21st-century computation technologies, **FEMA, in coordination with other Federal agencies that use these data and techniques, should support funding of NOAA efforts to upgrade precipitation frequency estimates, upgrades to the USGS gaging program, and the Advisory Committee on Water Information Subcommittee on Hydrology revision of *Bulletin 17B***, which guides flood recurrence interval determinations.

Recognizing the national and international movement toward use of risk analysis in dealing with floods and their consequences, the significant strides that have been made in developing risk assignment techniques, and the current use of these techniques by USACE in levee design, **FEMA should modify 44 CFR 65.10 to phase out, over the next 10 years, use of the freeboard-based approach and should substitute the risk analysis methodology for levee-height determination**. During the transition period, FEMA should permit either approach to be used in levee design and recertification analysis.

4. Observations

In the course of its review, the committee encountered issues that did not specifically relate to the challenges faced by the Flood Map Modernization program, but in the committee's opinion, these issues should be brought to the attention of FEMA and would merit action by FEMA.

a. Strong consideration should be given to not recognizing, for NFIP purposes, levees that provide protection to highly urbanized areas unless they provide protection against floods greater than 100 years (e.g., the 500-year flood). There is a long history of recommendations and analyses to support protection to 500-year or greater levels. Given the large number of existing levees, the transition would not be quick or easy. Nevertheless, FEMA should take steps to immediately examine this issue in detail and determine if a change in the standard for recognition should take place.

b. Non-Federal levees exist at the sufferance of the States and counties in which they are located. Federal levees, for the most part, are passed to State and local sponsors following their completion for operation and maintenance. State and local agencies must play a significant

role in dealing with levee issues as they arise. Federal agencies should recognize the State and local roles and develop incentives and support mechanisms to ensure that State and local agencies can effectively carry out their responsibilities.

c. Property owners behind levees continue to face the residual risk of flooding, yet they are not required to share in the mitigation of this risk through insuring their property against the dangers of the residual risk. FEMA should address the challenge of the residual risk in the following ways:

   — Seeking legislative change to require property owners to purchase some level of flood insurance for structures behind levees (new Zone XL).

   — Requiring communities to establish special early warning systems and to develop flood warning – preparedness plans for those areas that are protected by levees.

d. The current H&H approach for calculation of the BFE ensures that structures being designed to comply with the BFE are out of date by the time they are constructed. Future H&H conditions are not directly addressed. FEMA, working closely with other Federal agencies, States and communities, should examine how best to deal with climate change, sea-level rise, and future development. Such efforts will require the commitment of significant resources. It also represents a conceptual shift from specifying the mapping criteria to reflect present conditions to establishing criteria based on possible, but not fully quantifiable, future conditions.

e. When communities are not able to document immediately the recertifiability of currently certified levees and the levees are not known to be at risk, FEMA should notify the communities of the need for a more detailed examination of the levees and provide a specific schedule for that activity. Communities should be required to notify all residents who are living in areas behind the levees of the re-examination and identify for them the residual risks and the need for information about the levees. This action would closely parallel ongoing FEMA efforts to permit completion and adoption of new countywide maps that contain levees needing further study.

f. A major challenge facing those responsible for levee certification is conduct of appropriate and rapid geotechnical assessments of levee integrity. These assessments are critical to providing assurances of levee safety. However, such assessments, depending on the nature of the material and the cross section of the levee, are very costly. The bulk of the costs are related to the number and depth of soil borings. While some research is underway in Japan and the Netherlands on use of remote electro-magnetic sensors, no methods or technologies are currently available in the United States to replace soil borings, and little effort is underway in the Research and Development (R&D) community to deal with the challenge. FEMA, USACE and USGS should support R&D efforts focused on improvement of rapid assessment of levee geotechnical integrity and should jointly recommend to the National Science Foundation that attention be given to this area of research.

5. The Challenge Ahead

The committee recognizes that the recommendations and observations it has offered will require significant resource commitments at both the Federal and State levels. In a period of intense pressure on budgets, such proposals certainly will not be well received. The issue, in reality, is one of "pay me now or pay me later." The harsh truth about levees is their potential for eventual failure. It is incumbent on leaders at all levels of government to argue forcefully for dealing with those issues now, while costs are far less than they might be in the future when another Katrina-type event occurs.

1. Levees and the FEMA Flood Map Modernization Initiative

1.1. The Levee Challenge

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding, as shown in figure 1-1. Floodwalls are concrete structures designed for urban areas that have insufficient room for levees, as shown in figure 1-2. Both levees and floodwalls, together with the pumps and drainage equipment that complete a levee system, are important components of the flood risk reduction systems of many flood-prone communities across the nation.

Over the years, these systems have prevented billions of dollars in damages to property and have protected millions of people from the threat of floods. However, some levees and floodwalls and their appurtenant structures have been stressed beyond their capabilities to withstand floods and have failed—with catastrophic results. The Department of Homeland Security's Federal Emergency Management Agency (FEMA) currently estimates that levees are found in approximately 22 percent of the nation's 3,147 counties. Forty-three percent of the population lives in counties with levees.[9]

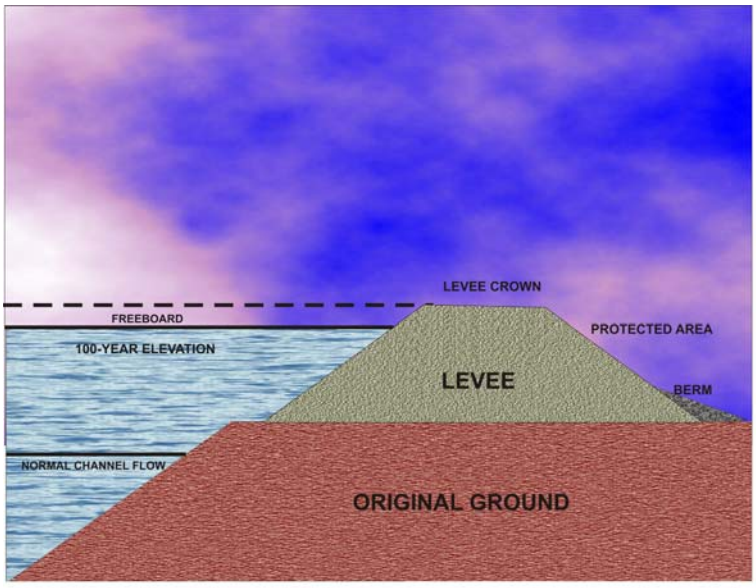

Figure 1-1. Levee Cross Section

[9] Statistics are not available for the percentage of the population actually protected by levees.

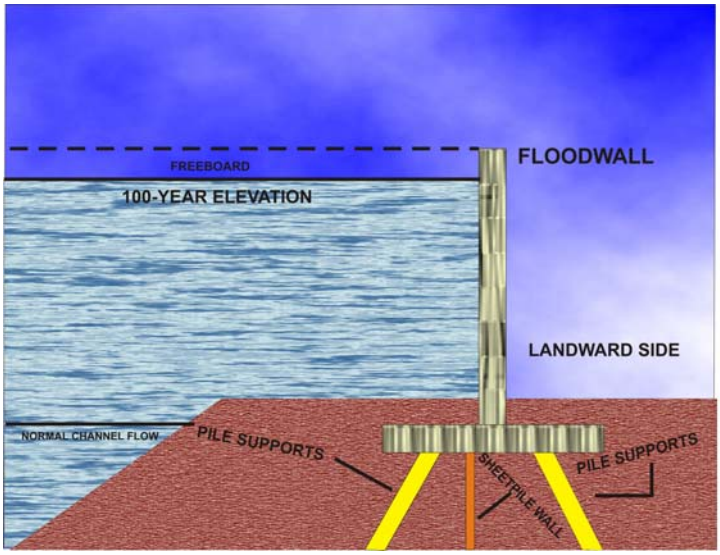

Figure 1-2. Floodwall Cross Section. In this figure, the floodwall is supported by piles and a sheet pile wall. Other floodwalls are supported only by a concrete "T" or similar base.

In July 2004, as it initiated work under the Flood Map Modernization (Map Mod) initiative, FEMA determined that analysis of the role of levees in flood risk reduction would be an important part of the efforts of Map Mod. At that time, FEMA directed the initiation of a scoping study to analyze the challenges to Map Mod and the National Flood Insurance Program (NFIP) that would arise as Map Mod progressed. The study group's report, issued in spring 2005, noted that the status of the Nation's levees was not well understood, and the condition of many levees and floodwalls had not been assessed since their original inclusion in the NFIP. This report recommended undertaking a more detailed study and issuing interim guidance to Map Mod participants on how to deal with levees. In August 2005, FEMA codified this guidance in Procedure Memorandum 34.

1.2. The Interagency Levee Policy Review Committee

In September 2005, FEMA established the Interagency Levee Policy Review Committee to examine the levee situation and directed the committee to:

- Review current levee policy as articulated in 44 CFR 65.10 and recommend changes to the policy, including the rationale supporting those changes and the identification of suggested modifications to FEMA regulatory or guidance documents and insurance rating practices
- Prepare a public awareness strategy to inform stakeholders of any changes in policy and their roles in its implementation
- Oversee development of a draft Geographic Information System (GIS) framework (for a national inventory of levees containing or providing access to pertinent data)

FEMA also directed the committee to prepare a report that would:

- Identify potential problems, if any, with current policy and give examples of situations that manifest those problems

- Discuss the need, if appropriate, for regulatory changes and provide the reasoning behind any recommended changes and an implementation concept
- Provide recommendations regarding the application of the suggested levee policy to counties that already have modernized maps
- Discuss the need, if appropriate, for revisions to insurance rating practices in areas protected by levees and provide the reasoning behind any recommended changes and an implementation concept

Committee participants are listed in Appendix A.

1.3. Levees and the NFIP

The flood damage/risk reduction that a levee system provides is a function of the levee crown's elevation along its entire length, the levee's structural integrity, the stage (i.e., the height) of the flood against which the levee is designed to provide protection, and the functioning of the appurtenant structures. Over time, all four of these elements are subject to substantial change, thereby changing the level of damage/risk reduction originally ascribed to the levee system. When levee systems fail because of structural or foundation problems, or when they are overtopped and the embankment erodes to failure stage, the results can be catastrophic. Depending on the topography, the depth of water in the flooded area can rise from 0 feet to more than 20 feet in a matter of minutes and that water remain trapped behind the levee for an extended period of time. (Ground levels for sections of some levee-protected areas in California are more than 20 feet below the top of the levee. Much of the New Orleans area that lies behind levees is at or below sea level and is subject to deep flooding.)

The goals of the NFIP, established by the National Flood Insurance Act of 1968, as amended, are:

- To better indemnify individuals for flood losses through insurance
- To reduce future flood damages through State and community floodplain management regulations
- To reduce Federal expenditures for disaster assistance and flood control

FEMA has also established, as an implied goal for the NFIP, the restoration and preservation of the natural and beneficial values of floodplains.

The NFIP implements its insurance ratings and requirements for land use controls through Flood Insurance Rate Maps (FIRMs). The FIRMs are also used by Federal agencies and lenders to apply the mandatory flood insurance purchase requirement of the NFIP. Although these maps are produced for insurance and regulatory purposes, they are often the only existing form of flood hazard mapping for a community. They are used by many communities and agencies as a guide for

other flood-related activities. In effect, these maps represent the principal means by which the Federal government communicates flood risk to the public.

When an area behind a levee that provides damage/risk reduction from the 100-year flood[10] is shown on a FIRM, that area is considered to be outside the 100-year floodplain. Residents in these protected areas are not required to obtain flood insurance, and the community is not required to apply FEMA floodplain management regulations to the area. 44 CFR 65.10 provides criteria for determining whether the NFIP should recognize a levee for the purposes of removing the protected area from the floodplain. Communities requesting official recognition of their levees must submit certification by a professional engineer that the levee meets the requirements of 44 CFR 65.10, or they must demonstrate that a Federal agency has indicated that the levee meets the NFIP standard.

Formal certification of levees began in 1982. Prior to that date, levees were included in the NFIP when FEMA, another Federal agency, or a local sponsor indicated that the levee met general engineering standards for levees.

Over the past decade, Federal and State agencies have studied the hydrology and hydraulics (H&H) in many areas where levees provide damage/risk reduction. New and better data and modern techniques have led to significant revisions of their estimates of the 100-year flood stage. (In some areas along the lower Missouri River, the height of the 100-year flood has been recalculated and is as much as 4 feet higher in some reaches than is shown in current flood maps. It is also as much as 2 feet lower in other reaches.) The 100-year stage represents the Base Flood Elevation (BFE) used to establish floodplain regulation and insurance under the NFIP. A major factor in many of the increases in elevation across the Nation has been the increase in frequency and magnitude of large floods, many of which have caused failure or overtopping of levees. In addition, over time, through subsidence or partial levee failures, the profile and integrity of many levees have deteriorated.

In 2004, FEMA initiated Map Mod to digitize and update its FIRMs over a 5-year period. When a levee is shown on a map panel that is undergoing revision, FEMA faces one of three situations.

- Information is available to verify that the levee is in good condition and provides the level of damage/risk reduction shown. (The area can be mapped with levee protection included.)
- Information is available to verify that the levee does not (or never did) provide the required level of damage/risk reduction. (The area "protected" by the levee is mapped as if the levee does not exist, and the residents behind the levee will be required to obtain flood insurance and to comply with FEMA floodplain management regulations.)

[10] The 100-year flood is equivalent to the terms 1-percent-annual-chance flood, FEMA base flood, and base flood.

- Available information is inadequate to determine the status of the levee, other than its previous inclusion on the map as providing damage/risk reduction. (FEMA must either assume that the levee continues to provide damage/risk reduction or take action to determine the present status of the levee.)

This report addresses the current criteria for evaluating levees and floodwalls under the NFIP, the procedures for applying these criteria to the above situations, and the impact these actions may have on the local community, Map Mod, and the NFIP. The report also recommends actions to be taken to revise current criteria and procedures.

2. The Role of Levees in the NFIP

2.1. Mapping of Protected Areas

Mapping of areas "protected" by levees has been a critical issue for the NFIP since it was established by the National Flood Insurance Act of 1968. The Act directed the U.S. Department of Housing and Urban Development (HUD) to establish floodplain management criteria and to map the Nation's flood hazards, but did not specify a standard. HUD contracted with the University of Chicago's Center for Urban Studies to conduct a seminar of experts to recommend floodplain management criteria and a mapping standard. The Chicago Seminar recommended that "the 100-year flood would be a reasonable level to use in identifying flood-prone areas." HUD subsequently adopted the 100-year flood as the standard for NFIP flood hazard mapping, floodplain management, flood insurance rating, and later for implementation of the mandatory purchase requirement. However, the report did not specify how that standard should to be applied to levees.

When the NFIP was established, thousands of individual levees existed across the United States, ranging from recent U.S. Army Corps of Engineers (USACE) flood control projects, with known levels of damage/risk reduction and well documented engineering, to small agricultural levees built by individual farmers. Most levees lay somewhere in between. The challenge was to determine which of these levees should be recognized as providing protection from the 100-year flood.

2.2. Roles and Responsibilities

Although this report primarily addresses the process that FEMA uses to determine whether levee systems can be credited with providing protection from the 100-year flood, it is important to recognize that all levels of government have roles and responsibilities in the design, construction, and operation and maintenance of levee systems. These levels include:

- **Federal levee construction agencies.** Federal agencies such as USACE, the Natural Resources Conservation Service (NRCS), and other agencies design and construct levees pursuant to authorizations and appropriations from Congress.[11] These projects usually require a local sponsor, which can be a community or a special district.
- **State governments.** States play several roles in levee construction and levee safety. Some States directly regulate levee construction, including the establishment of design standards and the review and approval of levee engineering. States may also require operation and maintenance plans as a condition of levee approval, conduct levee inspections, and require emergency action plans. States also perform important roles in implementation of the NFIP including floodplain management and flood hazard mapping.
- **Local governments.** Local governments, including communities and special districts, can design and construct levee systems or act as the local sponsor when a Federal agency designs and constructs a levee system. In both situations, the local government will usually assume the responsibility for operation and maintenance of the levee system and for emergency planning. Local governments have a critical role in determining the level of damage/risk reduction provided by a levee system since they must fund the design and

[11] Most NRCS levees are designed to provide 4 percent (25-year) protection to support agricultural use of the land.

construction of the system or, as the local sponsor, be willing to share in the cost of the system with the Federal government.

- **Federal Emergency Management Agency.** FEMA administers the NFIP and, as part of that program, conducts flood hazard mapping for the Nation. As part of the mapping program FEMA must determine whether a levee can be credited as providing 100-year protection.

2.3. Levee Design, Certification, and Accreditation

FEMA has established procedures to govern the determination that a levee can be credited as providing protection from the 100-year flood. FEMA's determination is made for the purposes of administering the NFIP's floodplain management, flood insurance, and mandatory purchase requirements, and does not necessarily mean that the levee provides *adequate* damage/risk reduction for a particular community. Depending on the circumstances, higher levels of damage/risk reduction may be warranted. For purposes of this report, it is important to recognize the differences between levee design, levee certification, and levee accreditation. FEMA procedures include consideration of:

- **Levee design.** When designing a levee system**,** the most critical decision that must be made is the design level of damage/risk reduction to be provided by the levee system. The optimal design level of damage/risk reduction for a levee will vary based on a number of factors, such as the severity of the risk of flooding to life and property, the critical nature of the facilities to protected, the economics of levee construction, and other factors. FEMA has established *minimum* design criteria for crediting levees for the purposes of administration of the NFIP. FEMA design criteria need to be taken into account during the design process, but should not be the primary factor in determining the design level of damage/risk reduction for the levee system.
- **Levee certification.** A registered professional engineer must certify that a levee system complies with the structural requirements of 44 CFR 65.10. Certification is further defined in 44 CFR 65.2. As an alternative, a Federal agency with responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the base flood. FEMA does not certify levee systems.
- **Levee accreditation.** Accreditation is the process of determining whether a levee can be credited as providing protection from the 100-year flood. FEMA bases its decision on information submitted by the community or another party seeking recognition of the levee and, in particular, places reliance on the certification by a registered professional engineer or a Federal agency with responsibility for levee design.

2.4. The Early Days

When the NFIP was established, little guidance was available to deal with the inclusion of existing flood damage/risk reduction systems in the program. A 1982 report by the National Academy of Science's National Research Council (NRC) offered a succinct history of how levees were credited during the initial years of the program:

> "For the conduct of this mapping program (the initial FHBMs), FEMA did not provide guidance for evaluation and acceptance of local flood protection works, such as levees, as sufficient for removal of special flood hazard area designations. The assessment of a particular protection work was left to the

> judgment of the agency or consultant who produced the map. In most instances, because of time and cost constraints, levees with crown elevations exceeding estimated 100-year flood levels were credited with providing protection against the 100-year flood. Little or no consideration was given to freeboard requirements, structural stability, or maintenance.
>
> As a result of the Flood Disaster Protection Act of 1973, the mapping to define flood risk zones, called flood insurance studies, was also accelerated. The lack of a specific policy for treating leveed areas carried over into the rate mapping program, and the study contractor's evaluations were made primarily on the basis of field reconnaissance and a comparison between levee crown elevations and computed 100-year flood levels."
>
> In 1975, following the initiation of a significant number of rate studies, the need for a formal levee policy became more apparent. The Federal Insurance Administration (FIA) began receiving requests from study contractors for guidance on evaluation of levees. Land developers began requesting that FIA provide standards that levees must meet so that "protected" areas could avoid the special flood hazard designation. Various groups were constructing 100-year design levees for the sole purpose of removing property from the floodplain management, lender notification, and insurance purchase requirements under the NFIP."

Throughout this early period, decisions were made on whether to credit thousands of levees. Because there were no levee standards and crediting of a levee was left largely to the judgment of the study contractor, many levees were credited as providing flood protection even though they would not meet the current NFIP levee standards as stated in 44 CFR 65.10. During subsequent remappings, many of these levees were re-evaluated and either credited as providing flood protection or not credited. An unknown number are currently shown as providing flood protection, but do not meet the standards of 44 CFR 65.10 or have never been evaluated against those standards. Some of these areas have been restudied, but the initial crediting of the levee was not reevaluated, and the FIRM continues to show the levee as providing 100-year protection.

2.5. The Brooks Amendment and the Establishment of A99 Zones

Once the Flood Disaster Protection Act of 1973 was passed, establishing the mandatory flood insurance purchase requirement, the FIA faced increased pressure to recognize levees as providing flood protection. The crediting of levees now determined whether or not property owners would have to purchase flood insurance in order to obtain a mortgage from a federally insured or regulated lender or other Federal financial assistance. The U.S. Congress passed the Brooks Amendment in 1974, leading to the establishment of A99 zones. Under the Brooks Amendment, any community that has made adequate progress on the construction of a flood protection project that will afford protection from the 100-year flood is eligible for flood insurance at rates no greater than the rate that could be charged had the project been completed (A99 rates are currently the same as Zone B, C, and X rates). Adequate progress was defined as:

> "(1) 100 percent of the project cost of the system has been authorized, (2) at least 60 percent of the cost of the system has been appropriated, (3) at least 50 percent of the cost of the system has been expended, and (4) the system is at least 50 percent completed."

FIA's implementing regulations at 44 CFR 61.12 further limit A99 zones to flood protection systems involving Federal funds. Apparently, this is based on the amendment's language about the cost of the project being authorized and appropriated and the belief that federally funded flood damage/risk reduction systems were more likely to be completed than those funded by local

governments or the private sector. Because A99 zones continue to be Special Flood Hazard Areas (SFHAs), the mandatory flood insurance purchase requirement remains in effect. Buildings in A99 zones do not have to be elevated or floodproofed to the BFE, but they do have to meet other floodplain management requirements.

The Brooks Amendment is important for two reasons. First, it codified the 100-year flood as the standard for the recognition of levees. Second, it set a precedent for special treatment of areas protected by levees in a levee system that no longer provides protection from the 100-year flood.

2.6. FEMA's 1981 Interim Levee Policy and Issuance of 44 CFR 65.10

During the late 1970s, FIA's policy toward crediting levees evolved as more Flood Insurance Studies (FIS) were conducted, and decisions had to be made on crediting individual levee systems. This culminated in the issuance of The FEMA Interim Levee Policy on February 10, 1981. This policy included many of the same elements found in 44 CFR 65.10. Key elements of the Interim Levee Policy included the following:

- Privately owned, operated, or maintained levee systems would not be recognized unless local ordinances or State statutes mandated operation and maintenance.
- A minimum of 3 feet of freeboard was established, with provisions for exceptions for lower freeboard where the applicant demonstrated a lower level of uncertainty.
- The study contractor was required to inspect and evaluate the levee or obtain certification from a Federal or State agency or registered professional engineer.
- FIA would not recognize levees that require human intervention for the purpose of raising the levee's design level during a flood. Any closure structures must be designed to be an integral part of the system.
- Protected areas were to be shown as Zone B (now Zone X (shaded)) on the FIRM and internal drainage areas mapped as appropriate. Floodway boundaries were to be at the landward toe of the levee.
- The USACE manual for Design and Construction of Levees (EM 1110-2-1913) was to be used in conjunction with the policy.
- Standards relative to seepage, surface erosion, and settlement were defined.

Guidelines for Operation and Maintenance of Levees, Floodwalls, and Interior Drainage Facilities also were developed at this time.

FIA was advised in the early 1980s by FEMA's Office of General Council that, for legal reasons, the levee policy needed to be promulgated by regulation. FEMA issued a final rule on August 25, 1986 adding 44 CFR 65.10 to the NFIP regulations.

2.7. National Research Council Report

In addition to issuing the Interim Levee Policy, FEMA contracted with the National Academy of Science's NRC to make recommendations for a comprehensive levee policy for use in administering floodplain management, insurance, and risk mapping aspects of the NFIP.

A committee of experts assembled and issued a report titled *A Levee Policy for the National Flood Insurance Program* at the end of 1982. FEMA's request to NRC cited numerous concerns with levees:

- Levee overtopping or failure is involved in approximately one-third of all flood disasters.
- As a design standard, the 100-year flood is generally too low for densely populated areas.
- Most earthen levees with their crowns at the computed 100-year flood level will not provide protection against the true 1-percent-annual-chance flood due to uncertainties in determining flood elevations, changing hydrologic conditions, and the possibility of failure before they are overtopped.
- The degree of protection from a 100-year design levee is less than that obtained by elevating individual buildings to above that elevation due to catastrophic damages that would occur as a result of overtopping or failure.
- Crediting a levee system as providing 100-year protection removes floodplain management and insurance purchase requirements and may violate the spirit of the NFIP by encouraging development in damage-prone areas.

The NRC report recommends criteria for recognizing levees, many of which are consistent with current provisions of 44 CFR 65.10. The report also includes recommendations that have not been incorporated into the NFIP or of particular interest to this study. These recommendations include:

- Existing levees that provide at least 25-year protection and meet design criteria should be recognized for the purpose of reducing flood insurance rates.
- FEMA should monitor watershed and channel changes where hydrologic risk is increasing and respond to significant changes with restudies and map revisions.
- FEMA should inventory all levees previously credited as providing 100-year protection, set priorities, and schedule the communities for restudies to re-evaluate the levees.
- The levee owner must formally adopt a specific operations and maintenance plan if the levee is to be credited and continue to be credited. The plan should provide for periodic inspections by a registered professional engineer.
- FEMA should require the purchase of flood insurance for all buildings behind levees that provide less than 500-year protection.
- Local officials should periodically notify owners, tenants, and lenders behind levees of potential risk.
- Local officials should prepare a warning and evacuation plan for levee-protected areas.
- FEMA should contract to develop a list of key factors to evaluate the physical condition of the levee and guidance on using those factors to estimate geotechnical risk.
- All levees, dikes, or floodwalls should be clearly labeled as such on the FIRM. Areas protected by 100-year levees should be delineated on FIRMs and Flood Hazard Boundary Maps (FHBMs).
- A series of recommendations are made about a very detailed set of zone designations for levees providing various levels of protection. The concern appears to be establishing actuarial insurance rates that accurately reflect risk behind levees.

Several of these recommendations are at least partially addressed in 44 CFR 65.10; others are not.

2.8. Establishment of Flood Control Restoration Zones (Zone AR)

Floods along the American River in Sacramento, California, and the Los Angeles River in Los Angeles County during the 1980s led USACE to reevaluate the hydrology of the two river systems and the level of damage/risk reduction provided by both flood damage/risk reduction systems. USACE concluded that the flood damage/risk reduction systems provided less than 100-year protection and notified FEMA. Normally, the next step would have been for FEMA to restudy the rivers and issue new FIRMs showing the areas behind the levees as AE zones. Decertification of these flood damage/risk reduction systems would have directly affected hundreds of thousands of people in the Los Angeles and Sacramento areas.[12] In Los Angeles County alone, 14 Congressional Districts were directly impacted.

The severity of these impacts (thousands of property owners would have to purchase flood insurance) led the California Congressional delegation to propose and Congress to pass certain provisions in the Housing and Community Development Act of 1992, which amended Section 1307 of the National Flood Insurance Act of 1968 to establish AR zones This new zone type was intended to provide the affected communities with time to restore their flood damage/risk reduction systems so that they would meet the requirements of 44 CFR 65.10 without the areas being designated as AE zones. FEMA worked with the California delegation to develop language that could be implemented and provided some relief to property owners and the affected communities while the levees were being restored. Key provisions of the Act include:

- The project must have been previously credited as providing 100-year frequency flood protection but no longer does so.
- A Federal agency in consultation with the local sponsor must deem the system restorable.
- A minimum level of flood protection must still be provided.
- Restoration must occur within a designated time period in accordance with a progress plan negotiated between FEMA and the community.
- While the area was designated Zone AR, flood insurances rates could not exceed those applied in Zone X.
- AR zones were to be SFHAs and the mandatory flood insurance purchase requirement would apply.
- Floodplain management criteria would not apply to improvements to existing structures and elevation requirements for new construction could not exceed 3 feet above grade in developed areas.

FEMA adopted implementing regulations that became effective on October 25, 1994. These regulations limited AR zones to levees constructed using Federal funds. The Act itself only requires that a Federal agency in consultation with the project sponsor deem the system restorable.

[12] On approval of levee certification documentation prepared by a professional engineer or an appropriate federal agency, FEMA will recognize the levee as providing protection against the base flood. When the levee no longer provides the specified protection, it is considered to be decertified and the recognition is withdrawn.

The supplemental information to FEMA's Final Interim Rules includes the following rationale for this further limitation:

> "FEMA concludes that a lack of Federal involvement in the restoration process would introduce too great an uncertainty that the restoration project would be completed in a timely manner."

In both areas, the levee systems were restored to provide 100-year flood protection. The areas are now shown as shaded X zones. Although several communities have expressed interest in Zone AR designation in the years since, no additional AR zones have been designated. This may change as Map Mod proceeds.

The problems with the American River levee system brought to the forefront the issue of residual risk behind levees. Of greatest concern was the Natomas Basin, a 55,000-acre, partially developed area immediately north of downtown Sacramento. The concern was that, if the levee system was restored to provide 100-year protection, the area would be fully developed and an estimated $15 billion of dollars of additional development would be at risk if the levee system was overtopped or failed. The NRC assembled a committee to evaluate alternatives to provide flood damage/risk reduction along the American River. Its report, *Flood Risk Management and the American River Basin; An Evaluation*, published by the National Academy of Sciences in 1995, discussed in detail the issue of residual risk and recommended in part that local governments work with FEMA to require that landowners purchase actuarially sound flood insurance to address the residual risk behind levees.

2.9. Midwest Flood of 1993

In 1993, the Midwest Flood again brought issues related to levees to the forefront. The flood approached or exceeded the 100-year threshold on most major rivers and resulted in overtopping or failure of large numbers of levees, most of them agricultural levees that provided various levels of damage/risk reduction. Most of the levee issues related to the advisability of repairing agricultural levees and to the operation of the PL 84-99 levee repair program by USACE.

Although only a few of the levee systems that were credited as providing 100-year protection were overtopped or failed, several levee systems protecting major urban areas, including parts of the City of St. Louis, were threatened. Had the flood been somewhat larger, these levee systems could also have been overtopped or failed. The single most costly levee failure during the Midwest Flood was the Monarch-Chesterfield Levee at Chesterfield, Missouri. This levee was an agricultural levee that had been upgraded during the early 1980s and was credited by FEMA as providing protection from the 100-year flood. Once the levee was credited, industrial and commercial development occurred. When floodwaters threatened the levee, most businesses bought flood insurance. When the levee failed, more than $13 million in claims were paid, 5 percent of the total claims for the Midwest Flood. This levee has since been rebuilt and upgraded to provide 500-year flood protection.

In the aftermath of the Midwest Flood, the Administration established the Interagency Floodplain Management Review Committee to review the causes and consequences of the flood and make recommendations for improvements to Federal floodplain management programs and policies.

Its report, *Sharing the Challenge: Floodplain Management into the 21st Century (Interagency Floodplain Management Review Committee, June 1994,* made the following recommendations regarding levees protecting urban development:

- Reduce the vulnerability of population centers to damage from the standard project flood discharge.
- Require actuarial-based flood insurance behind all levees that provide protection less than the standard project flood.
- Establish USACE as the principal federal levee construction agency.

The Midwest Flood also resulted in a reevaluation of the 100-year flood discharges and the flow lines along the Mississippi River. Incorporating the new flow lines into Map Mod will require reevaluation of many of the levee systems along the Mississippi River that are currently credited as providing flood protection.

2.10. Hurricane Katrina

Hurricane Katrina hit the New Orleans area on August 29, 2005, as a Category 3 storm. It first appeared that most levees protecting the City of New Orleans itself had not been overtopped, although levees in St. Bernard Parish to the south had been inundated by storm surge, as shown in figure 2-1. One day later, it became apparent that a number of floodwalls along canals in the city had failed and that the city was slowly filling up with water. What initially appeared to be a large flood event quickly became the most costly natural disaster in the history of the United States. New Orleans not only faces the challenge of protecting itself against external flood threats, but must also provide for the major infrastructure necessary to pump rain waters from inside the levees. Many New Orleans residents are subject to mandatory insurance purchase because they reside in a SFHA created because the city cannot pump out storm waters.

Figure 2-1. New Orleans was inundated by floodwaters following Hurricane Katrina.

As of the date this report was written, floodwall failure mechanisms, pumping system performance, and the level of damage/risk reduction actually provided by the pre-hurricane levee systems all are still being debated.

New Orleans and the surrounding areas have historically been one of the most flood-prone areas of the nation due to internal drainage problems. Much of the area is below sea level and major infrastructure, including canal systems and pumping stations, are required to collect storm water and pump it out over the levees. Many areas are designated as SFHAs due to internal drainage and, as a result, significant numbers of property owners fortunately had flood insurance at the time of the event. After Hurricane Katrina, this internal drainage problem created an added dimension to the flooding by requiring pumping from areas below sea level, which took weeks to complete.

USACE initially intended to restore the level of protection provided by the levee systems to their pre-Katrina level (protection from a Category 3 storm) by the start of the 2006 hurricane season. Widespread discussion continues on the subject of raising the city's level of protection (i.e., protecting it from a Category 5 hurricane) to restore public confidence in the New Orleans levee systems and assist in economic recovery. However, the need to correct structural problems with the levees and floodwalls and the need to raise or reinforce the levees in many areas apparently could make achieving even Category 3 protection difficult and costly. Additional storm frequency information and flood elevations developed after Hurricane Katrina have resulted in further re-evaluation of the level of protection provided by the levee systems. USACE and FEMA jointly announced that 100-year flood protection will not be achieved until 2010 for most areas.

In the interim, FEMA has issued Advisory Base Flood Elevations and recommended requirements within the levee systems. The FEMA guidance states that the requirements are similar to those in Zone AR. FEMA recommends that new and substantially improved buildings are to be elevated to the current BFE or 3 feet above existing ground elevation, whichever is higher. Presumably, the area could then become Zone AR when a new FIRM is issued. If the communities do not adopt this requirement, BFEs would be "without levee" BFEs, once the new FIRMS are issued. The issue of providing a higher level of damage/risk reduction will not be resolved until completion of a USACE technical report analyzing higher levels of damage/risk reduction.

Many lessons were learned as a result of Hurricane Katrina, including the following:

- Failure of a levee system in a major urban area can result in a catastrophe with billions of dollars of damage and significant loss of life.
- Levees and floodwalls can fail during flood events of lesser magnitude than the design flood. (Prior to Katrina, the chance of failure of a major flood control project was largely discounted and the major threat was though to be overtopping by a flood larger than the design flood.)
- There is renewed debate over the appropriate level of flood damage/risk reduction to provide in a major urban area.
- The public should now be more aware of the consequences of levee overtopping or failure.
- The politics of levees may have shifted, at least for the immediate future, in the direction of greater caution and higher levels of damage/risk reduction.

It remains to be seen whether Hurricane Katrina will result in long-term changes to national levee policy.

3. FEMA Requirements for Mapping Levees: Challenges, Opportunities, and Options

This section examines the current FEMA requirements, policies, and guidelines that provide the framework for the inclusion of levees on NFIP maps and their recognition by FEMA. It also identifies the most important challenges and issues with the current requirements and policies facing FEMA, as identified by the Interagency Levee Policy Review Committee, and concludes with recommended changes to the FEMA mapping requirements.

3.1. Current FEMA Requirements for Mapping Levees

FEMA requirements for mapping levees include NFIP regulations, FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners (Guidelines and Specifications)*, and FEMA procedure memoranda.

3.1.1. Regulatory Requirements

Regulatory requirements for the NFIP are contained in 44 CFR Chapter 1, Parts 59-77. Specific regulatory requirements governing the treatment of levees in the NFIP are described below.

3.1.1.1 44 CFR 59.1, Definitions

This subsection provides the regulatory definitions of levee, levee system, and freeboard.

A levee is defined as "…a manmade 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."[13]

A levee system is defined as "…a flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices."

Freeboard means "… a factor of safety usually expressed in feet above a flood level for the purpose of floodplain 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."[14]

[13] The term "temporary flooding" indicates that levees provide protection against temporary water level rises. When water is against a linear structure on a permanent basis as part of dam or lock system, it is normally referred to as a dike or a component of the dam and not as a levee. There are cases, however, where these structures have been labeled levees.

[14] Freeboard is intended to account for uncertainty in establishing the design water surface elevation that results from uncertain flow estimates and hydraulic conveyance. Factors that can be estimated and accounted for should not be relegated to freeboard. Accounting for such as effects as future watershed development (if permitted), bridge impairments, and wave action should be estimated and included in the design water surface elevation.

3.1.1.2 44 CFR 61.12, Rates Based on a Flood Protection System Involving Federal Funds

As discussed in Section 2.c of this report, 44 CFR 61.12 (commonly referred to as the "Brooks Amendment") provides for the mapping of flood damage/risk reduction systems, such as levees and levee systems, undergoing federally funded restoration where adequate progress has been made toward achievement of 100-year flood protection. 44 CFR 61.12 provides the specific criteria for determining whether adequate progress has been made. These criteria include:

- 100 percent of total cost authorized
- At least 60 percent of total cost appropriated
- At least 50 percent of total cost expended
- All critical features under construction and at least 50 percent complete
- Community has not been responsible for any delay in project completion

Areas protected by levees that meet the criteria of 44 CFR 61.12 are mapped so that the protected area is designated as Zone A99 on the FIRM, with no flood depths or BFEs specified. The mandatory flood insurance purchase requirement applies in Zone A99, but the rates are based on the flood insurance zone that will apply after the levee system is complete (typically Zone B, C, or X).

3.1.1.3 44 CFR 64.3, Flood Insurance Maps

This section, which does not specifically address levees, provides the regulatory definition of the flood insurance zones depicted on flood insurance maps. Zones B and X (shaded) are defined as "area of moderate flood hazards" and purchase of flood insurance is voluntary and at lower rates than in Zones A, AE, A1-30, AO, and AH. On the standard FIRM panel legend, Zone X (shaded) is defined as "Areas of 0.2% annual chance flood; areas of 1% annual chance flood with depths less than 1 foot or with drainage area less than 1 square mile; and areas protected by levees from the 1% annual chance flood." Thus, there is no distinction in flood insurance zone designation for areas in the 500-year floodplain, areas of the 100-year floodplain with shallow depths and/or small drainage areas, and areas protected by levees.

3.1.1.4 44 CFR 65.10, Mapping of Areas Protected by Levee Systems

Provides the data analysis and submission requirements that levee systems must meet, and continue to meet, to be recognized on FIRMs as providing protection from the 100-year flood. The criteria include design, operation, and maintenance standards. Design criteria include minimum freeboard requirements, closures, embankment protection, embankment and foundation stability, settlement, and interior drainage. Structural requirements must be certified by a registered professional engineer and certified "as built" plans must be submitted. However, in lieu of the structural requirements, a Federal agency with responsibility for levee design may certify that a levee has been adequately designed and constructed to provide protection against the base flood.

Operation and maintenance plans must be formally adopted and be under the jurisdiction of a Federal or state agency, an agency created by Federal of state law, or a community participating in the NFIP.

3.1.1.5 44 CFR 65.14, Remapping of Areas for Which Local Flood Protection Systems No Longer Provide Base Flood Protection

This section describes the procedures for designation of AR zones for flood damage/risk reduction systems, such as levees, that no longer provide 100-year flood protection. A community may be eligible to apply for this designation if the system was constructed using Federal funds, recognized previously as providing protection from the base flood on the effective FIRM, and decertified by a Federal agency responsible for flood protection design or construction. The restoration must be complete within 10 years from application submittal for restoration projects with Federal funding and 5 years from application submittal for restoration projects with no Federal funding. In areas designated as Zone AR, mandatory flood insurance purchase requirements apply and the rates have been set at the non-SFHA level by administrative order. To date, this designation has only been used in the Los Angeles and Sacramento areas of California.

3.1.2. FEMA Guidelines and Specifications for Flood Hazard Mapping Partners

Guidelines and Specifications Appendix H, Guidance for Mapping Areas Protected by Levee Systems, provides guidance to FEMA engineering and mapping contractors and Cooperating Technical Partners (CTPs) for mapping of areas protected by levee systems. Appendix H of the *Guidelines and Specifications* provides steps for contractors and CTPs to evaluate levees when performing hydrologic and hydraulic analyses of flooding sources with levees, including the following:

- Determining levee ownership
- Determining status of all system elements (e.g., credited or unaccredited)
- Obtaining all available supporting documentation (e.g., as-builts, interior drainage analyses) from the system owner, operator, or FEMA repository
- Obtaining written confirmation of any previous certification
- Performing/updating hydraulic analyses of 10-percent-, 2-percent-, 1-percent-, and 0.2-percent-annual chance floods reflecting levee in place
- Assessing freeboard using "as built" levee profiles or topographic data and the 1-percent-annual-chance profile
- Reviewing available operation and maintenance plans to determine compliance with 44 CFR 65.10

The contractor or CTP then is to prepare a final letter report to the Regional Project Officer summarizing the results and conclusion of the levee evaluation. The Regional Project Officer, in consultation with the regional engineers, makes the final decision concerning the credibility of the levee system.

Appendix H of the *Guidelines and Specifications* also provides the procedures for preparing floodplain mapping and flood profiles for levee areas. For levees meeting 44 CFR 65.10, as determined by the Regional Project Officer, flood profiles reflect the "with levee" condition. The protected area is designated as Zone X (shaded), and the interior drainage areas are designated as 100-year floodplain (e.g., Zone AH, AE). The regulatory floodway is delineated at the landside toe of the levee.

For levees not meeting the requirements of 44 CFR 65.10 (as decided by the Regional Project Officer), both sides of the levee are shown as 1-percent-annual-chance floodplain (i.e., Zone AE). The area on the unprotected (riverward) side of levee is designated based on the "with levee" 1-percent-annual-chance profile (the top of levee elevation can be used if the "with levee" 1-percent-annual-chance profile overtops the levee). The area on the landward side of levee is based on the recomputed "without levee" profile. The line along the levee centerline separates the areas of different BFEs on the FIRM. The flood profile sheets may have up to five profiles: the 10-, 2-, and 1-percent-annual-chance profiles for the "with levee" condition for the riverward side of levee; and 1- and 0.2-percent-annual-chance profiles for the "without levee" condition for the landward side of levee. The regulatory floodway widths are determined based on the "without levee" condition, and two BFEs (riverside and landward side conditions) are included in the "Regulatory" column of the Floodway Data Table. In cases for which levees exist on both sides of a stream, evaluation shall consider simultaneous levee failure, failure of only the left side, and failure of only the right side.

Lastly, *Guidelines and Specifications* Appendix H requires mapping contractors and CTPs to ensure that levees in/adjacent to floodplains are documented and inventoried in the Web-based FEMA Levee Inventory System (FLIS).

3.1.3. FEMA Procedure Memoranda

FEMA has issued three procedure memoranda related to mapping of levees for the NFIP. An overview of each is provided below.

3.1.3.1 Procedure Memorandum 30 - FEMA Levee Inventory System (December 23, 2002)

This memorandum established a process for maintaining the FLIS and provided protocol for data entry to electronically store the system data. The process provided for the FEMA Mapping Coordination Contractors (MCCs) to perform levee inventories for FEMA-contracted mapping projects and community-initiated map revisions. The inventories are to be performed by checking, validating, and updating as appropriate, information in the FLIS, or by adding new records for levees not already entered in the FLIS.

3.1.3.2 Procedure Memorandum 32 - Levee Review Protocol (June 4, 2003)

This memorandum established a tiered system of review protocol for the evaluation of levees along flooding sources that are not part of a specific study or restudy. Inherent to this review protocol is a requirement that the MCC keep a watchful eye for levees that were not properly identified, classified, and/or inventoried in past map actions. For credited levees along non-studied/restudied flooding sources, the protocol calls for a quick visual assessment for obvious anomalies in the mapping. Obvious anomalies for levees shown as providing protection from the 100-year flood include the following:

- No indication in the FIS report that the levee has minimum freeboard
- No note on the effective NFIP map in the protected area warning of residual flood risks
- Floodway (when present) not delineated at the inside toe of the levee

Performing this visual inspection for levees outside the primary scope of the map project enables the revision to proceed while a back-check is conducted to validate 44 CFR 65.10 criteria. If problems are determined during the back-check, those problems may be addressed separately. Depending on the gravity of the problems, the map action may either be halted (in extreme cases) or addressed in a follow-up action.

3.1.3.3 Procedure Memorandum 34 - Interim Guidance for Studies Including Levees (August 22, 2005)

This memorandum provides interim guidance on how mapping contractors and CTPs should treat levees to minimize delays in near-term mapping projects while a long-term levee policy is being established. A key part of this interim guidance is that for all levees along non-restudied flooding sources, full compliance with 44 CFR 65.10 must be documented. (As described previously, Appendix H of the *Guidelines and Specifications* only calls for levee assessments when new or updated H&H analyses are being performed). This has a profound impact because many of the mapping projects initiated during the early years of Map Mod are "digital conversions" in which the community-based, paper FIRMs are upgraded to full countywide Digital Flood Insurance Rate Maps (DFIRMs). Although these countywide DFIRM conversions frequently include redelineation of floodplain boundaries on new topographic data, their scope typically includes new or updated H&H analyses for very few, if any, flooding sources.

The memorandum establishes that FEMA will not be conducting detailed examinations of levees to determine how a structure or system will perform in a flood event. Rather, as required in 44 CFR 65.10(a), the memorandum reaffirms that it is the responsibility of the community or party seeking recognition of a levee system to provide the data specified in 44 CFR 65.10. A deadline for submission of the data to FEMA will be established and, if the required data and documentation are not provided by the deadline, the levee cannot be recognized as providing protection from the base flood as part of the mapping project.

3.2. Challenges and Issues with Current Requirements and Policies

After careful consideration and evaluation of the FEMA requirements for mapping levees under the NFIP, the Committee identified the following challenges and issues:

- Many levees shown on current NFIP maps as providing protection from the 100-year flood have never been evaluated against the criteria of 44 CFR 65.10 (see discussion of "grandfathered" levees in Section 2). As Map Mod is implemented, Procedure Memorandum 34 will require that these "grandfathered" levees be evaluated against 44 CFR 65.10 requirements. For levees that are found not to meet 44 CFR 65.10, the areas behind the levees will be identified as SFHAs. The impacts on the community of such an action will be significant.
- The protection afforded by many certified levees decays over time due to various factors, such as changed hydrology or channel characteristics, erosion or deterioration of the embankment due to rodents or tree growth , general lack of proper maintenance, subsidence, or partial levee failures. However, there is no mechanism in place to regularly verify continuing accreditation of levees against 44 CFR 65.10. Procedure Memorandum 34 establishes that all currently credited levees will be checked against the 44 CFR 65.10 criteria as Map Mod is implemented. When combined with reviewing "grandfathered"

levees as described above, this should bring the accreditation status for all levees up to date in the program. There is still no mechanism in place to periodically revisit the levee accreditation status in subsequent years unless a FIRM update is initiated for the community for other reasons (and then only if the requirements of Procedure Memorandum 34 are followed by the contractor or CTP).

- FEMA does not certify levees, but rather relies on certification provided by Federal agencies or State, local, or other parties seeking accreditation on NFIP maps. In implementing Procedure Memorandum 34, because levees were often "grandfathered" or certification of 44 CFR 65.10 criteria cannot be found, FEMA is reiterating that it is the responsibility of communities to provide the necessary certification. Frequently, communities do not have the requisite resources or technical expertise to properly evaluate the levees against the 44 CFR 65.10 requirements and will have to hire engineering firms to do this work. The amount of time needed to accomplish this recertification could impact schedules, delaying issuance of preliminary and effective DFIRMs and slowing completion of Map Mod.
- As Procedure Memorandum 34 is implemented, many levees ultimately will not meet the criteria of 44 CFR 65.10 and will have to be shown as "failed" on FIRMs. The performance of detailed levee failure analysis as required by Appendix H of the *Guidelines and Specifications* will be costly, particularly for countywide DFIRM conversion projects and in counties and communities with large numbers of levees. In some instances, the detailed restudy and assessment of levees may cost nearly as much, if not more, than the DFIRM conversion project itself. This may significantly delay finalizing modernized maps and/or severely limit the number of counties and communities that can be mapped in any given year. These problems must be balanced against the threat to safety of not performing adequate analyses.
- The regulatory requirements of 44 CFR 65.10 lack adequate specificity for minimum operation and maintenance standards. In addition, although the maintenance requirements require that maintenance plan must ensure that levee stability, height, and overall integrity are maintained, there is no specific requirement for ensuring that the flood-carrying capacity of the main river channel is maintained. In some instances, the main river channel has lost flood-carrying capacity adjacent to a levee due to silt and sediment deposits in the channel. Further, encroachments into levees can range from a sprinkler pipe buried in the face of an urban levee to a six foot diameter sanitary sewer pipe placed under the levee. In California, the Department of Water Resources (DWR) has issued permits for more than 18,000 encroachments in the Sacramento and San Joaquin Levee System alone. These encroachments can hinder operations and maintenance and/or the ability to flood fight or even compromise levee integrity. Maintenance programs must include control of new encroachments and correction of problems with existing encroachments prior to levee certification.
- Risks in areas behind certified levees are not adequately communicated to map users. For example, areas protected by levees certified to meet 44 CFR 65.10 criteria are given the same flood insurance zone designation (Zone X (shaded)) as the 500-year floodplain and the 100-year floodplain with depths less than 1 foot or drainage areas less than 1 square mile. In addition, the standard levee note that is used on FIRMs is "This area protected from the 1-percent-annual-chance (100-year) flood by levee, dike, or other structures subject to possible failure or overtopping during floods." The use of the word "protected" in this note may give an undue sense of security to map users. At a minimum, maps should indicate that protection is designed only for specific flood events.

- Current requirements treat levees in a binary manner—either they meet 44 CFR 65.10 or they do not. Therefore, residual risk is greatly under-represented, and differences in risk that may exist to those behind certified levees are disregarded. In addition, no distinction between graceful versus chaotic capacity exceedance exists in the way levees are mapped, and there is no identification of the most highly hazardous areas immediately behind/along levees in the event of levee failure.
- Interior drainage due to rainfall ponding behind levees is often under-represented on many FIRMs. Regulations and *Guidelines and Specifications* lack specificity in acceptable techniques for analyzing and mapping interior drainage. For many levees, little or no analysis of interior drainage exists. The issue of interior drainage, as a contributing factor to residual risk, is largely unstudied.
- For levees determined to meet 44 CFR 65.10, Appendix H of the *Guidelines and Specifications* requires only analyzing the "with levee" hydraulic profile. Thus, the area subject to inundation in the event of levee failure can not be identified without additional study.
- The regulations do not require submission of "for the record" data for certifications by a Federal agency responsible for levee design. Thus, in later years, if FEMA needs to revisit the 44 CFR 65.10 certification of a particular levee, it may only have on file a letter of certification from the Federal agency, rather than the backup data upon which the Federal agency based its certification. FEMA is encountering precisely this situation now in implementing Procedure Memorandum 34.
- The regulations and *Guidelines and Specifications* Appendix H lack clarity in the treatment of roads, railroads, and other embankments (natural or manmade) that may function as levees, leading to confusion by contractors and CTPs and may lead to erroneously mapping the areas as "de facto" levees. Further, map revision requesters sometimes attempt to make revision requests under 44 CFR 65.10 based on railroads, highways, and other embankments not designed or intended for flood damage/risk reduction.

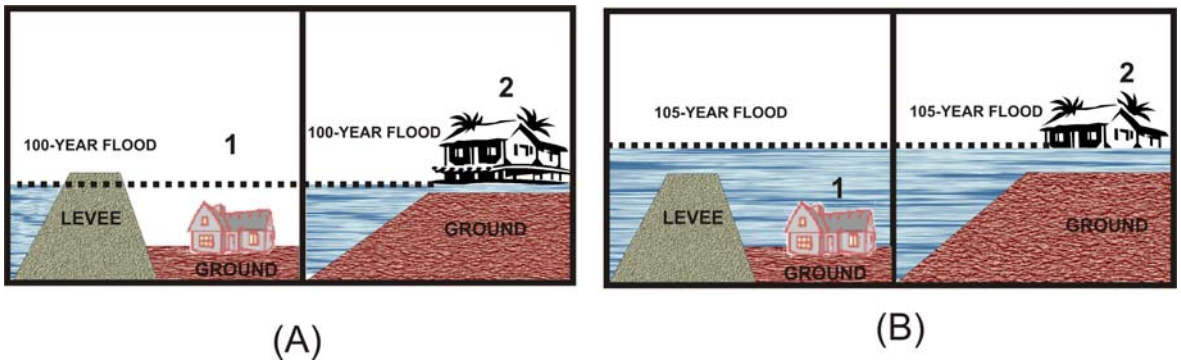

Figure 3-1. Residual Risk. Illustration (A) shows the situation when the water level in the river is below the BFE. The levee protects Home 1 up to the 100-year level. Illustration (B) shows the situation when the water reaches the 105-year flood level and overtops the levee. Home 1 is submerged and Home 2 is subjected to minimal damage.

3.3. Conclusions

Based on its review of current mapping standards and requirements, the committee concludes that:

- Levees only reduce the risk to individuals and structures behind them. They do not eliminate the risk and, in many cases, can create significant and potentially catastrophic residual risk that may increase as conditions in the region change. Levees should be considered as flood risk reduction structures, as opposed to flood protection structures, and treated accordingly. A structure elevated to the 100-year base flood elevation faces significantly less risk that a structure behind a levee designed to withstand the 100-year flood.
- Current regulations and guidance for recognition and mapping of levees in the NFIP are not adequate for making the initial determination that the levees meet minimum design, operation and maintenance standards. The regulations and guidance do not provide adequate oversight of levees' continued conformance with the NFIP criteria. Therefore, they may permit inclusion and/or retention in the program of levees that do not provide the required level of protection.
- Levees should be certified and accredited as systems that include not only levees and floodwalls but also the pumps, interior drainage systems, closures, penetrations and transitions that provide for systems integrity.

3.4. Recommended Changes to FEMA Levee Mapping Requirements (and Attendant Levee Certification)

The committee recommends that:

- FEMA define a new flood insurance zone (Zone XL) for areas behind levees meeting requirements for inclusion in the NFIP and, in coordination with other agencies, identify the level of risk to those behind these levees. Zone XL would include those areas behind the levee subject to inundation under the 100-year flood in the "without levee" condition. The area between the 100- and 500-year lines would be shown as a shaded Zone X. Levees would also be identified under a scientifically based levee risk classification system (e.g., high, medium, or low) that would be based on factors including potential depth of flooding in the event of failure or overtopping; type and density of development in protected areas behind the levee, and steps taken to ensure that levee failure does not occur during levee capacity exceedance (overtopping), warning times, and the number and types of egress so that people who may be inundated may move out of harm's way. This levee risk classification would be designated on the FIRM and in the FIS report.
- FEMA require levee sponsors to:
  - Conduct annual inspections of the levee systems
  - Submit to FEMA biennially the results of the annual inspections, levee system operation and maintenance records, and an assessment of the levee system during any flood events that occurred within the reporting period

  - — Submit to FEMA every 10 years a report, prepared by a registered professional engineer or Federal agency responsible for levee design, that recertifies the engineering and geotechnical conditions of the levee system.
- FEMA should also revise its regulatory and administrative documents as indicated in the following paragraphs.

3.4.1. Regulatory Changes

44 CFR 59.1 Definitions

- Modify the definition of levee to specifically exclude embankments, such as roads, railroads, and natural high ground that were not engineered to provide damage/risk reduction from flooding.

44 CFR 64.3 Flood Insurance Maps

- Define a new flood insurance zone (Zone XL) for areas behind a levee meeting 44 CFR 65.10 requirements. This will more clearly distinguish areas behind credited levees from the 0.2 percent annual chance floodplain and the 1-percent-annual-chance floodplain with depths less than 1 foot and/or drainage areas less than 1 square mile.

44 CFR 65.10 Mapping of Areas Protected by Levee Systems

- Modify section to specifically exclude application of 44 CFR 65.10 for embankments, such as roads, railroads, and natural high-ground that were not engineered to provide protection from flooding to revise the FIRMs to remove the SFHA behind the embankment [65.10(a)].
- Add a requirement for the community or other party seeking accreditation to notify property owners in the area behind levee to be removed from the SFHA as a condition of levee being accredited under 44 CFR 65.10. Each individual property owner should be notified in writing, clearly explaining the residual risks for levee overtopping and interior drainage, the potential for levee failure, and information on how to purchase flood insurance at reduced rates. FEMA should prepare a template notification letter for use by the community or levee owner. Communities could send a notice to property owners every year with their tax bills, as some already do.
- As noted above, add a sub-section requiring the community or other levee owner to proactively maintain 44 CFR 65.10 certification, rather than allowing accreditation to remain in effect in perpetuity or until the FIRM is revised for other reasons. As a condition of maintaining 44 CFR 65.10 certification for an accredited levee, operation and maintenance records, as well as a written assessment of the levee systems performance in any flood events that have occurred, should be submitted to FEMA every 2 years. The engineering and geotechnical aspects of the levee should be recertified and submitted to FEMA every 10 years by a registered professional engineer or Federal agency responsible for levee design. If the required data and documentation are not submitted (or submitted but determined by FEMA review to no longer meet 44 CFR 65.10 requirements), the levee will be decertified and the FIRMs updated to show that the levee no longer provides protection from the 1-percent-annual-chance flood. The ongoing conversion of the FIRM inventory to DFIRM format by FEMA and the ongoing database of flood damage reduction projects by USACE will ultimately provide the GIS platform needed to track and manage the levee recertifications.

- Expand the requirements for maintenance plans to specifically include requirements for ensuring that the flood carrying capacity of the main river channel is maintained, thereby preserving the required level of protection and ensuring that encroachments are controlled and do not affect the integrity of the levee or the ability of its owner to maintain the levee and flood fight. As mentioned previously, there have been some instances in which the main river channel has lost flood-carrying capacity adjacent to a levee due to siltation in the channel, thereby reducing the levees ability to pass the 100-year flood. Levees should not be considered to be properly maintained unless a plan is in effect and working to control encroachments. In addition, FEMA should require the preparation, as part of operation and maintenance plans, of emergency action plans for those levees where failure would cause catastrophic losses. [65.10(d)].
- Reference USACE Engineer Manual EM 1110-2-1413, "Engineering and Design, Hydrologic Analysis of Interior Areas" as the acceptable/preferred methodology for interior drainage analysis. [65.10(b) (6].
- Reference the USACE "Levee Owners Manual for Non-Federal Flood Control Works" as required for operation, maintenance, and inspection guidance and procedures for non-Federal levees and floodwalls. [65.10(c) and 65.10(d)].
- Require submission to FEMA of all data, analyses, and documentation used by a Federal agency to certify levees and floodwalls for compliance with 44 CFR 65.10. Although the Committee does not recommend that FEMA perform detailed review of the data or the certification by another Federal agency, FEMA should maintain copies of the data in the backup data for the community's FIS and DFIRM. [65.10(e)].

3.4.2. Guidelines and Specifications for Flood Hazard Mapping Partners

- Expand Appendix H of the *Guidelines and Specifications* to cover the evaluation and treatment of levees along non-restudied flooding sources following the Procedure Memorandum 34 process.
- Modify the analysis process in Appendix H to more clearly indicate the requirement for analysis of the "without levee" condition for levees meeting 44 CFR 65.10 so that the new Zone XL can be accurately delineated and the "without levee" profile produced.
- Provide clarifying guidance that embankments, such as highways, railroads, or natural embankments, not specifically designed and engineered to provide flood protection should not be modeled and mapped as levees in performing flood insurance studies and restudies (Appendix H of the *Guidelines and Specifications*).
- Reference USACE Engineer Manual EM 1110-2-1413, "Engineering and Design, Hydrologic Analysis of Interior Areas" as acceptable/preferred methodology for interior drainage analysis (Appendix H of the *Guidelines and Specifications*).[15]
- Revise the levee mapping and FIRM graphical mapping standards to reflect the new Zone XL designation as well as the levee risk classifications (Appendices H and K of the *Guidelines and Specifications*).

[15] The cited USACE Manuals are being revised or will be in the near future.

3.4.3. FEMA Procedure Memoranda

Issue a follow-up to Procedure Memorandum 34 that provides further guidance to the FEMA Regions and its mapping contractors and CTPs. Specifically, this further guidance should address:

- Best practices in evaluating the suitability of existing 44 CFR 65.10 certification data and documentation available in FEMA's records in determining a levee's continued accreditation status.[16]
- Cost-effective methods for modeling and mapping levees determined not to meet 44 CFR 65.10. For example, approximate or limited detail study techniques could be utilized in lieu of full detailed study/restudy methods, especially for levees determined to be in the low or medium risk classification.
- How communities can determine whether an existing levee meets the criteria of 44 CFR 65.10 and how a certification package should be prepared.

[16] Consideration could be given to including in the FIS issues related to the history of the levees, relative protection provided by the levees, and similar risk reduction systems, the inherent risk in building residential and non-residential structures on the landward side of these systems, and alternative floodplain development practices that could be considered in levee affected areas. The FIS could become a part of the awareness and outreach approach or part of the delivery vehicle.

4. Levee Height and Structural Integrity - The Role of Risk Analysis Methodologies

4.1. Determination of Levee Height

Levees are planned and constructed by Federal, State, and local government agencies, and private businesses. Federal agencies undertake water resource investments for such measures as levees within the broad confines of the Principles and Guidelines (U.S. Water Resource Council, 1983) (P&G). P&G generally requires that Federal projects contribute to national economic development, which means that they must be economically justified (i.e., benefits should exceed costs). USACE has planned and constructed the majority of Federal levees, and most of the levee systems protecting major urban area in the United States. USACE implementation of the P&G requires that flood damage reduction projects, including levees, are planned so that the project scale contributes as much as possible to net national economic development (NED) benefits. For levees, this means that the maximization of net benefits is an important consideration in the determination of the height and other features of the levee system. In most instances in urban areas, USACE levee projects adhering to these principles are higher than required to meet FEMA base flood[17] protection requirements. In those urban settings in which levee height is less than FEMA base flood protection under these principles, the levee heights are generally increased to ensure FEMA base flood protection. The resulting project must still be economically justified and the local sponsor may be required to pay the cost for the difference in levee height between the NED project and the height required for base flood protection.

USACE levee projects protecting agricultural areas are often sized to the NED scale without further efforts to raise the height to that needed to provide FEMA base flood protection. For non-Federal levee projects, the target is often simply to provide protection from the FEMA base flood so that the levee system may be certified and the protected floodplain remain free of development controls. There are, of course, many special cases. Prior to P&G, USACE policy was to seek protection from what was referred to as "Standard Project Flood," or "Standard Project Hurricane" in the case of coastal projects. There are many such projects throughout the country.

The majority of Federal and local levee systems in non-agricultural areas provide protection from the FEMA base flood, or an even higher flood; as a result, the mandatory flood insurance purchase and floodplain management requirements of the National Flood Insurance Program (NFIP) no longer apply in these areas. Local governments are often not willing to pay the incremental cost of providing additional protection once this level of protection is achieved. The FEMA base flood has increasingly become the de facto design standard for levees.

4.2. Freeboard

As indicated previously, freeboard is an increment of levee height added to the design flood height to increase the likelihood of containing a specified level of flood. Most definitions of freeboard center on height addition to accommodate uncertainty in the design flood elevation. This, in turn,

[17] In Sections 4 through 8, several terms for the 1-percent-annual-chance flood are used interchangeably. These include the 100-year flood, the base flood, and the FEMA base flood. As is the case in Part 4.1., the context determines which particular term is used.

may reflect uncertainty in estimating the design discharge and uncertainty in computing design elevations from design discharge. In USACE design guidance, prior to the risk and uncertainty policies discussed below, freeboard was to be designed to reflect the site-specific conditions of each project. Small additional height increments above the base-designed freeboard are added to ensure protection for critical features such as bridges and water and waste treatment plants during overtopping floods. There are references to 3-feet freeboard in several USACE guidance documents, but that does not appear to be stated as a required minimum. Over time, Federal and local agencies tended to implement 3 feet as a minimum freeboard for the majority of levee projects. There are notable exceptions: for the major levees in the Mississippi Valley and the Central Valley of California freeboards up to 5 feet are common.

With the publication of 44 CFR 65.10 (FEMA guidelines for levee certification) in 1986, which specified a minimum of 3 feet, this number effectively became the default standard for many non-USACE levees throughout the United States. 44 CFR 65.10 specifies slightly different minimums for coastal environments, reflecting the unique setting of tides, storm surges, and wind generated waves.

4.3. USACE Risk Analysis Approach – 1996

USACE evolved its present risk analysis policy in response to challenges to flood damage reduction project proposals and justification documents by the Office of Management and Budget (OMB) and an array of local and special interests,. The substance of the policy developed over a period of 3 to 4 years in the mid-1990s and culminated in the publication of ER 1110-2 101, *Risk Analysis for Flood Damage Reduction Studies*, in March 1996, updated in January 2006. The thrust of the policy is to improve decision making and confidence in the project formulation/evaluation process by quantifying and disclosing risk and uncertainty in key data and parameters. The policy and associated methods are contained in several USACE Engineer Regulations, Engineer Manuals, Engineer Technical Letters, and policy letters.

The fundamental tenets of the policy may be summarized as:

- Make accurate and unbiased estimates of the probability of flooding and of exposure, and publish and communicate those findings.
- Acknowledge uncertainties associated with a project and its performance, and quantify, publish, and communicate that information. The key items of information that must be addressed are discharge-frequency and uncertainty, stage-flow and uncertainty, geotechnical and structural performance and uncertainty, operational uncertainty, and project benefits and uncertainty. Other key elements, depending on the specific setting, must also be addressed.
- Emphasize residual risk (the probability and the consequences of that the project capacity may be exceeded) by conducting residual risk analysis and document and communicate findings.

USACE recognized that its risk analysis policy and methods had implications for floodplain management and the associated task of levee certification, and immediately engaged FEMA leadership in discussions. In 1997, USACE and FEMA agreed on an approach to levee certification that embraced risk analysis, and published a policy letter to USACE field offices. The essential elements of the 1997 risk analysis levee certification guidance are: (2a). Respect the elements and

principles of 44 CFR 65.10 (i.e., demonstrate a degree of assurance that the base flood will be contained); (2b). Replace the fixed, minimum freeboard criterion of the certification with a quantified assurance (Conditional Non-Exceedance Probability – referred to as "assurance") as follows: Use 44 CFR 65.10 minimums provided that they achieve at least a 90-percent assurance of containing the base flood (may require higher, stronger levees); but protection need not be greater than that necessary to provide 95-percent assurance of containing the base flood (may certify for lower-height levees than 44 CFR 65.10 minimums); and (2c) to the extent possible, quantify and include in the analysis uncertainty in the performance of the geotechnical and structural features of the levee system. The risk analysis levee certification policy has been in place since the policy letter was issued in 1997.

4.4. Implementing Risk Analysis Concepts in 44 CFR 65.10

When the 1982 NRC Report was issued, the freeboard approach was the most feasible approach to dealing with the uncertainty and natural variability factors involved in the calculation of flood heights and structural integrity. Over time, technology and increased computational capabilities made it possible to consider more accurately uncertainty and variability through the application of risk analysis methodologies; these methodologies now are generally accepted as a more accurate way to establish levee and floodwall heights. A 2000 study by the NRC, "Risk Analysis and Uncertainty in Flood Damage Reduction Studies," was targeted specifically at USACE initiation of such studies, and commended USACE "…for adopting the new techniques and departing from the traditional freeboard approach. The risk analysis paradigm for flood damage reduction studies represents a step forward…."

4.5. Conclusion

The committee concludes that:

- Advances in technology and computational capabilities have made possible the widespread adoption within the engineering community of risk analysis methodology for determination of levee heights and that this methodology represents the appropriate approach for use by FEMA in 44 CFR 65.10 in place of the current freeboard methodology.

4.6. Recommendation

The committee recommends that:

- FEMA modify CFR 65.10 to phase out use of the freeboard-based approach over the next ten years and to substitute the risk analysis methodology at a 90-percent assurance of passing the base flood. During the transition period, FEMA should permit either approach to be used in levee design and in recertification analysis. The existing 44 CFR 65.10 is shown in Appendix B. The committee provides, in Appendix C, two alternative proposed revisions to 44 CFR 65.10. In one, it updates 44 CFR 65.10 to reflect both use of the current approach and use of the risk analysis methodology. In the second, the committee replaces entirely the current freeboard methodology with the risk analysis methodology. It defines the risk analysis framework throughout the document. The revision distinguishes between new levees, in which design criteria and levee height required to contain the base

flood and the associated uncertainty are the primary factors; and existing, aged, and aging levee systems, in which the levee system in its as-constructed and currently maintained state and up-to-date data about base flood stages and geotechnical and structure integrity are the key factors. Freeboard is no longer referenced in favor of quantified assurance related to levee height and structural integrity. The committee includes additional information on what must be demonstrated, how to reflect uncertainty in stage and structural integrity, and what the specific requirements are for operation and maintenance plans and records. It also adds a new section to define and address residual risk and public safety as an important certification requirement.

5. Computation of the 1-Percent-Annual-Chance Flood – Problems and Solutions

Since levee height is normally determined by the elevation of the 100-year flood, accurate computation of the 1-percent-annual-chance flood is particularly critical. Errors in computation could lead to undersizing of the levee and, in turn, to the catastrophic consequences of levee overtopping or failure. Errors in the other direction could require a community to build a higher levee than required for NFIP compliance. The determination of the height of the 1-percent-annual-chance flood requires extensive H&H computations and reliance on baseline H&H data concerning the area under study. Approximately 45 percent of levee designs and flood risk determinations are based on precipitation frequency estimates that are as much as 45 years old. Approximately the same percentage of designs and determinations are based on flow frequency guidelines that are at least 25 years old. Many communities lack long-term streamflow records. This section discusses the problems that have developed in H&H computation and provides possible solution to these challenges.

5.1. Precipitation Frequency Estimates

The precipitation frequency estimates provided by NOAA's National Weather Service (NWS) (www.nws.noaa.gov/hdsc), as shown in Table 5.1, are as much as 45 years old.

Table 5-1. Current Precipitation Publications

	5 – 60 minutes	1 – 24 hours	2 – 10 days
Western U.S.	Frederick & Miller (1979) Arkell & Richards (1986)	NOAA Atlas 2 (1973)	Tech Paper 49 (1964)
AZ, NV, NM, UT, Southeast CA	NOAA Atlas 14 Vol 1 (2003)	NOAA Atlas 14 Vol 1 (2003)	NOAA Atlas 14 Vol 1 (2003)
Eastern U.S.	Tech Memo 35 (1977)	Tech Paper 40 (1961)	Tech Paper 49 (1964)
IL, IN, OH, PA, NJ, DE, MD, DC, VA, WV, NC, SC, TN, KY	NOAA Atlas 14 Vol 2 (2004)	NOAA Atlas 14 Vol 2 (2004)	NOAA Atlas 14 Vol 2 (2004)
Hawaii	Tech Paper 43 (1962)	Tech Paper 43 (1962)	Tech Paper 51 (1965)
Alaska	Tech Paper 47 (1963)	Tech Paper 47 (1963)	Tech Paper 52 (1965)
Puerto Rico	NOAA Atlas 14 Vol 3 (2006)	NOAA Atlas 14 Vol 3 (2006)	NOAA Atlas 14 Vol 3 (2006)

NWS publishes these estimates at the request of and with funds provided by agencies that use them for regulation and design standards. The oldest standards were published in the early 1960s and covered the entire country. In 1973, there was a major update for the western states and in 2003, 2004 and 2006 NOAA Atlas 14 provided new estimates for the semiarid southwest, the Ohio River Basin and surrounding states, and Puerto Rico and the U.S. Virgin Islands. NOAA Atlas 14 introduced new, more reliable, more robust statistical techniques, as well as new techniques for spatial interpolation. NOAA Atlas 14 also provided, for the first time, estimates of the uncertainty associated with specific precipitation frequency estimates in different locations. These uncertainties are on the order of plus or minus 25 percent in the upper and lower 90-percent confidence intervals in extreme cases. The publication of uncertainty estimates has highlighted the real uncertainties associated with resulting hydrologic estimates of stage, levee height requirements, and potential areal extent of flood risk. As a result, NOAA Atlas 14 provides a basis for dealing with these design and regulatory uncertainties, a capability that must be extended to the rest of the country.

NOAA Atlas 14 is currently being updated for Hawaii. However, updates for large portions of the country, as shown in figure 5-1, remain unfunded. In particular, much reconstruction and re-estimation of flood risk in the Gulf Coast states is based on Technical Paper 40 published in 1961.

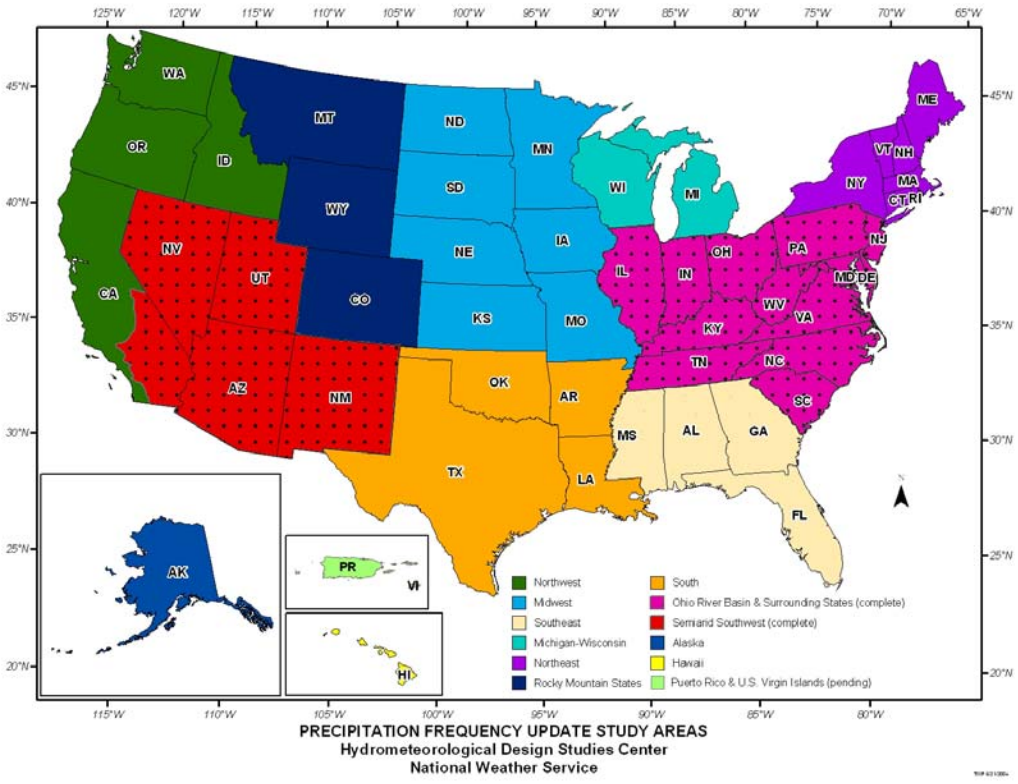

Figure 5-1. Precipitation frequency estimates need updating in large parts of the country.

The long hiatus between publication of NOAA Atlas 2 and the current NOAA Atlas 14 effort led to a lack of institutional awareness of the need and responsibility for updating the estimates. This was recognized by the Federal Advisory Committee's Subcommittee on Hydrology, which, in 2004,

recommended that NWS update the estimates with funds provided by Federal user agencies. However, the funds have not been forthcoming. Other bodies, such as the American Association of State Highway and Transportation Officials Technical Committee on Hydrology and Hydraulics, the Transportation Research Board's Technical Committee on Hydrology, Hydraulics and Water Quality, and NOAA's National Stakeholder Forum, also have recommended updates. Figure 5-2 shows that while recently updated estimates are consistent with previous estimates in many areas, there are significant changes that could lead to problems in many other areas.

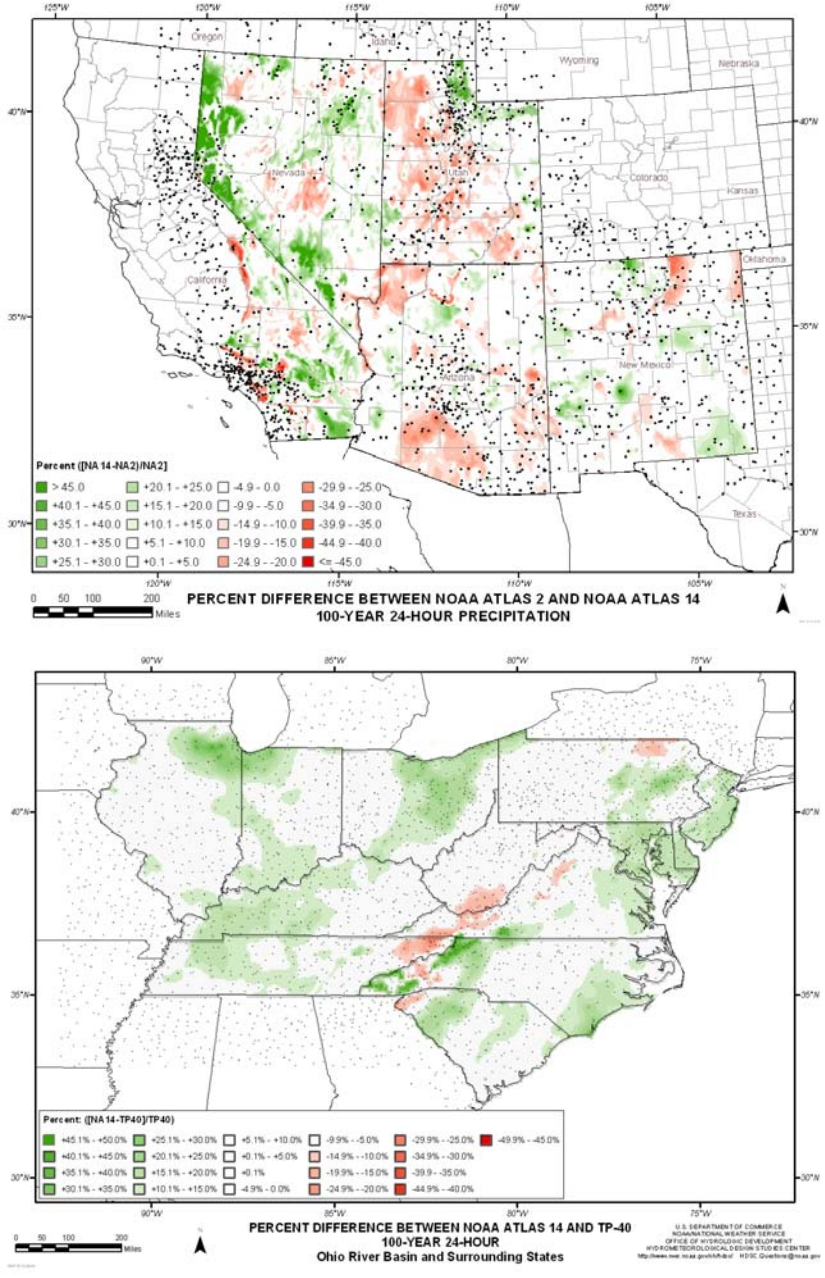

Figure 5-2. Recent updates show significant changes in precipitation frequency estimates.

5.2. Estimating Flow Frequency

Hydrologic methods for estimating flow frequency for FEMA's Flood Hazard Mapping program are described in *Guidelines and Specifications for Flood Hazard Mapping Partners* Appendix C, "Guidance for Riverine Flooding Analyses and Mapping."

The recommended procedures for flow frequency analysis for unregulated gauged streams is defined by Bulletin 17B, *Guidelines For Determining Flood Flow Frequency*, Interagency Advisory Committee on Water Data (1982). Annual maximum peak flows used in the flood flow frequency analyses are available on the USGS Web site at http://water.usgs.gov/nwis/sw/peaks. The two most commonly used computer programs for performing Bulletin 17B analyses are *HEC-FFA Frequency Analysis* (USACE, 1992) and *PEAKFQ, Annual Flood Frequency Analysis Using Bulletin 17B Guidelines* (USGS, 1998). (If the mapping partner determines that Bulletin 17B is not applicable, then alternative procedures must be justified and documented.)

Bulletin 17B was published more than 20 years ago and significant research has occurred in the interim. There may be more accurate and reproducible procedures available today for defining the 1-percent-annual-chance flood discharge that is used in levee analyses. The Hydrologic Frequency Analysis Work Group (HFAWG) of the Subcommittee on Hydrology, Advisory Committee on Water Information, has proposed a plan for revising Bulletin 17B. The detailed plan can be viewed at the HFAWG Web site at http://water.usgs.gov/wicp/acwi/hydrology/Frequency. The HFAWG is pursuing three major areas of investigations that relate to improved estimates of the 1-percent-annual-chance flood discharge: improved procedures for analyzing low and high outliers and historical flood data; improved procedures for estimating regional or generalized skew; and improved procedures for estimating confidence limits. These investigations will be completed and documented in 2007 and will likely lead to publication of a revision to Bulletin 17B. The development of improved procedures for flood discharges relates directly to risk analysis procedures used by USACE for levee certification.

No nationally accepted procedures for flow frequency analyses exist for streams whose flood frequency is regulated by major flood-control structures. Mapping partners use many different methods, depending on the type, quality, and quantity of data available. USACE Engineering Manual No. 1110-2-1415 (USACE, 1993) provides some guidance on flow-frequency analyses for regulated watersheds, but additional guidance is needed. The lack of recommended procedures for regulated frequency analysis lends itself to challenges and appeals of hydrologic analyses and to delays in publishing FIS reports. The most reasonable approach for regulated frequency analysis is not always clear, given the many circumstances that arise in practice. HFAWG is also developing guidance on flow frequency analyses for regulated watersheds.

Regional analysis and rainfall-runoff models are the recommended procedures for hydrologic analysis for flood hazard mapping of ungaged streams. Regional regression equations are applicable only for unregulated streams; rainfall-runoff models can be used for both unregulated and regulated ungaged streams. USGS Regional regression equations can be found on the Web at http://water.usgs.gov/osw/programs/nffpubs.html. These equations are also included in the USGS National Flood Frequency Program (http://water.usgs.gov/software/nff.html).

Rainfall-runoff models are often used in hydrologic analyses and for levee certifications. In order to use rainfall-runoff model estimates in risk analysis procedures, USACE assumes the equivalent

years of record and then employs the confidence limits in Bulletin 17B. The assumption of the equivalent years of record is based primarily on engineering judgment. Although the assumed equivalent years of record appear reasonable, additional investigations are needed to quantify more accurately the uncertainty of flood estimates from rainfall-runoff models.

5.3. Conclusion

The committee concludes that:

- Much of the baseline information used to determine the1-percent-annual-chance flood height is out of date. This results in levee designs and flood risk determinations that are overly expensive or that place those behind levees and in the floodplain at an unacceptable level of risk.

5.4. Recommendation

The committee recommends that:

- To ensure that the base data used to support the hydraulic and hydrologic analyses reflect 21st century computation technologies, FEMA, in coordination with other Federal agencies that use these data and techniques, should support the funding of NOAA efforts to upgrade precipitation frequency estimates, the upgrades to the USGS gaging program, and the Advisory Committee on Water Information Subcommittee on Hydrology revision of Bulletin 17B. Funding of these efforts will improve the determination of flood recurrence intervals.

6. Levee Inventory Database

To effectively manage the variety of NFIP programs, including mapping and floodplain management, as well as to support preparedness and response activities, Federal, State, and local officials must know where levees are and the condition of those levees. This section reviews the status of documentation of the location and condition of levees and associated structures recognized by the NFIP. It documents prior levee inventory and database activities and current efforts underway to inventory the nation's levees. This section also makes recommendations on a levee database design framework.

6.1. Existing Levee Inventory Systems and Databases

There are several existing levee inventory and database systems. These have been established by Federal and State agencies with little coordination among the efforts. Most of these systems are incomplete, some are not tied to modern geographic information systems, and overall they provide little information about the condition of the levees of the Nation.

6.1.1. FEMA Levee Inventory System

FEMA has developed an online database (http://flis.pbsjdfirm.com) to inventory each accredited and non-accredited levee structure. The FLIS captures several aspects of levees:

- Characteristics inherent to the levee structure such as levee type, flooding source, bank length, freeboard, and certification status, some of which are mentioned in the 44 CFR 65.10 criteria for levee accreditation and certification
- Communities that are affected by the levee
- FIRM panels that are affected by each levee and the protected vs. unprotected area flood zones

FEMA Procedure Memoranda 34, 32, and 30 define a process and protocol detailing how MCCs are to inventory and document levees using the FLIS system. With the beginning of Map Mod, that responsibility passed from the MCCs to the mapping partners producing the DFIRMs.

The FLIS has a major limitation in that it is not a spatially-based inventory. While levees are referenced by name and include textual descriptions of their location and information on FIRM panels, the underlying tabular data is not tied to GIS-based data that permits accurate coordinates (latitude and longitude points) of levee centerline locations on the ground. The spatial aspect of the levee location is critical in analyzing the impact of levee structures on surrounding flood-prone areas and assessment of risks from levee failures. Without this tie to a spatial dataset, it can be difficult to know which levee or levees a FLIS record is describing and where the beginning and ending points of certain levee characteristics are.

The lack of geospatial explicitness in the FLIS greatly reduces its usability. Attempts have been made to associate levee records in the FLIS with levee records in a GIS dataset so that the abundance of attributes in the FLIS may be harnessed, but such attempts have limited success because one-to-one association between the two is not always possible.

6.1.2. Current FEMA DFIRM Data

The FEMA DFIRM database is a GIS-based data model of flood hazard information for NFIP communities. While no specific levee theme or layer exists within the model, the FEMA *Guidelines and Specifications,* Appendix L, specifies how levees are identified within the GIS standards DFIRM database.

Specifically, levees are located in a GIS theme called "General Structures" or S_Gen_Struct. The general structures theme includes dams, channels, and culverts, as well as levees. Levees are then identified as a subtype in the general structures layer in a STRUCT_LID field. This field has a code that points to a lookup table of structure codes. Within a GIS, it is possible to select all the levees with the general structures theme by querying levees from the structure type field and saving out the query into a separate GIS theme or layer.

The current manner in which levees are modeled in the DFIRM data model presents some limitations in the usefulness of the data. Although the DFIRM data provides accurate locational information on levees, few attributes are collected specifically about levees. Because the theme includes the super set of flood-control structures, the data provided specifically on levees do not contain enough information to evaluate levee failure.

6.1.3. State Databases

The Association of State Floodplain Managers (ASFPM) reported on a survey of State levee databases. To date, Wisconsin and North Dakota have geospatial inventories; Illinois, Mississippi, North Dakota, Ohio, and California have some levee database efforts underway. The vast majority of States do not have a levee inventory of any sort.

6.2. Levee Inventory Systems and Databases under Development

The Federal Government is moving ahead with several initiatives to develop comprehensive, geospatially based levee inventory and assessment databases. Federal support of the State of California forms the basis for one such effort.

6.2.1. California DWR Levee Database

The California DWR is developing a statewide levee database. The effort is being funded with support from FEMA Region IX, utilizing FY 2005 Map Modernization Management Support funds. The project is a 3-year effort, with most first–year work geared towards capturing accurate spatial levee location.

The California Levee Database will show the location and pertinent data for more than 10,000 miles of levees within the State. This project includes the design of an Oracle/SDE Geodatabase that will support DWR levee inventory and maintenance activities.

The database will capture various information, including spatial location, engineering, and planning information. The first phase of the project involves capture of levee location and ownership data. The second phase of work involves development of standard datasets of interest to various DWR operating units. These datasets will capture risk factors related to each operational interest. For

example, the risk factors for floodplain management may include the status of levee certification, while the risk factors of maintenance may include the most recent date of levee inspection.

The data development process includes interviews with Federal, State and local agencies that are involved with levee maintenance. Data is captured through an internal Oracle/SDE database.

The design of the database will incorporate design elements from the USACE Special Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) data standard, the DWR levee information system, and FEMA's FLIS. The California database ultimately will be able to input data from and output data to these systems. The California database will also include a Web-based interface to distribute levee information over the Internet and provide a mechanism to update and maintain this data library.

6.2.2. U.S. Army Corps of Engineers

USACE is embarking on the development of a nationwide database of flood damage reduction structures including levees and floodwalls. The various USACE districts throughout the Nation currently maintain separate levee information both digitally and in paper-based formats. The Corps' approach is to develop a "proposed geospatial database structure and application framework [that] will provide technologies to support the population of a standard, comprehensive, spatially precise, authoritative, consistent and temporally explicit levee project database for USACE." This database structure will allow stakeholders to load, view, modify, and share project-related data, documentation, and information. The system will also provide decision making tools for project planning, design, and implementation."

In 2006, USACE created a levee database design using SDSFIE standards. USACE will begin the inventory process with a survey of all levees in the EP 500-1-1 program (Federal levees, federally constructed –locally operated, and levees in the PL 84-99 program). Five Corps districts will populate the database in a pilot effort; the effort then would be expanded to include other Corps districts. The current scope of work for the Corps database will focus on the federally constructed levees as well as non-federally constructed levees protecting against a 100-year-or-greater flood event. However, in many States such as California, Federal levees constitute only a portion of all levees.

6.2.3. FEMA GIS Database

In summer 2005, FEMA initiated an effort to develop a geospatially supported levee database framework. In the process of conducting its initial survey, it became aware of the USACE database effort and joined with USACE in defining the structure of the database. Each of the agencies determined that agency-specific data would be developed, but the amount of common data merited a cooperative effort. Since fall 2005, FEMA has been working closely with USACE database developers and with the State of California and its developers. ASFPM is also cooperating with FEMA and USACE to ensure that the needs of State agencies are considered in the database effort.

To ensure that FEMA's needs are considered in the Corps database design, FEMA has been working with USACE to provide recommendations on the type of data—both entity level and attribute level—to be collected. FEMA is also assisting USACE in identifying where spatial data about levees may already exist, providing geometry that may be useful in building the National

Levee Database. This data can come from several different sources, such as preliminary and effective DFIRM data, States, and local communities.

In the course of its work, the committee has developed specific recommendations on database framework technical aspects. These recommendations are contained in Appendix E.

6.3. Conclusion

The committee concludes that:

- Information about the location and condition of levees across the Nation is spotty and not in a form that supports effective management and decision making. Various levee databases have been developed but for the most part are not geospatially referenced, are incomplete, and lack usable information concerning the condition of the levees and attendant supporting structures. Current efforts by USACE and FEMA to coordinate and develop a multi-agency, Federal/State approach to inventory and assessment will provide significant benefits.

6.4. Recommendation

The committee recommends that:

- FEMA and USACE should continue their efforts to develop a joint database structure that will meet the needs of both agencies and other Federal and State organizations to maintain an inventory and assessment of flood damage reduction structures, including levees. While a need will exist for agency-specific components of such a database, the management and fiscal benefits that accrue from a common core and adherence to the national spatial data infrastructure will be significant. FEMA and USACE database developers should incorporate in their database design the recommendations in Appendix E.

7. Decertification of a Levee

Levees generally are decertified when a community is restudied and it is determined that the levee does not meet the levee standards in 44 CFR 65.10, or no available documentation demonstrates that the levee meets those criteria. This section addresses the procedures for decertification, the impact of decertification on the local community, and the options available after completion of the decertification process.

7.1. Levee Decertification

For federally funded flood damage/risk reduction systems, the Federal agency usually is responsible for notifying FEMA that it is questionable whether the levee currently provides sufficient damage/risk reduction. Once the decision has been made to decertify a levee, a restudy may be required to establish BFEs, initiate an appeals period, and provide the community 6 months to amend its floodplain management regulations before the revised FIRM becomes effective. This process may take several years.

When the revised FIRM becomes effective, the area that had been protected by the levee is usually designated as Zone AE, with BFEs established. In rural areas where no detailed engineering studies have been conducted, the area may be designated as Zone A, without BFEs. Flood depths behind the levee (the difference between the BFE and ground elevation) can range from less than 1 foot to 20 feet or more. Flood depths play a significant role in determining the severity of the impact of decertification. The impacts of decertifying a levee include the following:

- **Mandatory Flood Insurance Purchase Requirement.** The most immediate impact is that the mandatory flood insurance purchase requirement now applies to the area. Individuals must purchase flood insurance in order to obtain mortgage loans from federally insured or regulated lenders or other federally related financial assistance. Lenders would review their loan portfolios and require flood insurance on properties now shown as being in the SFHA. Eventually, most properties previously protected by the levee would have to purchase flood insurance.
- **Floodplain Management Requirements.** The area behind the levee is now subject to the community's floodplain management requirements. New and substantially improved residential buildings must now be elevated to or above the BFE and non-residential buildings elevated or floodproofed to that elevation. In areas of shallow flooding, this can usually be accomplished at minimal additional expense. However, as flood depths increase, the cost of construction will increase and, at some point, it will be not be practicable to meet the elevation requirements. Although some individual property owners may be willing to meet the elevation requirements, most developers are likely to delay construction on undeveloped land until such time as the level of damage/risk reduction provided by the levee can be restored and save them the cost of any protection measures.
- **Flood Insurance Rating.** Existing buildings behind the levee are considered pre-FIRM buildings and are eligible for pre-FIRM flood insurance rates and premiums. Insurance rates on these buildings are less than the actuarial rate and the premiums are subsidized. If owners purchased flood insurance for existing buildings prior to the FIRM becoming effective and maintained continuous coverage, they could insure the buildings at Zone B, C, or X rates, which are substantially lower than pre-FIRM rates. New and substantially improved buildings are subject to actuarial rates based on the elevation of the building in

relation to the BFE. Assuming these buildings are built in compliance with the communities' floodplain management requirements (protected to or above the BFE), the premiums should be less than those charged the existing pre-FIRM buildings.

- **Property Values and Tax Base.** A decline in property values and the resulting tax base of the community may result. Most studies show that the difference in property values for comparable properties inside and outside the floodplain is not great for most flood hazard areas. This likely will be true when a levee is decertified, provided that the properties are subject to shallow or moderate depths of flooding. Some diminution in value of existing buildings may result from the identification of the hazard and the expense of a flood insurance premium, but the risk is moderated by the ability to purchase flood insurance. New buildings in these areas will be subject to some increase in construction costs to elevate buildings to the BFE and an annual cost of insurance. A portion of loss will be reflected in loss of value to the undeveloped land. However, if individual property owners continue to believe that the levee provides significant damage/risk reduction even though the levee has been decertified by FEMA, this could limit any reduction in property value.
- **Development delay.** The most significant impact likely will be on undeveloped land in areas subject to moderate or deep flooding where development is imminent. Large developments may be delayed until the levee is restored. These areas may experience a significant short-term impact on land value.
- **Impact on Tax Base Will Vary.** Communities with limited areas protected by decertified levees or with areas where the flooding is relatively shallow may see only minimal impact on their tax base and property tax revenues. Communities with large areas of deep flooding may see a significant decline in tax base and tax revenue.
- **Demands for Protection.** Decertifying a levee generally results in demands from the public and local governments that the levee be restored to provide 100-year flood protection. When this occurs quickly (within several years or so), the impact of the decertification may be transitory. However, restoration of a levee often will take much longer because of the need to obtain funding (particularly if an appropriation from Congress is required) and time required for design and construction. In addition, some levees will never be restored because of lack of funding, other economic factors, or the poor condition of the levee. For these areas the impact will likely be long term.

7.2. Use of Zones AR and A99

As discussed in Section 2, AR zones were established to provide some degree of relief in situations where the community demonstrates a level of commitment to restoring the previous level of flood protection. The Zone AR statutory and regulatory requirements were developed largely to reflect conditions connected with the decertification of the Los Angeles River and American River levee systems. Both levee systems protected large numbers of people, and the expectation was that funding could be obtained and 100-year flood protection restored within a reasonable period of time.

The principal requirements in the statute or in 44 CFR 65.14 for designation as Zone AR are as follows:

- FEMA must determine that the community is engaged in the process of restoring a flood damage/risk reduction system that was constructed using Federal funds, recognized as

providing 100-year protection on the effective FIRM, and decertified by a Federal agency responsible for flood protection design or construction.

- A community that receives Federal funds for the restoration must complete restoration or meet Zone A99 requirements within 10 years from submittal of the application for Zone AR designation.
- A community that does not receive Federal funds for the restoration must complete restoration within 5 years of the submittal of the application.
- The community must submit a formal written request for Zone AR designation that includes a legislative action requesting the designation and provide supporting documentation that it will comply with requirements in 44 CFR 65.14.
- The community must submit a restoration plan that meets minimum requirements and continue to make adequate progress in accordance with the timeframes in the plan.
- The community must adopt a legal description of areas that are to be designated as developed areas within Zone AR and adopt floodplain management regulations compliant with 44 CFR 60.3(f).
- The community must certify annually that the restoration will be completed in accordance with the plan.

If, at any time, FEMA determines that the community will not complete restoration in the timeframe specified in the plan, FEMA can notify the community that the Zone AR designation will be removed and the area mapped as if no flood protection had been provided.

For most communities, the benefits of having the area designated as Zone AR include:

- Flood insurance will be available at rates no greater than if the project had been completed (generally Zone X rates unless an area will still be an SFHA when the project is completed).
- Floodplain management requirements in Zone AR for developed areas only require that new buildings be elevated to 3 feet above natural grade. No substantial improvements are required unless the area is designated as a dual zone in an underlying flood zone (will remain an SFHA after the levee is credited). More restrictive requirements apply outside developed areas. This is a significant benefit in areas of moderate or high flood depths.

The mandatory flood insurance purchase requirement still applies because the area remains an SFHA.

A Zone AR area can be converted to Zone A99 once the requirements for Zone A99 are met (100 percent of the project cost of the system has been authorized, at least 60 percent of the cost of the system has been appropriated, at least 50 percent of the cost of the system has been expended, and the system is at least 50-percent completed). The advantage to the community of converting from Zone AR to Zone A99 is that new buildings no longer have to be elevated to meet Zone AR requirements.

NFIP regulations currently limit Zone AR to projects that were constructed using Federal funds on the grounds that it is more likely that the level of protection would be restored in a timely manner if a Federal agency is involved. This limits the use of the Zone AR designation in situations where levees or floodwalls have been built by the community, a local flood-control district, or the private sector. For this reason, many levees that lose their accreditation as a result of Map Mod will not

qualify for Zone AR designation and will have to be remapped as Zone AE with all that it entails. Yuba County, California, is currently upgrading its levees without Federal funding. Recognizing the difficulty in obtaining Federal support, it is considering requesting Zone AR designation even though the funding is locally provided. One way to mitigate the impact of decertification of levees may be to remove the requirement that the levee be federally funded while retaining the requirement in the statute that a Federal agency determine that the levee is restorable. Strict requirements could be put in place to ensure that the community or flood-control district proceeds with restoration within the permissible time frame. If a community cannot meet these new Zone AR requirements, the area would be remapped as Zone AE.

7.3. Recognition of and Dealing with the Impact of Decertification

The sections above highlight the legal and regulatory impact of decertification, including the requirement for mandatory insurance and the imposition of land use controls. The sections did not include discussion of the secondary social and economic impact that might result from those actions. Homes with Federal mortgages will have to purchase insurance, and the rates may be high. Furthermore, resale value of such property may be lessened due to the high insurance cost. In addition, pending development must comply with floodplain land use regulation, which may result in an increase in cost or cancellation of the development.

As communities face the challenge of recertifying their levees and, in some cases, restoring levees that fail to meet certification requirements, it would be unrealistic to assume that all, or even many, communities have the financial capability to remedy deficiencies without some Federal involvement. The potential Federal sources of funding, the USACE Flood Damage Reduction program and the FEMA Flood Map Modernization initiative, today face severe budget constraints.

The net effect of these actions and other actions needed to bring the community into compliance will certainly generate stress within the community and a cry for political action to prevent decertification. While this outcome should be recognized and ameliorated where possible by remedial action to recertify the levee, there must also be a clear recognition that decertification identifies a risk to the community that can not be ignored. Working to deal with both of these issues will require close cooperation among FEMA, USACE, the States, local governments, and elected representatives.

7.4. Conclusions

The committee concludes that:

- Under Procedure Memorandum 34, when a levee is about to be remapped, levee sponsors must provide to FEMA documentation of previous certification of the levee and evidence that the levee currently meets the 44 CFR 65.10 criteria. Where such certification information does not exist (e.g., a grandfathered levee), the sponsor must provide certification. In other cases, the initial documentation may be incomplete or a physical inspection of a levee is inconclusive as to its condition. Under these circumstances, the levees will have to be recertified. Since the certification process may require a lengthy period of survey and analysis, completion of a countywide project may be delayed until the certification information is provided for what may be only one panel.

- When the physical condition of the levee indicates that the levee will not be certifiable, the recognition of the levee should be immediately removed.
- When the issue of certifiability is in question and could be resolved positively or negatively, action should be taken to resolve the issue, either by considering the levee as not providing protection or by initiating remedial action and seeking Zone AR or A99 status. In this case, to deal with the requirements of map production, three approaches could be taken:
  - Wait for certification documentation to be provided and delay completion of either the FIRM panel or the countywide map.
  - Move forward with issuing the panel, showing the levee as not providing protection from the 1-percent-annual-chance flood and making the community subject to mandatory insurance provisions at Zone A rates.
  - Issue the panel, designating the area as a special zone and indicating that the certification is in progress and that the action must completed within a 2-year period or the area reverts to unprotected status. Under this option, the community would be responsible for notifying all residents of the lack of certification and the potential residual risk.
- The process of conducting certification activities and, if required, restoration of decertified levees will place a heavy burden on local communities. These communities are already turning to the Federal Government for support, and the Federal Government should expect these requests to increase. These requests will place heavy burdens on related FEMA and USACE programs that are already stretched thin fiscally.

7.5. Recommendations

The committee recommends that:

- When communities are not immediately able to document that currently certified levees can be recertified and the levees are not known to be at risk, FEMA should notify the communities of the need for a more detailed examination of the levees and provide a specific schedule for that activity. Communities should be required to notify all persons who are in areas behind the levees of the re-examination process and identify for them the residual risks and the lack of information about the levees.
- FEMA should consider seeking legislative action to permit use of A99 designation and procedures by communities that are able to self-fund levee upgrades.
- FEMA and USACE should review existing authorities and funding available to assist communities in performing certification analysis and make recommendations to OMB and Congress if the funding and authorities are not available. FEMA and USACE should also develop expedited processes to assist communities in remediation of publicly owned levees and seek OMB and congressional approval of these processes and recognition of the need for resource commitments to support them.

8. Public Awareness and Outreach

8.1. FEMA and Outreach

As the Federal agency responsible for administering the NFIP, FEMA identifies areas prone to flood hazards nationwide and then develops and distributes flood hazard and flood risk information about the affected areas in an appropriate manner. Since the 1970s, flood hazard maps and collateral reports have been the primary vehicles to distribute flood hazard and risk information to the 20,000 communities participating in the NFIP. In addition to issuing guidelines and standards documents, FEMA has developed and distributed—through a variety of sources—hazard-specific public awareness and outreach materials in an effort to improve the awareness of community officials and citizens nationwide.

FEMA is not responsible for the design, construction, or maintenance of levees and comparable flood-control structures, or for creating, implementing, or enforcing State and local floodplain management regulations. FEMA does not certify levees, but relies on certification provided by the local sponsor of a levee or an appropriate Federal agency. Therefore, from FEMA's perspective, levee-related public awareness and outreach activities have primarily been the responsibility of the Federal, State, and local agencies with the primary responsibility for these structures and systems. FEMA has only become involved in the information dissemination process when specific structures or systems are out of compliance with NFIP regulations and mapping standards and create significant changes to the floodplain boundaries shown on the FIRMs for the affected communities. In those situations, FEMA's primary activities have been to explain why the FIRM is changing, clarify the NFIP regulations, and inform community officials and others what they must do to get the structure or system back in compliance with NFIP regulations and to reduce the mapped floodplain.

FEMA has not undertaken a wide-scale, nationwide effort to inform community officials and citizens about such topics as the relative protection provided by levees and similar flood risk-reduction systems, the inherent risk in building on the landward side of these systems, and alternative floodplain development practices that should be considered in levee-affected areas.

As documented elsewhere in this report, flood-related disasters continue to occur in areas where such structures and systems have been constructed, and the loss of life and property has been significant. The disastrous impact of levee failures in New Orleans made it apparent that community officials and citizens nationwide must be better informed. This does not mean that FEMA should take on this burden alone. In fact, research has shown that local champions are most successful in conveying such messages. However, by combining their resources, FEMA, its Federal and State agency partners, and active nongovernmental organizations such as the professional associations participating in the Mapping Coalition (e.g., ASFPM, National Association of Flood and Stormwater Management Agencies (NAFSMA)) working together can craft the appropriate messages, identify the appropriate delivery vehicles, and deliver messages to affected community officials and citizens nationwide.

The execution of Map Mod activities heightens the necessity for outreach, because the procedures being used to re-evaluate existing levees (documented in FEMA Procedure Memorandum No. 34) have, for the most part, placed new responsibilities on States, communities, and levee

owners/sponsors. The potential for no longer recognizing the flood protection capabilities of levees—with pertinent changes in flood insurance and floodplain management requirements for the affected areas—has also raised the awareness of the public and of elected officials at all levels. A sound, comprehensive public awareness and outreach program, initiated prior to or concurrent with any FEMA actions regarding levees, will reduce the stress of all parties and minimize delays in the production of updated maps.

8.2. Strategy Development and Implementation

As FEMA moves forward to develop and implement policy, regulatory, and procedural changes, it must also implement a public awareness and outreach strategy to improve community officials' and citizens' awareness and understanding of levee-associated hazards and risks and to inform them of the processes of conducting levee assessments. FEMA should also work with its Federal, State, and local partners—both governmental and nongovernmental—to build on these partners' successes, avoid their mistakes, and lead the development of a comprehensive, synergistic strategy that can and will be implemented consistently wherever levee structures and systems are located. The public awareness and outreach program must also involve the transmission of information from governmental and nongovernmental organizations to the public about the residual risks landward of levees and the level of those risks, even after a levee is credited on the map with providing 1-percent-annual-chance or greater flood protection.

Listed below and in Appendix D are some initial steps to be considered for carrying out the public awareness and outreach program:

8.2.1. Awareness and Outreach Approach

The primary purpose of public awareness and outreach activities should be to:

- Explain the relative advantages (benefits) and disadvantages (risks) of levee structures and systems
- Emphasize the possibilities of levee overtopping and failure and the catastrophic aftermath of such events
- Elaborate on structural and nonstructural alternatives in levee-affected areas
- Foster stakeholder understanding of State and local policies, regulations, procedures, and responsibilities in regard to the construction and maintenance of levee structures and systems
- Foster stakeholder understanding and acceptance of Federal (FEMA, USACE, and other) policies, regulations, and procedures in regard to the evaluation of levees and the mapping of levee-affected areas, with specific emphasis on the accreditation process and any changes that may occur in the future
- Enable communities and other partners to acquire, prepare, and submit supporting documents to evaluate or reevaluate levees as a result of the policy, regulatory, and procedural changes
- Foster stakeholder understanding of the floodplain management and insurance impacts of changing the flood hazard information shown on the flood map for levee-affected areas

- Encourage, through collaborative efforts, community-wide education of property owners, developers, builders, and other affected citizens in regard to levee-related risks and protective actions

In line with the overall Map Mod strategy for outreach and risk communication, the levee-related public awareness and outreach activities and all materials developed in support of these activities should be based on the following assumptions:

- Information about true flood hazards, as presented on flood maps and in FIS reports, is critical for making informed risk management decisions.[18]
- Flood hazard information must be accurate, accessible, and understandable to a wide range of stakeholders.
- To realize the full, long-lasting benefit of modernized maps, the user community must be expanded and better informed.
- Collaboration and the engagement of stakeholders will enable messages to reach the affected public.
- As indicated in the more detailed information provided in Appendix D, Federal, State, and local agencies and nongovernmental organizations that are involved with the construction and maintenance of levee structures and systems should collaborate on the following actions:
  - Clearly define the messages that are to be delivered, and train FEMA personnel how best to distribute them
  - Identify the audiences to whom the messages must be delivered
  - Define the roles and responsibilities of all public- and private-sector organizations and individuals that should be involved in this effort
  - Identify the most effective delivery vehicles
  - Identify potential roadblocks, and discover actions that should be taken to mitigate or eliminate these roadblocks
  - Establish mechanisms for collecting feedback to measure the success of the public awareness and outreach activities and vehicles
  - Implement a system that uses the collected feedback to improve messages, activities, and delivery vehicles
- Explain to the public the difference between "certifying" and "crediting" a levee on NFIP maps.
- On this committee's recommendation, explain to stakeholders the transition from a freeboard-based approach to a risk analysis approach.

The committee recognizes that this is a bold, large-scale undertaking that departs from current practice. However, the committee likewise believes that such action must be taken to increase the safety of people throughout the Nation.

[18] Sacramento County and the City of Sacramento combined to create flood risk maps for the public. These maps included the depth of flooding given various levee failure scenarios, the area of flooding, and the time between a levee failure and a flood inundation to one's property (by zone). The maps are in color and, with a little study, can be extremely informative. The website is http://www.cityofsacramento.org/utilities/flood/Sacramento_Flood_Maps.html.

8.3. Conclusion

The committee concludes that:

- The initiation of levee reevaluations, as outlined in Procedure Memorandum No. 34, significantly modifies the procedures initially discussed with communities and levee owners/sponsors and has the potential to create significant public opposition to the NFIP and Map Mod. A fully funded, well-executed public awareness and outreach program should be implemented immediately to accompany the execution of Procedure Memorandum No. 34, levee reevaluation activities, and the implementation of the recommendations in this report.

8.4. Recommendations

The committee recommends that:

- FEMA, working with its Federal, State, and local partners and levee sponsors, should develop and implement a public awareness and outreach strategy that will improve public officials' (including the Administration and U.S. Congress) and citizens' awareness and understanding of levee-associated hazards and risks. As part of this public awareness and outreach effort, levee sponsors should be required, through changes to the NFIP regulations, to annually notify property owners in areas behind a levee of the nature of the residual risk that exists and the risk classification of the levee.

In executing future public awareness and outreach activities, FEMA should carefully consider the procedural recommendations listed above and the recommendations listed in Appendix D.

9. Handling of Counties Where Maps Have Become Effective

Because the Flood Map Modernization initiative has been underway for more than 2 years, mapping has been completed or is in process for nearly 400 counties where levees existed. It is likely that, at the time the mapping was completed, neither the existing certification documents nor the development of information to support recertification were thoroughly reviewed. The local residents who rely on these maps can only assume that, if the maps are issued, FEMA has reviewed with "due diligence" the condition of the levees involved.

Fortunately, fewer than a quarter of the maps have become effective, with the remainder somewhere in the study or adoption process. The committee believes that it would not make sense to stop all work on countywide maps until a detailed levee review has been completed for the panels with levees. Rather, FEMA should seek local adoption of the new maps, without the panels containing levees, and should concurrently notify the relevant adopting communities that a more detailed examination of their levees is needed, and provide a schedule for that activity. Communities should be asked to notify all people residing in areas behind levees of the reexamination, and to explain to them the residual risks and the lack of information about their levees. This action might closely parallel ongoing FEMA efforts to support the completion and adoption of new countywide maps that contain levees needing further study.

10. Overarching Issues

Several topics arose during the conduct of committee activities that, although not specifically part of the task given to the committee, merit comment. They are the adequacy of the level of protection provided by levees, the residual risk that exists for those behind levees, the treatment of future conditions, "system" reliability, interagency cooperation, and the need for research and development (R&D) on rapid levee geotechnical assessment. While two of these topics are addressed directly by this report, all merit attention by FEMA and other Federal agencies.

10.1. Level of Protection

Under the NFIP, the SFHA was defined as the area encompassed by the 100-year flood. It thus seemed logical, when the decision was made to recognize that properly constructed levees reduce the risk to those behind levees, that when those levees provided protection against at least the 100-year flood, the levees could be assumed to remove the protected areas from the floodplain of the 100-year flood and the requirement for insurance. Unfortunately, the primary motivation for some communities to construct or upgrade a levee system has been the desire to have the levee credited by FEMA as providing 100-year protection, so that the NFIP floodplain management and mandatory flood insurance purchase requirements no longer apply. Once this has been achieved, many communities view additional levels of protection as an unnecessary expense. FEMA's minimum standards for levee accreditation have become the de facto design standard for levees in many instances, even though higher levels of protection might be advisable because of the residual risk of flooding and the threat to lives and property.

As history has indicated, when a flood greater than the 100-year flood occurs, the risk to a home with a first-floor elevation at the level prescribed for the 100-year flood may be far smaller than the risk to the individual whose home is behind an overtopped levee, who will face flood elevations that could be measured in tens of feet. The nation's experience with catastrophic flooding after levee overtopping and breaches highlights the residual risk to those behind levees. Ever since the BFE was established as the minimum level for levees to be recognized by the NFIP, the need to require levees to provide protection to an elevation higher than the 100-year standard has been discussed.

As indicated in Section 2, FEMA expressed great concern about the fragility of levees in 1981, noting that levee overtopping or failure is involved in approximately one-third of all flood disasters. FEMA stated that:

- 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 cost of damages that can that can be prevented
- Only a fraction of all earthen levees built with crown elevations at the computed 100-year flood elevation can be expected to provide protection for the true 100-year event because of the following factors:
  - the uncertainty involved in establishing flood elevations
  - changing hydrologic conditions
  - the possibility of structural failure before overtopping

In June 1977, USACE reported to HUD 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 also stated that a larger flood, such as the Standard Project Flood (SPF), should be adopted as the required level of protection. In September 1977, the Director of FEMA's Engineering Division recommended that the NFIP recognize only levees designed to provide protection against the SPF. In 1979, USACE issued a policy memorandum stating, "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." Shortly thereafter, the FIA Administrator recommended to the Director of FEMA "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."

In 1994, following the failure of levees throughout the Midwest, the Interagency Floodplain Management Committee stated in its report to the White House that urban centers should, at a minimum , be equipped with levees providing protection against the SPF.

Following Hurricane Katrina, ASFPM and NAFSMA publicly recommended that the minimum level for recognition of urban levees should be the 500-year flood level. The State of California is considering requiring levees that protect urban areas to be at least at the 200-year level.

Moving to a higher level of protection may not meet the guidelines established in the Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* unless, as recommended in several recent NRC studies, the guidelines are revised to better consider social and economic costs and benefits.

This committee has not had the opportunity to study the subject in detail, but it believes that strong consideration should be given to requiring that levees provide protection against floods greater than the 100-year flood. The committee believes that FEMA should give strong consideration to not recognizing, for NFIP purposes, levees protecting highly urbanized areas unless they can protect the area against events greater than 100-year floods (e.g., 500-year floods). As indicated above, a long history of recommendations and analyses support the need for protection to 500-year or higher levels. Given the large number of levees in existence, the transition would not be quick or easy. Nevertheless, FEMA should immediately take steps to examine this issue in detail and to determine whether a change in the standard for recognition should take place.

10.2. Dealing with Residual Risk

Previous sections have referred to the need to deal with the residual risk for individuals and structures behind levees. The committee believes that FEMA should:

- Take steps to ensure that those living behind levees are formally notified about the residual risk they face and the level of protection they are being provided
- Consider requiring some level of insurance for those protected by levees[19]

[19] The National Association of Homebuilders (NAHB) points out that any move toward mandatory purchase of flood insurance behind levees should be supported by analysis indicating that the increased costs to homeowners are outweighed by the benefits. Simply acknowledging that residual risk exists does not automatically justify the costs of mandated insurance purchase.

- Require communities to establish special early-warning systems and to develop a flood warning preparedness plan for those protected by levees
- Examine approaches for indicating on DFIRMs the nature of the residual risk in an area protected by levees (as indicated earlier in the report, these areas could receive a special zone classification)

10.3. Future Conditions

Current FEMA regulations do not require the hydrology of potential future climatic conditions to be analyzed or the effects of potential upstream or downstream development on the H&H of the area under study to be considered. However, these factors work together to change (likely reduce) the level of protection provided by structures such as levees and modify (likely raise) the elevation of the 100-year flood.

Although considerable debate continues over the parameters or even the existence of climate change, climate variability is a fact and has been reflected in the recent increases in storms and changes in the nature of annual precipitation patterns. National climate change assessments forecast increases in weather events that lead to flooding, and recent studies indicate increases in the severity of coastal events.

The expansion of major urban areas into nearby rural areas has also 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. A study on the impacts of future development being completed for FEMA by ABSG Consulting as part of the Evaluation of the National Flood Insurance Program provides an important perspective on this issue. The study, which uses HAZUS$_{TM}$ modeling and common assumptions about the effect of development on runoff, indicates that building in a watershed is expected to change the flood conditions and, in some cases, can increase the damage to structures by multiple orders of magnitude depending on the flood conditions. Examination of modeling results from several counties or parts of counties indicated that future conditions flooding from the 100-year flood event increase flood damages relative to the existing conditions flooding by somewhat modest percentages to very large percentages, depending on the expected development and specifics of each area. Although these findings cannot be generalized nationally, they are expected to be broadly representative of findings in other parts of the country.

It is also important to understand that rural, suburban, and urban areas are in a continuum and to recognize the relationship among levee systems along a river. While agricultural levees may not appear to have any immediate relationship to downstream suburban or urban levees, the failure of an agricultural levee may have a pronounced effect on the suburban or urban areas downstream, if the floodwaters remain landward of the levee as they move downstream. This situation occurred during the 1993 Mississippi River flood. This type of understanding calls for comprehensive floodplain modeling, using digital mapping products and GIS, and analyzing different potential failure scenarios.

The committee recognizes that dealing with climate change, sea-level rise, linked levees, and future development requires the commitment of significant resources and represents a conceptual shift from basing criteria on present conditions to basing criteria on possible, but not fully quantifiable, future conditions. Nevertheless, the committee believes that this step must be taken and

recommends that FEMA, in coordination with other Federal agencies, States, and communities, should closely examine how to undertake such efforts.

10.4. System Reliability

The effectiveness of a levee system depends on the effectiveness of all of the components of that system. These components include the levees and floodwalls themselves, openings through the levees that must be blocked during a flood by gates or other structures, pipes that run through the levees, and features such as railway and highway embankments; the failure of any of these would cause the system as a whole to be compromised. FEMA's recognition of a levee should be predicated on its own review of all the components of the system and, of special importance, the links among these components. As the post mortems on the New Orleans levees indicated, the system as a whole was threatened by the failure to deal with locations where differing components met, or to ensure that critical system elements, such as gates, were available and could be installed. The same issues arose during the 1993 Mississippi River floods, when a gate failure caused the flooding of the Des Moines, Iowa, water treatment facility. Given the current staffing of the FEMA Regional Offices, such an approach will require significant but necessary resource increases.

10.5. Federal, State, and Interagency Cooperation

The structure of this committee and the participation of non-Federal observers opened the committee's discussions to a wide variety of viewpoints. The agencies' competing and complementary efforts to deal with the levee challenge were placed on the table. By bringing together Federal and State agencies in the development of a levee inventory and assessment process, this committee recognized the potential benefits to all parties in a cooperative effort. A considerable exchange of information took place with respect to the challenges faced in computing the 100-year flood and dealing with the geotechnical considerations of levee certification. The committee recommends that participating agencies seek opportunities to conduct such joint efforts with a view to strengthening the ongoing relationships among groups working on these issues.

10.6. Research and Development – Geotechnical Assessment of Levee Integrity

Early in its deliberations, the committee recognized that a major challenge facing those responsible for levee certification was the performance of appropriate and rapid geotechnical assessments of levee integrity. Such assessments, depending on the nature of the material and the cross section of the levee, could cost more than $100,000 per linear mile of levee, with the bulk of the costs related to the number and depth of soil borings and the determination of levee centerline elevations. The committee sought out current efforts, nationally and internationally, to address these issues, and found that no methods or technologies are currently available to replace soil borings. However, the LIDAR efforts of the U.S. Army Engineer Research and Development Center (ERDC) and USGS have reduced the costs and increased the speed of determining levee elevations.

The committee learned that a Canadian firm, Fugro Airborne Surveys, has developed electromagnetic induction sensing techniques, using a suspended, multicoil sensor platform hung below a helicopter, to perform conductivity surveys over levees. The ERDC has demonstrated the utility of airborne and ground-based geophysical methods to determine soil composition and

floodplain properties, and has developed an approach for the initial screening of levee integrity in levees controlled by the International Boundary and Water Commission along the U.S.-Mexico border. However, USACE has not directly funded any R&D program to further the research ERDC has made in this area or to develop techniques to characterize unstable levee signatures. Similar R&D efforts are underway in Japan, at a low level of funding, by the Public Works Research Institute. A California firm, DOER Subsea Robotics & Submersible Systems, has proposed to the California DWR the use of several techniques for such investigations.

Research also is needed to support the use of the geotechnical data in risk assessments. Methodologies must be developed to apply and compare remote and in situ sampling datasets with previous levee performance/failure data (from a GIS-managed databank) and failure models, to develop fragility curves and assign sector risks.

The task facing those responsible for levee assessment is monumental. The costs may be equally high. The performance of lengthy assessments can only delay the completion of map modernization. The committee believes that increased R&D resources should be focused on further developing the above-mentioned techniques and applying them to ongoing assessment efforts. The benefits of the program, if only minimally successful, could far outweigh the costs.

11. Next Steps

The committee cannot overemphasize the importance of dealing with the "levee issue" in a rapid and straightforward manner. On the other hand, the committee recognizes that new regulations cannot, in the Federal system, be developed and promulgated overnight. FEMA and other governmental agencies need to move where they can and to launch efforts to deal with items that will require a longer timeframe to accomplish. Given these constraints, the committee recommends that FEMA address the issues identified in this report in the manner described below.

11.1. Immediate Actions

The Committee urges FEMA and, as appropriate, other Federal agencies to take the following actions immediately:

- When communities are not immediately able to document whether currently certified levees can be recertified and the levees are not known to be at risk, FEMA should notify the communities of the need for a more detailed examination of the levees and provide a specific schedule for that activity. FEMA should require these communities to notify all people in areas behind the levees of the reexamination and identify for them the residual risks and the lack of information about the levees.
- FEMA should define, as a matter of policy, a new flood insurance zone (Zone XL) for areas behind levees that meet the requirements for inclusion in the NFIP. Zone XL would include those areas behind the levee that would be subject to inundation by the 100-year flood if there were no levee. The area between the 100-year and 500-year lines should be shown as a shaded Zone X.
- FEMA should initiate the revision of 44 CFR 65.10 and other appropriate FEMA guidance and specification documents, to address technical changes to the CFR recommended by this report.
- As a matter of policy, FEMA should require levee sponsors to conduct annual inspections of their levee systems; biennially submit to FEMA the results of the annual inspections, levee system operation and maintenance records, and an assessment of the levee systems during any flood events that occurred within the reporting period; and every 10 years submit a report that recertifies the engineering and geotechnical conditions of the levee system.
- FEMA and USACE should continue their efforts, in coordination with the States, to develop a joint database structure that will meet the needs of both agencies and other Federal and State organizations to maintain an inventory and assessment of flood damage reduction structures, including levees.
- FEMA, working with its Federal, State, and local partners and levee sponsors, should develop and implement a public awareness and outreach strategy that will improve the awareness and understanding of public officials (including the Administration and Congress) and citizens. The following issues should be included:
  - Levee-associated hazards and risks (as part of this public outreach effort, levee sponsors should be required, as a matter of policy, to provide annual notification to property owners in areas behind a levee of the nature of the residual risk that exists)
  - The current procedures to map and recertify existing levees and the attendant challenges created by decertification

- FEMA and USACE, recognizing the important State and local roles, should develop incentives and support mechanisms to ensure that State and local agencies effectively carry out their responsibilities with respect to levee operation and maintenance.
- FEMA should exclude embankments, such as roads and railroads, from the accreditation of new levee systems unless those embankments are engineered specifically to provide damage/risk reduction from flooding and meet the engineering criteria required of levees.
- FEMA, USACE, and USGS should support R&D efforts focused on improving the rapid assessment of levee geotechnical integrity and should jointly recommend that the National Science Foundation pay attention to this area of research.
- As a matter of policy, FEMA should require communities to establish special early warning systems and to develop evacuation plans for those protected by levees.
- FEMA should develop and disseminate levee certification guidance for communities and engineers.

11.2. Longer-term Actions

The committee, recognizing the need for additional study and regulation development, urges FEMA and, as appropriate, other Federal agencies to initiate action on the following longer-term recommendations and to take the following actions:

- FEMA should revise 44 CFR 65.10 to phase out, over the next 10 years, the freeboard-based approach and to substitute the risk analysis methodology, with a 90-percent assurance of passing the 100-year flood, to determine the required levee heights. During the transition period, FEMA should permit either approach to be used for levee design and recertification analysis.
- FEMA should take immediate steps to examine the feasibility of not recognizing, for NFIP purposes, levees that protect highly urbanized areas unless they provide protection from events greater than 100-year floods (e.g., 500-year floods).
- FEMA should address the challenge of the residual risk to structures behind levees by seeking legislative change to require property owners to purchase some level of flood insurance for structures behind levees (in the new Zone XL).
- FEMA, working closely with other Federal agencies, States, and communities, should examine how best to deal with climate change, sea-level rise, linked levee systems, and future development as major drivers of future conditions H&H, with a goal of determining a BFE based on possible, but not fully quantifiable, future conditions.
- FEMA, in coordination with other Federal agencies, States, and communities, should initiate studies to determine how levees could be identified under a scientifically based levee risk-classification system (e.g., high, medium, or low). This system would be based on factors that include the potential depth of flooding in the event of failure or overtopping; the type and density of development in protected areas behind the levee; steps taken to ensure that levee failure does not occur when the levee capacity is exceeded (overtopping); warning times; and the number and types of egress so that people who may be inundated may move out of harm's way. This levee risk classification would be designated on the FIRM and published in the FIS report.
- FEMA, in coordination with other Federal agencies that use H&H data and techniques, should support funding of NOAA efforts to upgrade flood frequency estimates, upgrade the

USGS gaging program, and revise *Bulletin 17B*, which guides flood recurrence interval determinations.

Appendix A. Interagency Levee Policy Review Committee

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	Mitigation – Risk Insurance	Donald Beaton
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Appendix B. 44 CFR §65.10

§65.9 Review and response by the Administrator.

If any questions or problems arise during review, FEMA will consult the Chief Executive Officer of the community (CEO), the community official designated by the CEO, and/or the requester for resolution. Upon receipt of a revision request, the Administrator shall mail an acknowledgment of receipt of such request to the CEO. Within 90 days of receiving the request with all necessary information, the Administrator shall notify the CEO of one or more of the following:

(a) The effective map(s) shall not be modified;

(b) The base flood elevations on the effective FIRM shall be modified and new base flood elevations shall be established under the provisions of part 67 of this subchapter;

(c) The changes requested are approved and the map(s) amended by Letter of Map Revision (LOMR);

(d) The changes requested are approved and a revised map(s) will be printed and distributed;

(e) The changes requested are not of such a significant nature as to warrant a reissuance or revision of the flood insurance study or maps and will be deferred until such time as a significant change occurs;

(f) An additional 90 days is required to evaluate the scientific or technical data submitted; or

(g) Additional data are required to support the revision request.

(h) The required payment has not been submitted in accordance with 44 CFR part 72, no review will be conducted and no determination will be issued until payment is received.

[51 FR 30315, Aug. 25, 1986; 61 FR 46331, Aug. 30, 1996, as amended at 62 FR 5736, Feb. 6, 1997]

§65.10 Mapping of areas protected by levee systems.

(a) *General.* For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive flood plain management criteria established by §60.3 of this subchapter. Accordingly, this section describes the types of information FEMA needs to recognize, on NFIP maps, that a levee system provides protection from the base flood. This information must be supplied to FEMA by the community or other party seeking recognition of such a levee system at the time a flood risk study or restudy is conducted, when a map revision under the provisions of part 65 of this subchapter is sought based on a levee system, and upon request by the Administrator during the review of previously recognized structures. The FEMA review will be for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and shall not constitute a determination by FEMA as to how a structure or system will perform in a flood event.

(b) *Design criteria.* For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided. The following requirements must be met:

(1) *Freeboard.* (i) Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

(ii) Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and

magnitude of debris, sediment, and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.

(iii) For coastal levees, the freeboard must be established at one foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site.

(iv) Occasionally, exceptions to the minimum coastal levee freeboard requirement described in paragraph (b)(1)(iii) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood loading conditions. Particular emphasis must be placed on the effects of wave attack and overtopping on the stability of the levee. Under no circumstances, however, will a freeboard of less than two feet above the 100-year stillwater surge elevation be accepted.

(2) *Closures.* All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice.

(3) *Embankment protection.* Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

(4) *Embankment and foundation stability.* Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, ''Design and Construction of Levees'' (EM 1110–2–1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).

(5) *Settlement.* Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, ''Soil Mechanics Design—Settlement Analysis'' (EM 1100–2–1904) must be submitted.

(6) *Interior drainage.* An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.

(7) *Other design criteria.* In unique situations, such as those where the levee system has relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA will also provide the rationale for requiring this additional information.

(c) *Operation plans and criteria.* For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.

(1) *Closures.* Operation plans for closures must include the following:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists for the completed operation of all closure structures, including necessary sealing, before floodwaters reach the base of the closure.

(ii) A formal plan of operation including specific actions and assignments of responsibility by individual name or title.

(iii) Provisions for periodic operation, at not less than one-year intervals, of the closure structure for testing and training purposes.

(2) *Interior drainage systems.* Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists to permit activation of mechanized portions of the drainage system.

(ii) A formal plan of operation including specific actions and assignments of responsibility by individual name or title.

(iii) Provision for manual backup for the activation of automatic systems.

(iv) Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes. No more than one year shall elapse between either the inspections or the operations.

(3) *Other operation plans and criteria.* Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.

(d) *Maintenance plans and criteria.* For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify

the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.

(e) *Certification requirements.* Data submitted to support that a given levee system complies with the structural requirements set forth in paragraphs (b)(1) through (7) of this section must be certified by a registered professional engineer. Also, certified as-built plans of the levee must be submitted. Certifications are subject to the definition given at §65.2 of this subchapter. In lieu of these structural requirements, a Federal agency with responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the base flood.

[51 FR 30316, Aug. 25, 1986]

§65.11 Evaluation of sand dunes in mapping coastal flood hazard areas.

(a) *General conditions.* For purposes of the NFIP, FEMA will consider storm-induced dune erosion potential in its determination of coastal flood hazards and risk mapping efforts. The criterion to be used in the evaluation of dune erosion will apply to primary frontal dunes as defined in §59.1, but does not apply to artificially designed and constructed dunes that are not well-established with long-standing vegetative cover, such as the placement of sand materials in a dune-like formation.

(b) *Evaluation criterion.* Primary frontal dunes will not be considered as effective barriers to base flood storm surges and associated wave action where the cross-sectional area of the primary frontal dune, as measured perpendicular to the shoreline and above the 100-year stillwater flood elevation and seaward of the dune crest, is equal to, or less than, 540 square feet.

(c) *Exceptions.* Exceptions to the evaluation criterion may be granted where it can be demonstrated through authoritative historical documentation that the primary frontal dunes at a specific site withstood previous base flood storm surges and associated wave action.

[53 FR 16279, May 6, 1988]

§65.12 Revision of flood insurance rate maps to reflect base flood elevations caused by proposed encroachments.

(a) When a community proposes to permit encroachments upon the flood plain when a regulatory floodway has not been adopted or to permit encroachments upon an adopted regulatory floodway which will cause base flood elevation increases in excess of those permitted under paragraphs (c)(10) or (d)(3) of §60.3 of this subchapter, the community shall apply to the Administrator for conditional approval of such action prior to permitting the encroachments to occur and shall submit the following as part of its application:

(1) A request for conditional approval of map change and the appropriate initial fee as specified by §72.3 of this subchapter or a request for exemption from fees as specified by §72.5 of this subchapter, whichever is appropriate;

(2) An evaluation of alternatives which would not result in a base flood elevation increase above that permitted under paragraphs (c)(10) or (d)(3) of §60.3 of this subchapter demonstrating why these alternatives are not feasible;

(3) Documentation of individual legal notice to all impacted property owners within and outside of the community, explaining the impact of the proposed action on their property.

(4) Concurrence of the Chief Executive Officer of any other communities impacted by the proposed actions;

(5) Certification that no structures are located in areas which would be impacted by the increased base flood elevation;

(6) A request for revision of base flood elevation determination according to the provisions of §65.6 of this part;

(7) A request for floodway revision in accordance with the provisions of §65.7 of this part;

(b) Upon receipt of the Administrator's conditional approval of map change and prior to approving the proposed encroachments, a community shall provide evidence to the Administrator of the adoption of flood plain management ordinances incorporating the increased base flood elevations and/

Appendix C. Proposed Revisions to 44 CFR §65.10, Mapping of Areas Protected by Levee and Floodwall Systems

Revision 1 – Interim Changes

44 CFR §65.10 Mapping of areas protected by levee systems

(a) *General.* For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those levee and floodwall systems (hereafter referred to as flood risk reduction systems) that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive floodplain management criteria established by §60.3 of this subchapter. Accordingly, this section describes the types of information FEMA requires to recognize, on NFIP maps, a levee system that provides protection from the 100-year flood, while concurrently recognizing the residual risk that continues to exist. The community or other party seeking recognition of such a levee system must provide this information to FEMA at the time a flood risk study or restudy is conducted, when a map revision is sought on the basis of a levee system, under the provisions of Part 65 of this subchapter and upon request by the Administrator during the review of previously recognized structures. The FEMA review will establish appropriate risk zone determinations for NFIP maps.

(b) *Design criteria.* For levees to be recognized, FEMA must receive evidence that adequate design, operation, and maintenance systems are in place to provide reasonable assurance of protection from the 100-year flood[20]. The following requirements must be met:

(1) *Freeboard.* (i) Riverine levees must provide a minimum freeboard of 3 feet above the water-surface level of the 100-year flood, but they must be at least of such height that there is a 90-percent conditional nonexceedance probability – referred to here as "assurance" – of containing the 100-year flood. Paragraph (b)(1)(v) below defines and has references related to "assurance." An additional 1 foot above the minimum is required within 100 feet on either side of structures (such as bridges) riverward of the levee, or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

(ii) Occasionally, exceptions to the minimum riverine freeboard requirement described in Paragraph (b)(1)(i) of this section may be approved. Appropriate engineering analyses that demonstrate adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The presented material must evaluate the uncertainty in the estimated BFE profile and include, but not be limited to, an assessment of the statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and magnitude of debris, sediment, and ice accumulation. It must also show that the levee will remain structurally stable during the 100-year flood, when such additional loads are imposed. Under no circumstances will a freeboard of less than 2 feet be accepted. Uncertainty analysis based on these

[20] The 100-year flood is equivalent to the 1-percent-annual-chance flood, the FEMA base flood, and the base flood.

factors, which demonstrates a 95-percent assurance of containing the 100-year flood, is acceptable justification for the 2-foot minimum freeboard.

(iii) For coastal levees, the freeboard must be established at 1 foot above the height of the 1-percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site. The freeboard must at least be of such height that there is a 90-percent assurance of containing the 1-percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site.

(iv) Occasionally, exceptions to the minimum coastal levee freeboard requirement described in Paragraph (b)(1)(iii) of this section may be approved. Appropriate engineering analyses that demonstrate adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The presented material must evaluate the uncertainty in the estimated 100-year flood loading conditions. Particular emphasis must be placed on the effects that wave attack and overtopping will have on the stability of the levee. Under no circumstances will a freeboard of less than 2 feet above the 100-year stillwater surge elevation be accepted. Uncertainty analysis that demonstrates a 95-percent assurance of containing the 1-percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site is acceptable justification for the 2-foot minimum freeboard.

(v) "Assurance" is defined as the percentage of chance that floodwaters associated with the discharge having a 1-percent chance of being exceeded in any given year will not inundate any area landward of a levee system that would be inundated without the benefit of the levee system. Assurance is a concept inherent in the USACE risk analysis framework as described in USACE manual ER 1110-2-101, entitled "Risk Analysis for Flood Damage Reduction Studies," and USACE manual EM 1110-2-1619, entitled "Risk-based Analysis for Flood Damage Reduction Studies."

(2) *Closures.* All openings must be equipped with closure devices that are structurally part of the system during operation and designed according to sound engineering practice.

(3) *Embankment protection.* Engineering analyses must be submitted to demonstrate that no appreciable erosion of the levee embankment can be expected during the 100-year flood, as a result of either currents or waves, and that the anticipated erosion will not result in direct failure of the levee embankment or foundation or indirect failure through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; the impact of debris; slope protection techniques; the duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

(4) *Embankment and foundation stability.* Engineering analyses that evaluate levee embankment stability must be submitted. These analyses should evaluate the expected seepage during loading conditions associated with the 100-year flood and should demonstrate that seepage into or through the levee foundation and embankment will not jeopardize the stability of the embankment or foundation. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the USACE manual entitled "Design and Construction of Levees" (EM 1110-2-1913, Chapter 6, Section II), may be

used. The factors that should be addressed in these analyses include depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).

(5) *Settlement.* Engineering analyses that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in Paragraph (b)(1) of this section must be submitted. These analyses must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, a detailed settlement analysis using procedures such as those described in the USACE manual entitled "Soil Mechanics Design - Settlement Analysis" (EM 1100-2-1904) must be submitted.

(6) *Interior drainage.* An analysis that identifies the source(s) of such flooding; the extent of the flooded area; and, if the average depth is greater than 1 foot, the water-surface elevation(s) of the 100-year flood must be submitted. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of equipment (such as drainage lines and pumps) that evacuates interior floodwaters.

(7) *Other design criteria.* In unique situations, such as those where the levee system has a relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA will also provide the rationale for requiring this additional information.

(c) *Operation plans and criteria.* For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual. The levee operator must provide a copy of this manual to FEMA when seeking levee or drainage system recognition or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.

(1) *Closures.* Operation plans for closures must include the following:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and a demonstration that the flood warning time provided will be sufficient to complete all structure closure operations, including necessary sealing, before floodwaters reach the base of the closure

(ii) A formal plan of operation, including specific actions and assignments of responsibility by individual names or titles

(iii) Provisions for periodic operation, at not less than 1-year intervals, of the closure structure for testing and training purposes

(2) *Interior drainage systems.* The interior drainage systems associated with levee systems often include storage areas, gravity,, outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities, and demonstration that the flood warning time is sufficient to permit the activation of mechanized portions of the drainage system

(ii) A formal plan of operation, including specific actions and assignments of responsibility by individual names or titles

(iii) Provision for manual backup for the activation of automatic systems

(iv) Provisions for periodic inspections of interior drainage systems and the periodic operation of any mechanized portions for testing and training purposes. No more than 1 year shall elapse between either the inspections or the operations.

(3) *Other operation plans and criteria.* Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA's determinations will be based.

(d) *Maintenance plans and criteria.* For FEMA to recognize levee systems as providing protection from the 100-year flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or the agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans should specify the maintenance activities to be performed, the frequency of their performance, and the name or title of the person responsible for their performance.

(e) *Residual risk and public safety*. The issues addressed here are focused on public safety during flood events exceeding the capacity of the levee system. The components that must be addressed are the probability of capacity exceedance, the consequence of capacity exceedance, an examination of project features that address capacity exceedance, and emergency plans to ensure public safety in the event of a flood that exceeds the levee system capacity.

(1) *Probability of capacity exceedance*. The threat to floodplain residents and businesses is best described by the probability of capacity exceedance. The probability must be estimated based on information on flood flow and stage and associated uncertainties, the integrity of the levee embankment and associated structures and the potential failure probabilities, and an analysis of closure devices and other components. The probability of capacity exceedance is to be expressed as Annual Exceedance Probability (AEP), as defined in USACE manual ER 1105-2-101.

(2) *Consequence of capacity exceedance*. The general scope and nature of the impact on floodplain residents, businesses, critical infrastructure systems, and the environment will be assessed and reported. The intent is not to produce a detailed impact analysis, but to assess the threat to floodplain occupants and to indicate the approximate numbers and demographics of residents, businesses, and disruptions that would likely occur from a capacity exceedance. This information would clearly distinguish between floodplains that may experience slow, shallow flooding and those that may experience rapid, deep flooding. It also would delineate between floodplains that have adequate routes and capacity for occupant evacuations and those that do not. Finally, it would separate floodplains that, if flooded from a levee system failure, would or would not result in the crippling of a regional economy or have significant national economic impact.

(3) *Project features for capacity exceedance*. Levee system projects will be expected to have means to accommodate possible capacity exceedance. Where feasible and practical, systems will be designed and constructed to account for possible capacity exceedance. Therefore, if capacity exceedance results in a failure of the levee system, the failure will occur gradually and in a predictable manner. Levee superiority is one physical means for such accommodation, and another is to harden sections to withstand overtopping (see USACE manual ER 1110-2-229, entitled "Overtopping of Flood Control Levees and Floodwalls"). Documented evidence of accommodating capacity exceedance is required.

(4) *Emergency response plan*. Communities with levee systems are required to have current (updated within 5 years) flood warning and emergency response plans that demonstrate that public safety from flood events that exceed levee system capacity has been planned for and that the plan has a high likelihood of being successful. Emergency response plans will address the key issues of flood threat recognition, warning dissemination, evacuation, and search and rescue. Documentation must be submitted to demonstrate that the plan will remain viable through an annual review of action plans and updating official contacts and their responsibilities. Periodic testing of the plan must also be documented.

(f) *Certification requirements.* Data supporting a given levee system's compliance with the structural requirements set forth in Paragraphs (b)(1) through (7) of this section must be certified by a registered professional engineer. Certified as-built plans of the levee must also be submitted. Certifications are subject to the definition given in §65.2 of this subchapter. In lieu of these structural requirements, a Federal agency with responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the 100-year flood.

Revision 2 – Total Change

(a) *General.* For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping those levee and floodwall systems (hereafter referred to as "levee systems") that meet, and continue to meet, minimum design, construction, operation, and maintenance standards consistent with the level of protection sought through the comprehensive floodplain management criteria established by §60.3 of this subchapter. Accordingly, this section describes the types of information FEMA requires to recognize, on NFIP maps, that a levee system provides protection from the 100-year flood while concurrently recognizing the residual risk that continues to exist from the 100-year flood. The community or other party seeking recognition of such a levee system must supply this information to FEMA at the time a flood risk study or restudy is conducted, when a map revision is sought on the basis of a levee system under the provisions of Part 65 of this subchapter, and upon request by the Administrator during the review of previously recognized structures. The FEMA review will establish appropriate risk zone determinations for NFIP maps.

(1) *Risk and uncertainty framework.* A risk analysis framework will be used to determine whether levees provide adequate protection from the 100-year flood. Quantitative assessment of the uncertainty associated with key engineering elements of the levee protection system will be required. These uncertainties will be formed into an analysis framework that measures whether the levee provides protection from the 100-year flood, referred to here as "assurance." Assurance is defined as the percentage of chance that floodwaters associated with the discharge having a 1-percent chance of being exceeded in any given year will not inundate areas landward of a levee system that would be inundated without the benefit of the levee system. The risk analysis framework is described in USACE manual ER 1110-2-101, entitled "Risk Analysis for Flood Damage Reduction Studies," and methods for performing such analysis are documented in USACE manual EM 1110-2-1619, entitled "Risk-based Analysis for Flood Damage Reduction Studies."

(2) *New levees vs. existing or reevaluated levees.* For newly constructed levees that are undergoing analysis for certification determination, the primary emphasis will be on assessing the design criteria, and the key issue will be the levee height required to contain the 100-year flood with 90-percent assurance. Uncertainties in factors other than the 100-year flood stage are likely to be of less importance. To evaluate existing levees not previously studied for certification, or to reevaluate existing levees that have not been reevaluated for some time, assessing the structural integrity of the levee in its constructed state will be the key issue. In the risk and uncertainty framework, assessing existing levees will include an analysis of the design criteria, if known, and the likely integrity of the geotechnical and other structural features through development and analysis of elevation-failure probability functions that reflect the uncertainty inherent in characterizing the structural integrity of existing, and sometimes aged and aging, levee systems. In this instance, the levee height to ensure a 90-percent assurance of containing the 100-year flood will not be the only determining factor; instead, the overall assurance that the levee system will contain the 100-year flood will govern.

(b) *Design, construction, and maintenance.* For levees to be recognized by FEMA, the certifier must provide evidence that adequate design and construction standards were employed, and that operation and maintenance systems are in place. This provides a reasonable and quantified assurance of protection from the 100-year flood. The analysis required to demonstrate assurance

will include an analysis of riverine and coastal 100-year flood stages and associated uncertainties, and the integrity of levee embankment and foundation structures, as quantified by levee elevation-failure probability relationships. These relationships will be formed into a risk analysis framework, and the assurance of protecting against the 100-year flood will be computed. The overall, combined assurance of protecting against the 100-year flood must be a minimum of 90 percent.

(1) *Riverine and coastal 100-year flood stages and uncertainties.*

(i) Riverine 100-year flood stage and associated uncertainties are derived from frequency analysis of stage records, stage frequency developed from unsteady flow model analysis, or stage frequency developed from 100-year flood discharge and stage-flow modeling. Also included in the uncertainty estimates will be the potential for sediment accumulation and debris and ice accumulation and blockage. The resulting relationships are the 100-year flood flow frequency and stage rating with associated uncertainties, or "100-year flood stage and associated uncertainty."

(ii) Coastal 100-year flood stage and associated uncertainties are the 1-percent wave or the maximum wave run-up (whichever is greater) associated with the 1-percent-annual-chance stillwater surge elevation at the site, and the associated uncertainties. The resulting relationship is an elevation-exceedance probability relationship and associated uncertainty.

(2) *Levee structural integrity and uncertainty.*

(i) Engineering analyses must be submitted to demonstrate that no appreciable erosion of the levee embankment can be expected during the 100-year flood as a result of either currents or waves, and that anticipated erosion is not likely to result in direct failure of the levee embankment or foundation or indirect failure through reduction of the seepage path and subsequent instability. A quantitative assessment of the integrity of the levee from erosion forces for the full range of flood stages must be conducted. A relationship depicting this assessment will define the probability of levee failure as a function of flood elevation. The factors to be addressed in such analyses include, but are not limited to: expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

(ii) Engineering analyses that evaluate levee embankment stability must be submitted. These analyses should evaluate the expected seepage during loading conditions associated with the 100-year flood and associated uncertainty, and should demonstrate that seepage into or through the levee foundation and embankment will not jeopardize the stability of the embankment or foundation. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case III or IV, depending on the specific circumstance, as defined in the USACE manual entitled "Design and Construction of Levees" (EM 1110-2-1913, Chapter 6, Section II), may be used. A quantitative assessment of levee integrity from an embankment stability perspective must be made. Embankment strength and seepage consequences for all flood stages should be assessed. A relationship depicting this assessment will define the probability of levee failure as a function of flood elevation. The factors to be addressed in the analyses include: depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design

factors affecting embankment and foundation stability (such as berms). USACE manual ETL 1110-2-556, entitled "Risk Analysis in Geotechnical Engineering for Support of Planning Studies," and USACE manual ETL 1110-2-547, entitled "Introduction to Probability and Reliability Methods in Geotechnical Engineering," are useful references for this analysis.

(iii) Engineering analyses that evaluate floodwall/structure stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the 100-year flood and associated uncertainty, and shall demonstrate that seepage into or through the floodwall foundation will not jeopardize foundation stability. A quantitative assessment must be conducted to show the integrity of the floodwall structural integrity and the foundation stability during the full range of flood stages. A relationship depicting this assessment will define the probability of levee failure as a function of flood elevation. The factors to be addressed in the analyses include: depth of flooding, duration of flooding, floodwall geometry and strength, length of seepage path at critical locations, foundation materials, foundation preparation, other design factors affecting seepage (such as drainage layers), and other design factors affecting floodwall foundation stability (such as berms).

(iv) A composite levee structural integrity relationship shall be derived from combining the flood elevation – levee failure relationships developed in Paragraphs (b)(2)(i), (b)(2)(ii), and (b)(2)(iii) above for use in the overall assurance computation required in Paragraph (2)(b).

(3) *Closures.* All openings must be provided with closure devices that are structural parts of the system during operation and designed according to sound engineering practice. Maintenance plans and annual test results of the operation plans for all closure structures must be submitted.

(4) *Consolidation, settlement, and regional subsidence.* Engineering analyses that assess the potential and magnitude of future losses of levee crest elevation as a result of consolidation, settlement, or regional subsidence must be submitted. The analysis must demonstrate that the required crest elevation will be maintained, or that plans exist for periodically raising levees to required heights over the expected life of the levee project. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the USACE manual entitled "Soil Mechanics Design - Settlement Analysis," (EM 1100-2-1904) must be submitted.

(5) *Interior drainage.* An analysis must be submitted that identifies the source(s) of such flooding; the extent of the flooded area; and, if the average depth is greater than 1 foot, the water-surface elevation(s) of the 100-year flood. This analysis must be based on the coincidental probability of interior and exterior flooding and the capacity of equipment (such as drainage lines and pumps) for evacuating interior floodwaters. See USACE manual EM 1110-2-1413, entitled "Hydrologic Analysis of Interior Areas," for guidance on these studies.

(6) *Other design criteria.* In unique situations, such as those where the levee system has a relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard upon which FEMA will base its determinations. FEMA will also provide the rationale for requiring this additional information.

(7) *Additional levee height.* The overall risk and uncertainty computation required in Paragraph (2)(b) will determine whether the levee height and structural integrity for the system being evaluated, taken together, equal or exceed the required 90-percent assurance. For riverine levees, superiority of an additional 1-foot height is required within 100 feet on either side of key structures (such as bridges) riverward of the levee, or wherever the flow is constricted. An additional one-half foot in height is required at the upstream end of the levee, tapering to not less than the levee height at the downstream end of the levee.

(c) *Operation plans and criteria.* For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual. The levee operator must provide a copy of the manual to FEMA when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community that participates in the NFIP. An assessment must identify the likelihood of the successful operation of system components during a flood event, considering the availability of such critical resources as access to devices, labor, power supply, needed materials, and the operational readiness of the features. The impact and consequence of unsuccessful operation must be determined and evaluated.

(1) *Closures.* Operation plans for closures must include the following:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and a demonstration that the flood warning time is sufficient to complete all closure operations, including locating, accessing, and installing the closure structures, and the necessary sealing, before floodwaters reach the base of the closure

(ii) A formal plan of operation, including specific actions and assignments of responsibility by individual names or titles

(iii) Provisions for periodic operation, at not less than 1-year intervals, of the closure structure for testing and training purposes

(2) *Interior drainage systems.* Interior drainage systems associated with levee systems usually include storage areas, gravity, outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and a demonstration that the flood warning time is sufficient to activate the mechanized portions of the drainage system

(ii) A formal plan of operation, including specific actions and assignments of responsibility by individual names or titles

(iii) Provision for manual backup for the activation of automatic systems

(iv) Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes. No more than 1 year shall elapse between either the inspections or the operations.

(3) *Other operation plans and criteria.* FEMA may require other operating plans and criteria to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA bases its determinations.

(d) *Maintenance plans and criteria.* For levee systems to be recognized as providing protection from the 100-year flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and the owner of the levee system must provide a copy of this plan to FEMA when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the name or title of the person responsible for their performance.

(e) *Residual risk and public safety*. The issues addressed here are focused on public safety during flood events that exceed the capacity of the levee system. The components that must be addressed are probability of capacity exceedance, consequence of capacity exceedance, examination of project features that address capacity exceedance, and emergency plans to ensure public safety in the event of a flood that exceeds the levee system capacity

(1) *Probability of capacity exceedance*. The threat to floodplain residents and businesses is best described by the probability of capacity exceedance. The probability is to be estimated based on information compiled for flood flow and stage and associated uncertainties; levee embankment and integrity and potential failure probabilities of associated structures;, and operations analysis of closure devices and other components. The probability of capacity exceedance is to be expressed as AEP, as defined in USACE manual ER 1105-2-101.

(2) *Consequence of capacity exceedance*. The general scope and nature of the impact on floodplain residents, businesses, critical infrastructure systems, and the environment will be assessed and reported. The intent is not to provide a detailed impact analysis, but to assess the threat to floodplain occupants and to indicate the approximate numbers and demographics of residents, businesses, and the disruptions that would likely occur from a capacity exceedance. This information would clearly distinguish between floodplains that may experience slow, shallow flooding and those that may experience rapid, deep flooding. It also would delineate between floodplains that have adequate routes and capacity for occupant evacuations and those that do not. Finally, it would separate floodplains that, if flooded from a levee system failure, would or would not result in the crippling of a regional economy or have significant national economic impact.

(3) *Project features for capacity exceedance*. Levee system projects will be expected to have features and other means to accommodate possible capacity exceedance. Where feasible and practical, the system will be designed and constructed to account for capacity exceedance.

Therefore, if capacity exceedance results in failure of the levee system, the failure will occur gradually and in a predictable manner. Levee superiority is one physical means for such accommodation; another is to harden sections to withstand overtopping (see USACE manual ER 1110-2-229, entitled "Overtopping of Flood Control Levees and Floodwalls"). Documented evidence of considering and accommodating capacity exceedance is required.

(4) *Emergency response plan*. Communities with levee systems are required to have current (updated within 5 years) flood warning and emergency response plans that demonstrate successful planning to safeguard the public against flood events that exceed levee system capacity. Emergency response plans will address the key issues of flood threat recognition, warning dissemination, evacuation, and search and rescue. Documentation must be submitted to demonstrate that the plan will remain viable through an annual review of action plans and the updating of official contacts and their responsibilities. Periodic testing of the plan must be documented.

(f) *Certification requirements.* Data submitted to show that a given levee system complies with the structural requirements set forth in Paragraphs (b)(1) through (7) of this section must be certified by a registered professional engineer. Certified as-built plans of the levee must also be submitted. Certifications are subject to the definition given in §65.2 of this subchapter. In lieu of these structural requirements, a Federal agency with the responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the 100-year flood.

Appendix D. Public Awareness and Outreach Approach

As indicated in Section 8 of this report, as FEMA moves forward with the development and implementation of levee-related policy, regulatory, and procedural changes, it must also develop and implement a public awareness and outreach strategy that will improve public officials' and citizens' awareness and understanding of levee-associated hazards and risks. To do this, FEMA will need to work with its Federal, State, and local partners—both governmental and nongovernmental—to build on these partners' successes, avoid their mistakes, and lead the development of a comprehensive, synergistic strategy that can and will be implemented consistently everywhere levee structures and systems are located. Some initial steps to developing such a strategy include:

- Definition of Roles and Responsibilities – To implement the public awareness and outreach approach effectively, many people will need to be involved, and the roles and responsibilities of those people will need to be clarified as soon as possible. In addition to establishing roles and responsibilities for FEMA Headquarters and Regional Office staff—including Mitigation, Legislative Affairs, Intergovernmental Affairs, Public Affairs, and External Affairs—and FEMA contractors (including the contractor leading the FEMA FloodSmart campaign), roles and responsibilities will need to be established for the following:
  - Federal agencies involved in the construction and maintenance of levees and levee systems
  - State agencies involved in the construction and maintenance of levees and levee systems
  - Regional and local agencies involved in the construction and maintenance of levees and levee systems
  - State NFIP Coordinators
  - Nongovernmental organizations such as ASFPM, NAFSMA, and the American Society of Civil Engineers
  - National and local media
- Message Content and Format – To improve stakeholders' understanding and compliance with current and future FEMA policies, regulations, and procedures, FEMA should provide them with appropriate information in a straightforward, easy-to-understand, question-and-answer format. This information could be provided together in pamphlet form or as a series of messages distributed separately as fact sheets or informational flyers. The information must be complete, audience targeted, and delivered in a timely manner.

Under the leadership of the FEMA Mitigation Division Director or his designee, a work group composed of public awareness and outrach specialists from FEMA Headquarters, FEMA Regional Offices, FEMA contractors, other Federal agencies, State agencies, and nongovernmental organizations should develop a comprehensive list of questions that need to be answered. The questions, and the answers to those questions, would form the basis for the key messages that are to

be delivered. Depending on the breadth and depth of the questions and answers, materials may need to be developed for both general and specific audiences so that those groups will see the impact on, and benefit to, them.

Some of the questions to be answered quickly, for those communities with levees for which flood map updates are already underway, are listed below.

- General Levee Information
  - What are levees?
  - What threats and risks are associated with levees?
  - What materials are used to build levees?
  - Why are levees constructed?
  - What level of safety do levees provide?
  - Are people who live near a levee safe?
  - What will happen if the levee does not perform as designed?
  - Where can people go to learn more about the levees in their community?
  - Why is it important to understand how the levee operates?
  - What are the benefits of the levees?

- Levee Construction and Maintenance Requirements
  - Who is responsible for maintaining the levees?
  - What does levee maintenance mean?
  - What are the Federal requirements for the construction and maintenance of levees?
  - What are the State requirements for the construction and maintenance of levees?
  - What are the local requirements for the construction and maintenance of levees?
  - What can families do to make their homes and themselves safer in a levee-protected area?
  - Whom should people contact if they have concerns about the levees near my home or business?
  - What can individuals do about levees?

- FEMA Mapping Practices
  - Why is it important to accurately portray the flood hazards in areas affected by levees?
  - For what reasons did FEMA institute its current policies, regulations, and procedures regarding the evaluation of levees and the mapping of levee-affected areas?
  - How do interested parties find out if the levees in their community are affected?
  - Where in the NFIP regulations are the requirements for the evaluation of levees and the mapping of levee-affected areas found?

- Where in the *Guidelines and Specifications for Flood Hazard Mapping Partners* are the requirements for the evaluation of levees and the mapping of levee-affected areas found?
- What changes will be made to the existing (effective) flood maps?
- When will the changes to the existing flood maps be made?
- How do interested parties find out if their community, property, etc., is affected by the changes to the flood map?
- What effect(s) will the changes have on floodplain management in the affected areas?
- What effect(s) will the changes have on flood insurance purchase requirements in the affected areas?
- What information must be submitted to refute the changes made to the flood map(s) in the affected areas?
- Who should prepare required supporting data and documentation to request that levees be credited with providing 1-percent-annual-chance (100-year) flood protection?
- How are the required supporting data and documentation to be submitted to FEMA?
- How will FEMA respond to requests to have levees credited with providing 100-year flood protection?
- What kind of support is available to communities who do not have resources to collect and submit the required data?
- Where can interested parties learn more about the NFIP regulations and the *Guidelines and Specifications*?
- What do affected citizens – property owners, builders, developers, and others – need to know and do?

If changes to levee-related policies, regulations, and procedures are made in the future, this same work group or a similar group would need to develop additional questions and answers.

Message Delivery Vehicles

The FEMA public awareness and outreach approach should, to the extent possible, build on relationships already established as part of other Map Mod, risk insurance, and risk reduction activities; leverage existing communication vehicles; and develop new or alternative communication vehicles to provide various audiences with the clear, vital messages that are required. Some existing and new communication vehicles that can be developed with a reasonable level of funding are summarized below.

- Existing Communication Vehicles:
  - A Web page dedicated to the evaluation and mapping of levees should be posted on the FEMA Flood Hazard Mapping Web site and should be linked to the home page of that site. The levee-dedicated Web page should have content similar to that of other important initiatives, such as the implementation of requirements for the use of future-conditions hydrology and the implementation of the consolidated *Guidelines and Specifications for Flood Hazard Mapping Partners*. Like those Web pages, the levee Web page should have a link for registering to receive levee-related e-mail messages

from FEMA and should include the "Ask a Map Specialist" e-mail link and the FEMA Map Assistance Center toll-free number for interested parties with questions. This will enable stakeholders and other interested parties to obtain accurate and appropriate information at any time. Once the Web pages have been posted, FEMA could post information on the Map Service Center (MSC) Web page and on the main page of the Mapping Information Platform to encourage map users and active participants in the mapping process to visit the levee-dedicated Web page and learn more about levees.

- Enclosures in e-mail message(s) to recipients of Map Mod messages and announcements could be distributed using the Lyris software vehicle that is already used for other map modernization announcements. FEMA already distributes Map Mod messages regularly using Lyris software. FEMA would need to update its database with the names and addresses of community officials and other stakeholders who should receive levee-related messages. The messages could forward the materials FEMA develops or direct the recipients to the levee-dedicated Web page.
- Enclosures could be sent with standard and nonstandard correspondence about topics other than levees that are sent to community officials and other stakeholders involved directly and indirectly in flood map updates. FEMA regularly communicates with community officials and other stakeholders through standard and nonstandard correspondence regarding Letters of Map Amendment (LOMAs), Letters of Map Revision Based on Fill (LOMR-Fs), and Letters of Map Revision (LOMRs). Along with the LOMA, LOMR-F, and LOMR correspondence, FEMA could forward levee-related question-and-answer materials as unreferenced enclosures or provide materials that direct the recipients to the levee-dedicated Web page to learn more. The FEMA MSC contractor also regularly distributes printed materials to various stakeholders. Levee-related informational materials could be distributed by the MSC contractor staff.
- PowerPoint presentation(s) could be prepared for FEMA Headquarters and Regional Office management and staff to use at briefings for oversight groups, community meetings, and stakeholder conferences. FEMA Headquarters and Regional Office management and staff have numerous opportunities to meet with groups of stakeholders, whether during community meetings, Community Assistance Visits, national and regional stakeholder conferences and meetings, or briefings with congressional delegations. To facilitate consistent and clear communication on levee policy, regulations, and procedures, it would be very beneficial for presenters to have and use a well-vetted PowerPoint or DVD presentation. FEMA could also provide this presentation to CTPs, State NFIP Coordinators, and others who may meet with groups of stakeholders without FEMA staff being in attendance.
- Toolkits of information about flood insurance and map changes available for communities could be placed on the levee-dedicated Web site and on the floodsmart.gov Website

- New Communication Vehicles:
  - An informational letter could confirm to community officials (specifically, Chief Executive Officers (CEOs) and floodplain administrators) that levees do exist in their communities and could document what FEMA plans to do and the actions the

community must take. A significant amount of time and effort will likely be required for communities to obtain and submit the required documentation to show that a levee provides 1-percent-annual-chance or greater flood protection. Therefore, using the sequencing information in the Multi-Year Flood Hazard Identification Plan and available information on the locations of levees as a guide, FEMA should consider sending informational letters to communities for which they already have or will be initiating a flood data update in 2006. If the levee-dedicated Web page can be set up first, the letter could direct the CEO, floodplain administrator, and others to visit the site; if it is not available, the letter would forward whatever question-and-answer materials are available at the time. It is not recommended that FEMA immediately send such letters to NFIP-participating communities with levees, if the flood data updates have not been initiated or will be initiated in 2007 or beyond. Sequencing and schedules could change, and community CEOs and floodplain administrators may not be able or motivated to act when an update is more than a year in the future.

  - A pamphlet could explain FEMA policy, regulatory, and procedural requirements regarding levee evaluation and mapping and explain where more information and assistance can be obtained. As mentioned earlier, the recommended pamphlet would present information in question-and-answer format and could be distributed to stakeholders as an enclosure to standard and nonstandard correspondence. If the pamphlet were to be assigned a document number, FEMA could also have the pamphlet produced in large volumes by its Printing and Publications Branch or by the U.S. Government Printing Office.
  - A tutorial that provides a step-by-step explanation of the levee protection evaluation processes could be developed. As a means of explaining these processes, FEMA should develop a tutorial, similar to the one made to explain the CTP program to potentially interested parties and the tutorials on the FEMA Flood Hazard Mapping Web site. This tutorial would guide community CEOs and floodplain administrators through both processes and walk them through a decision-making approach so that they may take the appropriate action regarding levees in their communities.
  - Produce print or multimedia materials that put levee safety in context for nontechnical audiences.
  - Use the FIS report to expand on issues related to the history of the levees, relative protection provided by the levees and similar risk reduction systems, the inherent risk in building residential and nonresidential structures on the landward side of these systems, and alternative floodplain development practices that could be considered in levee affected areas.

- Targeted Audiences – It is critical that FEMA, in implementing this public awareness and outreach campaign, should engage both public- and private-sector audiences. FEMA should develop a delivery strategy for each of these groups, as the messages may vary somewhat. One proposed approach has been documented already in a draft report entitled "FEMA Levee Policy Change Implementation: Proposed Public Awareness Approach," dated February 2006.
- The following are the public-sector audiences with whom FEMA should communicate:

  - Federal agencies that are not involved in the delivery of messages
  - Mapping Coalition members that are not involved in the delivery of messages
  - State NFIP Coordinators and other State agencies not involved in the delivery of messages
  - Regional entities not involved in the delivery of messages
  - Community officials

- The following are the categories of private-sector stakeholder groups with whom FEMA should communicate:
  - Engineers and surveyors
  - Construction, development, and real estate companies
  - Lending institutions and flood zone determination companies
  - Insurance companies and agents
  - Small business owners and homeowners

- A detailed list of the organizations and individuals in each of the public- and private-sector stakeholders is provided in Appendix A of the previously referenced February 2006 draft report.

Measuring Success of Public Awareness and Outreach Activities

To measure the success of the public awareness and outreach activities described in this Appendix, FEMA Headquarters, FEMA Regional Offices, FEMA partners, and the FEMA contractor staff involved in these activities must be aware of potential roadblocks so that their impact may be avoided or minimized. The staff involved also should collect and assess feedback from stakeholders.

- Potential Roadblocks – Some of the roadblocks that may hinder the successful fulfillment of the public awareness and outreach campaign are listed below. FEMA Headquarters and Regional Office staff should develop a comprehensive list through consultation with partners and contractors. The staff involved in this campaign should monitor communication activities and notify the FEMA leadership if these roadblocks come to fruition and will have a negative impact on the public awareness and outreach campaign:
  - Federal agency committee members do not disseminate information to their headquarters and district office staff members.
  - Federal agency Webmasters are unable or unwilling to post information on their Web sites.
  - FEMA is not able to meet with the full membership of the Mapping Coalition.
  - Mapping Coalition members are unable to identify points of contact for the professional associations they represent.
  - Professional associations are unable to include levee-related messages in routine newsletters, e-mail messages, or other routine communication materials sent to members.

  - The MSC contractor is unable to distribute hard copies of levee-related messages along with printed copies of flood maps and reports.
  - Technical problems with Lyris software cause delays in dissemination of levee-related e-mail messages or make this approach cost prohibitive.
  - FEMA insurance specialists and the NFIP Bureau and Statisticial Agent are unable to distribute levee-related messages along with other information sent to insurance companies and agents, or at training sessions.
  - State agencies, regional entities, and community officials are unable or unwilling to make levee-related messages available to the people they serve.
  - FEMA representatives do not attend national stakeholder conferences.
  - Association points-of-contact are not able to distribute levee-related messages at national and regional stakeholder conferences that FEMA does not attend.
  - FEMA staff are unable to carry out the public awareness and outreach activities, and FEMA does not have sufficient funding for FEMA contractors to carry out these activities.

- Feedback Collection Mechanisms – FEMA should collect feedback on the effectiveness of the public awareness and outreach campaign by tracking:
  - Number and content of incoming levee-related e-mails submitted through the "E-Mail a Map Specialist" page on the FEMA Web site
  - Number and source of comments, questions, and suggestions made by FEMA staff and FEMA contractor staff at regular coordination meetings (e.g., FEMA Headquarters "Map Mod conference calls" with FEMA Regional Offices)
  - Number and content of incoming levee-related calls to the FEMA Map Assistance Center
  - Number and content of inquiries received from congressional delegations
  - Number and source of comments, questions, and suggestions made by attendees at national and regional stakeholder conferences or training sessions attended by FEMA representatives
  - Number of subscribers reached through the Lyris e-mail notification
  - Number of visits to the levee Web page on the FEMA Flood Hazard Mapping Web site
  - Number of requests for FEMA-developed outreach materials and templates

Based on the collected feedback, FEMA should consider refining the public awareness and outreach materials developed or the approach taken to delivering those messages.

Appendix E. Levee Database Framework Design Recommendations

Overall Recommendations

The following overall recommendations are proposed to develop the framework for a levee inventory and database:

- Capture levee centerline location within a GIS framework.
- Come to an agreement among Federal agencies on a common vocabulary that defines levees and their characteristics.
- Include enough levee characteristics and attributes to permit a high-level analysis of mapped areas shown as providing protection, levee certification status, and the risks associated with levee failure.

Each is discussed in greater detail below.

The framework should be geospatial. The levee database should be a geospatially based dataset. The advantages of a spatially oriented dataset are:

- It answers the basic question of where levees are located.
- It provides a spatially oriented dataset that allows levees to be depicted on a map with other data such as flooding sources, drainage basins, USACE projects, FEMA communities, counties, FIRM panels, DFIRM datasets where available, congressional and assembly districts, etc.
- It permits the levee data to be incorporated into some hydrologic and hydraulic data models.
- It allows levees to be used in conjunction with other GIS datasets to answer spatial queries, such as in which congressional district the levee is located. This aspect also eliminates the need to capture elements of other datasets as attributes of the levee entity, thereby reducing the amount of data that needs to be stored with the levee entity and streamlining data maintenance.
- The GIS layer, if positionally accurate, could be used as part of the official FEMA DFIRM database in the S_Gen_Struct layer, when the DFIRM is created.

Establish a Common Vocabulary

- It is important that there be a common vocabulary to describe the entities and attributes that will make up a levee database. The various Federal agencies have different definitions for flood protection and risk and apply different procedures to levee certification, which may also be accomplished by nongovernment professional engineers. Documenting the data models or schemas will provide a foundation for the different interested parties to understand the information being captured and how it may benefit them.
- To establish this vocabulary, it is helpful to define the entities and attributes for the database and represent them in an entity-relationship (E-R) diagram. An E-R diagram provides a graphical representation of the data model and schema and allows easy identification of the

connections between different entities. It will also assist to define cardinality between the entities (i.e., where there are one-to-one, one-to-many, and many-to-many relationships).

- It is equally important that a data dictionary be created to identify the attributes being captured for each entity, how they are captured, and what appropriate vocabulary control mechanisms are in place to ensure data quality. The separate levee database initiatives documented in this report have different purposes but also areas of consistency. The data dictionaries will assist in getting all parties "on the same sheet."
- Before developing a data model, the essential elements of the database must be defined and used consistently. To some extent, the definitions of these elements are dependent on the ultimate purpose of the database and how it will be used. These definitions then are reflected in the data model. The following recommendations are offered as points of discussion about these primitives.
  - Defining a Levee – A levee is a manmade 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. Each unique levee is a continuous, unbroken segment that has a defined beginning and end point. Characteristics such as ownership, freeboard, and type of construction may change along the levee, but if the levee is contiguous, then it is considered a single levee.
  - Defining a Levee System – A levee system is a flood protection system that consists of a levee or levees and associated structures, such as closure and drainage devices, floodwalls, and natural topography, that are constructed and operated in accordance with sound engineering practices. Failure at any one point of the levee system will result in the flooding of the area on the landward side of the system. One levee system is separated by another levee system by flooding sources and topography. A levee system is unique if a failure within that system does not affect another levee system.
  - Adjacent Floodprone Areas – Different terms are used to describe potential flooding on either side of the levee – inward and outward, along and behind, right bank and left bank, protected and unprotected. Because some levees could completely enclose an area, these terms can be confusing. It is recommended that the term "waterside" be used for the area parallel to the levee that contains the flood source and "landside" for the area parallel to the levee that may be protected.
  - Flood Protection – Levees have been built to provide varying degrees of protection (for different storm events, different land uses on the landside of the levee, etc.). For the purposes of FEMA's levee database, all the requirements of 44 CFR 65.10 would have to be met before the levee could definitively be said to provide protection. Upon meeting the CFR criteria, the landside area of the levee can receive a flood zone designation that classifies it as outside the SFHA (X, X (shaded), B, or C).
  - Certification – Certification should represent a levee that has been certified by an appropriate governing agency to meet all the requirements of 44 CFR 65.10.

Capture Levee Characteristics and Attributes Needed for Analysis

The following levee characteristics should be included in the levee database framework. These characteristics are needed to perform a high-level analysis of levee protection status, certification status, and risk.

- Ownership Information –Because the owner is generally charged with maintenance and upkeep of the levee, the owning entity, whether public or private, should be identified, along with a contact person within the entity.
- Flood Protection Status – Levees that are shown as providing some level of protection are typically identified on a FEMA FIRM as Zone X (no SFHA), Zone X (shaded) (within the 500-year flood event), and their corresponding legacy zone designations of C (no SFHA) and B (within the 500-year flood event). In addition, it would be useful to identify where Zone D (undetermined) exists on the landside of levees as well.
- Another important attribute to capture in this category would be the flood zone designations on the waterside of levees. In many cases, the designations will be Zone A (100-year flood event), a Zone A designation with BFEs (e.g., AE, AH, AO), or the coastal flood designations of Zones V and VE. Identifying the zone designation on the waterside of levees will be useful in determining where detailed studies have been performed and where BFEs exist that will aid in freeboard analysis.
- Certification Status – Certification should represent a levee that has been certified by an appropriate governing agency to meet all the requirements of 44 CFR 65.10. Some levees were certified before 44 CFR 65.10 was enacted. It would be beneficial to note the locations of those levees but to designate them as not in conformance with the 44 CFR 65.10 criteria. It also would be beneficial to identify whether certifications are still valid (i.e., whether those levees with a current accreditation are based on professionally verified technical information). Problems such as seepage or the scouring of levee sidewalls may have occurred recently on a levee that had been certified to meet the CFR criteria.
- Risk Associated With Failure – Levees were designed and built to protect various land uses, from urban and suburban areas to agricultural fields. In any sort of high-level levee analysis, it is important to know which levee systems, levees, or portions of levees protect the areas with the greatest risk of life and property losses from a levee failure. Risk can be identified many different ways (e.g., people, property values, insurance valuation), but a good measure of risk is one of the population density adjacent to the levee.

Appendix F. FIRM Map Zone Designations

FIRM Map Zone Designations (source: FEMA)

Zone A. Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no 100-year 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 FIS by detailed methods. In most instances, 100-year 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 AR zones, elevation is not required for improvements to existing structures. However, for new construction, the structure must be elevated (or floodproofed for nonresidential 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 BFE does not exceed 5 feet at the proposed development site. For infill sites, rehabilitation of existing structures, or redevelopment of previously developed areas, a 3-foot elevation requirement is in effect, regardless of the depth of the BFE at the project site.

The Zone AR designation will be removed, and the restored flood-control system will be shown as providing protection from the 100-year flood on the NFIP map, when the restoration project is completed and all the necessary data is submitted 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 and V1-30. Zone VE and V1-V30 are the flood insurance rate zones that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. BFEs derived from 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 these zones. Zone X (shaded) is defined as areas of 500-year floods, areas of 100-year floods with depths less than 1 foot or with a drainage area less than 1 square mile, and areas protected by levees from the 100-year flood.

Appendix G. List of Acronyms

AEP	Annual Exceedance Probability
ASFPM	Association of State Floodplain Managers
BFEs	Base Flood Elevation
CEO	Chief Executive Officer
CTPs	Community Technical Partners
DFIRM	Digital Flood Insurance Rate Map
DWR	California Department of Water Resources
E-R	entity-relationship
ERDC	Engineer Research and Development Center
FEMA	Federal Emergency Management Agency
FHBM	Flood Hazard Boundary Map
FIA	Federal Insurance Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FLIS	FEMA Levee Inventory System
GIS	Geographic Information System
H&H	hydrologic and hydraulic
HEC-FAA	
HFAWG	Hydrologic Frequency Analysis Work Group
HUD	U.S. Department of Housing and Urban Development
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision Based On Fill
Map Mod	Flood Map Modernization
MCC	Mapping Coordination Contractor
MSC	Map Service Center
NAFSMA	National Association of Flood and Stormwater Management Agencies
NAHB	National Association of Homebuilders
NED	national economic development
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSP	National Service Provider
NWS	National Weather Service
OMB	Office of Management and Budget

P&G	Principles and Guidelines
R&D	research and development
SDSFIE	Special Data Standards for Facilities, Infrastructure, and Environment
SFHA	Special Flood Hazard Area
SPF	Standard Project Flood
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

Appendix H. References

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