Analysis and Mapping Procedures for Non-Accredited Levees

Proposed Approach for Public Review

December 9, 2011

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Executive Summary

Background

This public review document describes the Federal Emergency Management Agency (FEMA) proposed approach and procedures for analyzing and mapping areas on the landward side of non-accredited[1] levee systems on Flood Insurance Rate Maps (FIRMs). Under the former levee analysis and mapping approach—referred to by FEMA and stakeholders as the without levee approach—if a levee system did not meet the National Flood Insurance Program (NFIP) requirements detailed in the Code of Federal Regulations (CFR) at Title 44, Chapter 1, Section 65.10 (44CFR65.10), FEMA modeled and mapped the system to show that the entire system did not reduce flooding impacts on the landward side of the levee during the 1-percent-annual-chance flood.

As FEMA produced FIRMs for communities impacted by levee systems, some stakeholders expressed concern about the without levee approach. Members of both the House and Senate echoed this concern and asked FEMA Administrator Craig Fugate to consider discontinuing the former levee analysis and mapping approach and draw on current modeling techniques to more precisely reflect the level of flood hazard reduction that levee systems can provide, while at the same time recognizing that uncertainty will remain. Given the technological advances in data collection and flood hazard modeling, FEMA is able to implement an improved approach for mapping flood zones in leveed areas. The leveed areas are portions of the floodplain from which waters are excluded by a levee/floodwall.

Congress' request coincided with the ongoing FEMA comprehensive review of the NFIP to identify reforms that will enable FEMA to better address flood risks nationwide. In fact, FEMA had already identified the without levee approach as a concern and began addressing this former approach in its NFIP reform efforts in an effort to increase the credibility of FIRMs in areas where non-accredited levee systems are located.

FEMA proposes to replace the former levee analysis and mapping approach with a suite of procedures that are technically sound, understandable to stakeholders, and cost effective. This suite of procedures will better meet the needs of the public, provide more precise results, and recognize continuing uncertainty. While these procedures allow for more detailed modeling and mapping of flood hazards for non-accredited levee systems, the risk of flooding in leveed areas remains. Nothing proposed here change the need for levee system owners and communities to remain engaged in flood risk management and communication activities.

Recognizing that the details of the proposed new approach will take time to finalize and that the former approach had been used in performing flood hazard analyses for in-progress Flood Insurance Studies (FIS) and map revisions, FEMA delayed the finalization of FIRMs and FIS reports for communities where levee systems do not meet accreditation requirements and may be affected by the proposed approach. This temporary delay allows FEMA to evaluate affected levee systems using the proposed approach/procedures discussed in this public review document.

[1] "Non-accredited" means any levee that does not meet 44CFR65.10 requirements and is shown on a FIRM as not reducing the flood hazards posed by a 1-percent-annual-chance flood per 44CFR65.10. This includes de-accredited levees as well as levees that have never been shown on a FIRM as meeting the criteria of 44CFR65.10.

General Approach in Revising the Levee Analysis and Mapping Procedures

FEMA has designed a cost-effective, repeatable, and flexible approach that (1) complies with all statutory and regulatory requirements governing the NFIP, most notably 44CFR65.10[2]; (2) leverages local input, knowledge, and data through proactive stakeholder engagement; (3) aligns available resources for engineering analysis and mapping commensurate with the level of risk in the leveed area; and (4) considers the unique flooding and levee characteristics (solely from an engineering perspective) of each levee system.

To develop the approach, FEMA established a multidisciplinary project team with representatives from FEMA, the U.S. Army Corps of Engineers (USACE), and experts from the academic and engineering communities. The FEMA-led team explored a broad spectrum of levee analysis and mapping procedures, evaluated the procedures for a number of levee scenarios that communities might reasonably encounter, assessed the feasibility of these procedures using several key criteria, and obtained feedback from internal and external stakeholders. Among the key steps in this highly interactive process:

- The team narrowed the number of procedures to those determined to be most practical and potentially applicable for NFIP mapping purposes. The team then tested selected procedures in theoretical scenarios that simulated likely conditions in a community.
- Once the testing of the procedures was completed, FEMA asked the National Institute of Building Sciences to convene an Independent Scientific Body (ISB) composed of recognized experts and registered Professional Engineers to review the approach and provide comments.
- Following the ISB review, FEMA staff convened a Community Roundtable to gather feedback from a sample of community officials, floodplain managers, and levee owners.
- FEMA considered the feedback from both the ISB Review and the Community Roundtable in the proposed process and technical procedures that are described in Sections 3 and 4 of this public review document.

Hallmark Principles of the Proposed Levee Analysis and Mapping Procedures

FEMA recognizes the importance that the U.S. Congress and American public are placing on the need to revise the levee analysis and mapping procedures to assess flood hazards in leveed areas across the United States. In addressing this challenging issue, FEMA engaged in a rigorous process with a wide array of stakeholders having varying opinions and perspectives. This process led FEMA toward two hallmark principles: (1) an interactive stakeholder engagement process during the analysis of a particular system is critical; and (2) more robust analysis and mapping procedures are needed. These procedures must recognize that there is uncertainty associated with levee systems and that levee systems are made up of different components with varying flood hazard reduction capabilities.

Interactive Stakeholder EngagementProcess. The proposed levee analysis and mapping procedures include an interactive coordination process with key stakeholders, including State and

[2] The criteria of 44CFR65.10 for accreditation of levee systems are <u>not</u> being changed in any manner and will remain in effect after the procedures presented in this public review document are implemented.

community officials, officials of participating Tribes, and levee owners. This process may include the formation of a Local Levee Working Group, which could include members from the community, Tribal officials, and levee owners (for levee systems that are not owned by a community or Tribal entity). Through the stakeholder engagement process, FEMA will work with stakeholders and use their input when mapping flood hazards associated with non-accredited levee systems. Section 3 of this public review document describes the stakeholder engagement process.

More Robust Levee Analysis and Mapping Procedures. Formerly, FEMA used the so-called without levee approach to assess flood hazards associated with non-accredited levee systems. Under the proposed approach, communities with affected levees can provide input so that FEMA may select an analysis and mapping procedure that better reflects the communities' unique circumstances and better characterizes their flood hazard. The proposed levee analysis and mapping procedures (i.e., Sound Reach, Freeboard Deficient, Overtopping, Structural-Based Inundation, Natural Valley), discussed in more detail below and in Section 4 of this public review document, will each result in mapping that takes the hazard-reduction capabilities of the levee system into consideration.

Through implementation of the proposed procedures, FEMA will depict Special Flood Hazard Areas (SFHAs) if the hazard-reduction capability of the levee is such that some portion of the 1-percent-annual-chance flood can still reach the area landward of the levee. The SFHA is the area delineated on a FIRM as being subject to inundation by the 1-percent-annual-chance flood. Additionally, FEMA will represent the uncertainty of the hazards associated with levee systems through the use of the Zone D designation in some of the procedures. FEMA uses the Zone D designation on a FIRM to identify areas of undetermined, but possible flood hazard.

Recognition of the Uncertainty Associated with Levees. In some situations, FEMA will use the Zone D designation to reflect the possible, but undetermined, 1-percent–annual-chance flood hazard when the levee system is not accredited. The Zone D will supplement the SFHA developed through the applied procedure, as appropriate. The extent of the Zone D areas will be based on the Natural Valley Procedure, discussed below and detailed in Subsection 4.2.5, and applied to the entire levee system.

Analysis of Levee Reaches. The proposed levee analysis and mapping procedures recognize that levee systems are made up of different components, some of which have more flood hazard reduction capability than others. For the proposed procedures, these components are called reaches. A reach is defined as a discrete section of a levee for which one of the five levee analysis procedures discussed below can be applied.

Proposed Levee Analysis and Mapping Procedures

Under the proposed approach, FEMA will overlay an SFHA, as appropriate, on the system-wide Zone D using one or more of the procedures discussed below. The procedures can be applied to the entire system or a system can be divided into multiple reaches with different approaches being applied to different reaches. FEMA will merge the flooding that results from the procedure applied to each individual reach with that of other reaches, along with any flooding resulting from interior drainage; this will result in the delineation of a final SFHA on the landward side of the levee system.

Levee Analysis and Mapping Procedures

All engineering data developed for each procedure detailed below must be signed and stamped by a Registered Professional Engineer. The Registered Professional Engineer's signature and stamp has the same meaning as the certification required by Section 65.2 of the NFIP regulations (44CFR65.2).

Sound Reach Procedure

A Sound Reach is defined as a continuous section of a levee system that has been designed, constructed, and maintained to withstand and reduce the flood hazards posed by a 1-percent-annual-chance flood, in accordance with sound engineering practices. To be considered a Sound Reach, a community/levee owner must provide FEMA with an Operations Plan and Maintenance Plan that discusses closures; interior drainage management; and the stability, height, and overall integrity of the levee and its associated structures and systems. However, a single reach of levee within a levee system cannot be accredited unless that reach can be shown to be a fully functioning, hydraulically independent levee system as defined in 44CFR59.1.

FEMA will model the flood hazards associated with Sound Reaches showing the levee reach in place using standard processes for an accredited levee system that meets 44CFR65.10 criteria. FEMA will show the system-wide Zone D area landward of these reaches. If applicable, FEMA will show the results of the interior drainage analysis landward of the levee as well. The SFHAs from adjacent reaches where different procedures have been applied may be present behind Sound Reaches.

Freeboard Deficient Procedure

For NFIP purposes, freeboard refers to the vertical distance between the top of the levee and the water level that can be expected during the 1-percent-annual-chance flood. For a levee system to be accredited for NFIP mapping purposes, communities/levee owners must demonstrate that a minimum freeboard exists. The freeboard requirements are established in acknowledgement of the many unknown or unpredictable realities of flood hazards. Given the potentially catastrophic consequences should a levee system fail suddenly, freeboard is an important tool for flood risk management and public safety.

In some cases, a community/levee owner can provide data and documentation demonstrating that the levee system is structurally sound and the top-of-levee elevation is higher than the 1-percent-annual-chance flood elevation; however, the levee system does not have an adequate amount of freeboard. In these cases, FEMA will map the affected area on the landward side of the levee as Zone D based on the Natural Valley Procedure (discussed below and detailed in Subsection 4.2.5). Where appropriate, FEMA may depict interior drainage areas as well.

Overtopping Procedure

The Overtopping Procedure can apply when the 1-percent-annual-chance flood level is higher than the top of the levee. The Overtopping Procedure will only be applicable for a reach if the community/levee owner submits the following: an analysis, signed and stamped by a Registered Professional Engineer, indicating that levee overtopping will not result in structural failure; an Operations and Maintenance Plan; and information on the top-of-levee elevation.

For non-accredited levee systems that meet these criteria, the levee can be analyzed as a lateral weir (meaning that some portion of the floodwaters flow over top of the levee crest). FEMA will model only the overtopping volume of flooding on the landward side of the levee. FEMA will map the resulting inundation area on the landward side of the levee as an SFHA (using a zone designation of Zone A or Zone AE, depending on discussion between FEMA and the community). Where appropriate, FEMA may depict interior drainage areas as well.

Structural-Based Inundation Procedure

In some cases, levee systems are not accredited due to structural integrity issues or the structural integrity is unknown (a common occurrence for older levees) and there is a higher likelihood that flooding will occur due to the levee failing at specific locations that are less structurally sound. These issues might arise from insufficient foundation strength, seepage through the embankment, or seepage within the foundation causing piping or other structural issues. Levees with structural integrity issues may, however, provide some flood risk management benefits by impeding conveyance.

For these types of conditions, FEMA will map an SFHA on the landward side of the levee system, assuming that sections of the levee will fail. The Structural-Based Inundation Procedure will consider possible locations of system breaches, modes of failure, geometry, failure triggers, and failure duration for use in mapping the 1-percent-annual-chance flood resulting from the breaches. Where appropriate, FEMA may depict interior drainage areas as well.

Natural Valley Procedure

The Natural Valley Procedure is a methodology that may be used when a levee system would not obstruct the river from flowing within the entire natural valley of the floodplain during the 1-percent-annual-chance flood. For example, a levee system designed for the 10-percent-annual-chance (10-year) flood may have little to no impact on flooding during a 1-percent-annual-chance flood event. FEMA will use the Natural Valley Procedure when one or more of the following occur:

- The levee does not significantly obstruct the riverflow.
- There is a Low Hazard Potential in the area landward of the levee as defined by the USACE-led National Committee on Levee Safety for the National Levee Safety Program. (See Table 3-2 in Section 3 of this public review document.)
- Data necessary for more complex methods are not and will not be available.
- The community (or Tribal entity, when appropriate) provides feedback that it is the acceptable procedure to use.

For riverine levee systems, the Natural Valley Procedure will reflect the levee geometry in the hydraulic model, but will allow the discharge to flow on either side of the levee. For coastal levee systems, the Natural Valley Procedure will also reflect the levee geometry and will not add overland waves to the stillwater flood elevations landward of the levee system. The stillwater flood elevations are the projected elevations that floodwaters would reach in the absence of waves resulting from wind or seismic effects.

Next Steps

FEMA invites comments on the proposed levee analysis and mapping approach summarized in this public review document. Reviewers should address the questions below concerning stakeholder understanding of the approach, local impact of the approach, technical soundness of the approach, and local engagement. Additional suggestions for improving the levee analysis and mapping procedures will be considered.

1. Stakeholder Understanding of Approach
    a. How clear is the approach?
    b. Would you be able to explain the proposed approach to others in your community? Why or why not?
    c. Is the proposed approach more acceptable than the former "without-levee" approach?
2. Local Impact of Approach
    a. How does the proposed approach impact a local community's ability to manage its flood hazards and risks (consider activities such as ordinance enforcement, risk communication, and mitigation planning)?
3. Technical Soundness of Approach
    a. Is the approach technically sound?
    b. What could be done to make the approach more technically sound?
4. Local Engagement
    a. To what extent does the proposed approach allow for community participation in the process (i.e., local knowledge and input, local data and analyses, and community input on project decisions)?
    b. Do local communities and levee owners anticipate having the resources and time to support this local involvement?
    c. What would make local engagement more effective?
5. Suggestions for Improvement
    a. Please provide any additional suggestions for improvement. Please be as specific and detailed as possible.

FEMA will consider all comments submitted through the methods discussed below. FEMA may consider comments regarding insurance or floodplain management policies and those that would require changes to NFIP regulations as part of the ongoing NFIP reform effort or other long-term projects to address levees and the NFIP.

Comments must be submitted using one of the methods identified in a FEDERAL REGISTER notice published to announce the proposed levee analysis and mapping procedures documented in this public review document. That FEDERAL REGISTER notice, and other information about the proposed levee analysis and mapping process, is accessible through a dedicated Web page.

FEMA will review and consider all comments received during the public review process explained in the FEDERAL REGISTER notice. Regardless of the method used for submitting comments or supporting materials, FEMA will post all submissions, without change, to the Federal eRulemaking Portal.

Once all comments are considered and the proposed analysis and mapping approach summarized in this public review document is refined based on the comments, FEMA will issue guidance for the FEMA Regional Offices and State and local mapping partners to implement the proposed levee analysis and mapping approach and procedures.

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Section 1. Introduction

This public review document summarizes procedures that the Federal Emergency Management Agency (FEMA) proposes for the analysis of non-accredited levee systems and mapping of areas landward of the non-accredited levee systems on Flood Insurance Rate Maps (FIRMs). A non-accredited levee system is a levee system that does not meet the requirements spelled out in the National Flood Insurance Program (NFIP) regulations at Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44CFR65.10), *Mapping of Areas Protected by Levee Systems*, and is not shown on a FIRM as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood.

FEMA has designed a cost-effective, repeatable, and flexible process that (1) complies with all statutory and regulatory requirements governing the NFIP; (2) leverages local input, knowledge, and data through proactive stakeholder engagement; (3) aligns available resources for engineering analysis and mapping commensurate with the level of risk in the leveed area; and (4) considers the unique flooding and levee characteristics (solely from an engineering perspective) of each levee system.

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 reduce flood hazards posed by temporary flooding.

A **levee system** is a flood hazard-reduction system that 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.

An **accredited levee system** is a levee system that FEMA has shown on a FIRM as providing protection from the 1-percent-annual-chance or greater flood because the system meets the requirements of 44CFR65.10.

FEMA is replacing the former levee analysis and mapping approach—sometimes referred to by FEMA and stakeholders alike as the without levee approach—with a suite of procedures. Under the former approach, used before March 2011, FEMA modeled and mapped a non-accredited levee system to show that the entire system did not reduce flooding impacts on the landward side of the levee during the 1-percent-annual-chance flood. A detailed explanation of the without levee approach is provided in Appendix C of this public review document.

The proposed suite of procedures—Sound Reach Procedure, Freeboard Deficient Procedure, Overtopping Procedure, Structural-Based Inundation Procedure, and Natural Valley Procedure—are technically sound, understandable to stakeholders, and cost effective. The proposed suite of procedures will better meet the needs of the public and provide more precise results, while at the same time recognizing that uncertainty will remain. Detailed information on these procedures is provided in Subsection 4.2 of this public review document.

1.1 Program Overview

The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968 (42 U.S.C. §§ 4001-4129). The NFIP, administered by FEMA, allows property owners and lessees in participating communities, including participating Tribes, to purchase affordable flood insurance in exchange for State, community, and Tribal officials adopting and enforcing adequate floodplain management regulations that are consistent with Federal criteria.

The Act requires FEMA to identify and publish information on flood hazards nationwide and establish flood insurance zones. FEMA publishes this information on Flood Insurance Rate Maps (FIRMs). The primary vehicle that FEMA has used for developing the required flood hazard information is referred to as a Flood Insurance Study (FIS). The FIRMs produced by FEMA are accompanied by narrative documents referred to as FIS reports.

1.2 Levee Systems and Flood Hazard Maps

Levee systems are designed to provide a specific level of flood hazard reduction. No levee system eliminates all flood hazards that can affect the people and structures located landward of the levee system. Thus, some level of flood hazard exists in all areas within and surrounding levee systems.

FEMA does not own, operate, maintain, inspect, or certify levee systems. However, as the administrator of the NFIP, FEMA creates and disseminates flood hazard maps, including maps that depict the effects that levee systems have on flooding.

For FEMA to accredit a levee system with 1-percent-annual-chance flood hazard reduction capability on a FIRM, the community/levee owner must submit a package containing the required data and documentation to show that the levee system meets all design and operation requirements of 44 CFR 65.10. The text of 44CFR65.10 is provided in Appendix D of this public review document.

> FEMA does not own, operate, maintain, inspect, or certify levee systems. FEMA creates and disseminates accurate flood hazard maps that show the effect levee systems have on flooding.

When a levee system is considered by FEMA to be accredited for NFIP mapping purposes, FEMA does not show a Special Flood Hazard Area (SFHA) designation in the impacted area landward of the levee system, other than flood hazard areas associated with interior drainage. The SFHA is the high-hazard area that would be inundated by the 1-percent-annual-chance flood (also referred to as the base flood). Flood insurance is required for buildings with federally backed mortgages within the SFHA.

FEMA maps the area landward of an accredited levee system as a moderate hazard area, designated Zone X. FEMA uses the Zone X designation to identify areas of minimal to moderate flood hazard outside the SFHA. The mandatory flood insurance purchase requirements of the NFIP do not apply in areas designated Zone X, and flood insurance premium rates are generally lower for flood insurance policies in these areas.

1.3 Why Levee Systems Fail

Many Americans have levee failure on their minds, especially since the devastation that occurred in New Orleans following Hurricane Katrina in 2005 and the flooding along the Mississippi River and its tributaries in 2011. A large number of levees are over 100 years old, including many levees along the Mississippi River. It is important to understand that levees are designed to specific criteria; when those criteria are exceeded, the levee is likely to be unsuccessful in holding back floodwaters.

The exact cause of a levee failure may be difficult to discern, yet the most common causes of levee failure are overtopping, piping, saturation and seepage, erosion, and structural failure. Aging and poorly maintained levees and control structures such as locks, gates and pumps contribute to a higher probability of a levee failure. Exceptional events, such as higher than designed water flow rate or water-surface elevation, also contribute to levee failures. When a levee system fails, the results are often catastrophic.

1.4 Why FEMA Is Revising the Former Levee Analysis and Mapping Approach

As FEMA has performed flood hazard analyses and produced updated flood hazard maps, stakeholders expressed concern about the former without levee approach[3] used before March 2011. FEMA recognized that the former approach to mapping the flood hazard associated with levee systems that do not meet NFIP accreditation requirements, discussed in detail in Appendix C of this public review document, has been a concern for many stakeholders.

In February 2011, members from both the House and the Senate wrote letters requesting that FEMA discontinue the former approach for analyzing levee systems and mapping the areas impacted by the levee systems when those levee systems do not fully comply with the NFIP regulatory requirements cited at 44CFR65.10. In their letters, the Senators and Representatives requested that FEMA

> …discontinue the use of 'without levee' analysis in cases where a final [FEMA] determination has not been made and an affected community objects to such analysis in favor of more precise methods of flood modeling.

At the same time that the February 2011 letters from Congress were received, FEMA was engaged in an ongoing comprehensive review of the NFIP to identify reforms to enable FEMA to better address the flood hazards faced by Americans nationwide. FEMA included the without levee analysis and mapping approach issue as an important consideration in the ongoing NFIP reform efforts, yet recognized that NFIP reform is a long-term solution, and near-term changes were needed to address this issue. Consequently, the proposed approach presented in this public review document is the first step in addressing the levee issue. FEMA will continue to work on longer term levee issues as part of the reform efforts.

[3] The without levee approach neither considered graduated risk nor provided a more granular solution in defining risk behind non-accredited levees. Instead, it was a binary approach where the levee either met accreditation criteria or did not, with no middle ground.

In response to the congressional correspondence, FEMA suspended the issuance of final determinations for FIRMs that were based on the former levee analysis and mapping approach, meaning that the FIRMs would not become effective for NFIP floodplain management and flood insurance purposes in those areas. FEMA then convened a multidisciplinary project team with representatives from FEMA, the U.S. Army Corps of Engineers (USACE), and experts from the academic and engineering communities to evaluate technical options for non-accredited levees only.

The FEMA-led team explored a broad spectrum of levee analysis and mapping procedures. FEMA selected procedures for effectiveness in proof of concept case studies using a small number of theoretical scenarios that simulated real world situations that communities might reasonably encounter. FEMA assessed the feasibility of each procedure using several key criteria, and then solicited external feedback from key internal and external stakeholders.

After exploring and testing a broad spectrum of approaches, FEMA has created a proposed levee analysis and mapping approach that is flexible and will result in more precise flood hazard data.

Based on the results of the development, testing, and review effort, FEMA created a proposed levee analysis and mapping approach that is flexible and will result in development of more precise flood hazard data.

1.5 Scope of Proposed Approach and Procedures

FEMA will use the proposed procedures to produce FIRMs, FIS reports, and related products for communities and Tribes impacted by non-accredited levee systems. FEMA will not use the proposed procedures to determine the risk or probability of failure for specific levees or levee systems.

FEMA has not, and does not intend to, alter the NFIP regulatory requirements for levee accreditation provided in 44CFR65.10 as part of this effort. These regulatory requirements will remain in effect even after the proposed levee analysis and mapping procedures are implemented.

As part of this effort, FEMA also has not revised, and does not intend to revise, the regulatory requirements for new construction projects that have made adequate progress toward completion provided in Section 61.12 (44CFR61.12) of the NFIP regulations, *Rates Based on a Flood Protection System Involving Federal Funds*, nor for the regulatory requirements for de-accredited levee systems that are being restored to provide 1-percent-annual-chance or greater flood hazard reduction capability provided in Section 65.14 (44CFR65.14) of the NFIP regulations, *Remapping of Areas for Which Local Flood Protection Systems No Longer Provide Base Flood Protection*. These regulatory requirements also will remain in effect after the proposed levee analysis and mapping procedures are implemented.

FEMA also has not revised, and does not intend to revise, the procedural requirements for levee systems that are new construction projects that have made adequate progress toward completion, are being restored, or are Provisionally Accredited Levee (PAL) systems. The procedural requirements for these levee systems are provided in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (April 2003) and in Procedure Memorandums (PMs) that FEMA issued to clarify the requirements in Appendix H. Interested parties may access all procedural requirements, including Appendix H and the PMs, from dedicated pages on the FEMA Website. The regulations and procedures cited above will remain in effect after FEMA implements the proposed analysis and mapping approach summarized in this public review document.

The requirements of 44CFR65.10, 44CFR61.12, and 44CFR65.14 remain in effect. No change resulting from the proposed levee analysis and mapping approach diminishes, changes, or supersedes 44CFR65.10, 44CFR61.12, and 44CFR65.14, or any other part of the NFIP regulations.

Finally, the proposed approach and procedures are not currently intended to be applied to non-levee embankments. The guidance for non-levee embankments documented in PM 51, "Guidance for Mapping of Non-Levee Embankments Previously Identified as Accredited," issued by FEMA on February 27, 2009, is to be followed.

1.6 Stakeholder Input During Development of Proposed Approach and Procedures

To obtain external feedback from stakeholders, FEMA presented the proposed procedures and solicited input from an Independent Scientific Body (ISB) and a Community Roundtable.

After FEMA tested the proof of concept case studies mentioned in Subsection 1.4, FEMA coordinated with the National Institute of Building Sciences (NIBS). NIBS then convened the ISB, composed of recognized subject matter experts and Registered Professional Engineers. After the ISB deliberations concluded, FEMA reviewed the ISB members' comments on the documentation provided and addressed their feedback in this public review document.

Following the ISB review, FEMA convened a Community Roundtable composed of a variety of community stakeholders, including levee owners and community officials, to seek feedback on the proposed levee analysis and mapping approach. The Community Roundtable participants worked through a case study of a project to get the best possible understanding of the process and then identify potential improvements and additions to the approach. At the end of the session, participants agreed that the approach was directionally correct, yet provided substantial input. That input has led to further refinement of the overall approach.

Section 2. FEMA Levee Evaluation and Mapping Procedures During Flood Studies

To prepare maps that identify the flood hazards in a floodprone community, FEMA conducts flood hazard studies called Flood Insurance Studies (FISs). This section provides an overview of the FIS engineering and mapping process, which results in the development of flood hazard information for the 1-percent-annual-chance flood. The 1-percent-annual-chance flood, also referred to as the base flood, is the basis for the flood insurance zones designated on Flood Insurance Rate Maps (FIRMs). As the definition suggests, the base flood has a 1-percent chance of being equaled or exceeded in any given year. The 1-percent-annual-chance flood is the national standard used by the NFIP for the purposes of requiring the purchase of flood insurance and regulating new development.

Detailed information on the FIS engineering and mapping process is provided in Volume 1 of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003); in Section 1 of FEMA's *Document Control Procedures Manual* (FEMA, 2006); and in *Appeals, Revisions, and Amendments to National Flood Insurance Program Maps: A Guide for Community Officials* (FEMA, 2009).

When appropriate as part of an FIS, FEMA evaluates data and documentation provided by communities/levee owners for local levee systems to determine whether the levee systems meet the NFIP regulatory requirements of 44CFR65.10. Based on the community/levee owner-supplied data and documentation, FEMA maps flood hazards in leveed areas. Leveed areas are portions of the floodplain from which waters are excluded by a levee/floodwall.

2.1 How the Flood Insurance Study Engineering and Mapping Process Works

In conducting an FIS, FEMA considers all available information. The information considered can include statistical analyses of riverflow, storm surge and rainfall records; information obtained through consultation with the community; topographic and bathymetric data; surveys; and hydrologic and hydraulic analyses.

FEMA presents the results of the FIS on a FIRM and in an accompanying FIS report. The FIRM presents flood hazard information, including flood insurance zones, flood elevations/depths, regulatory floodways, and flood hazard reduction structures (e.g., levees, dams); roads; culverts; and other information.

The FIS report consists of a variety of text, graphic, and tabular information, including Flood Profiles, Floodway Data Tables, summaries of storm surge elevations, summaries of flood discharges, and descriptions of flood sources and prior flooding. The FIS report describes floodprone areas along rivers and streams, along coastal areas and lakeshores, and/or in shallow flooding areas.

FEMA employs scientifically and technically appropriate analytical methods in performing FISs. FEMA uses engineering practices that meet professional standards and result in accurate flood hazard information being shown on the FIRM and in the FIS report.

Throughout the FIS engineering and mapping process, FEMA works closely with community officials and, where appropriate, Tribal officials to describe technical and administrative procedures and to obtain input. FEMA holds meetings with community and Tribal officials and citizens to provide opportunities, both formal and informal, to review and comment on FEMA study findings.

Once the engineering analysis effort is complete, FEMA provides the community with preliminary versions of the FIRM and FIS report to review. After a review and comment period, FEMA conducts a formal meeting with community and Tribal officials —the Consultation Coordination Officer (CCO) meeting—to discuss the results of the FIS and to review the information shown on the preliminary version of the FIRM and FIS report. FEMA and the community and Tribal officials may also conduct Open Houses where the general public can learn more about the study outcomes and provide comments on the preliminary versions of the FIRM and FIS report.

> Throughout the FIS engineering and mapping process, FEMA provides community and Tribal officials and citizens with multiple opportunities to review and comment on FEMA study findings.

By statute, FEMA provides a 90-day appeal and comment period whenever new or modified flood elevation determinations are proposed. Effective December 1, 2011, FEMA expanded the definition of an appeal to include all new or modified flood hazard information shown on a FIRM and in an FIS report, including flood hazard information for leveed areas: Base Flood Elevations, base flood depths, Special Flood Hazard Area (SFHA) boundaries, zone designations, and regulatory floodways. During the appeal period, community and Tribal officials and affected property owners have the opportunity to submit technical and/or scientific data to appeal the proposed flood hazard determinations. Officials and citizens may also submit comments on the base map features (e.g., road names, road configurations, corporate limits) shown on the FIRM.

When the 90-day appeal and comment period is complete and FEMA has addressed all appeals and other comments submitted during that period, FEMA sends a Letter of Final Determination (LFD) to the community Chief Executive Officer (CEO) and floodplain administrator (FPA) to finalize the FIRM and FIS report. FEMA then proceeds with publication and distribution of the new or revised FIRM and FIS report. The FIRM and FIS report become effective 6 months after the LFD date.

The CEO is the community or Tribal official who has the authority to implement and administer laws, ordinances, and regulations for the community or participating Tribe. The FPA is the community or Tribal official who is responsible for implementing and enforcing floodplain management measures and for monitoring floodplain development.

An overview of the FIS engineering and mapping process is provided in Figure 2-1.

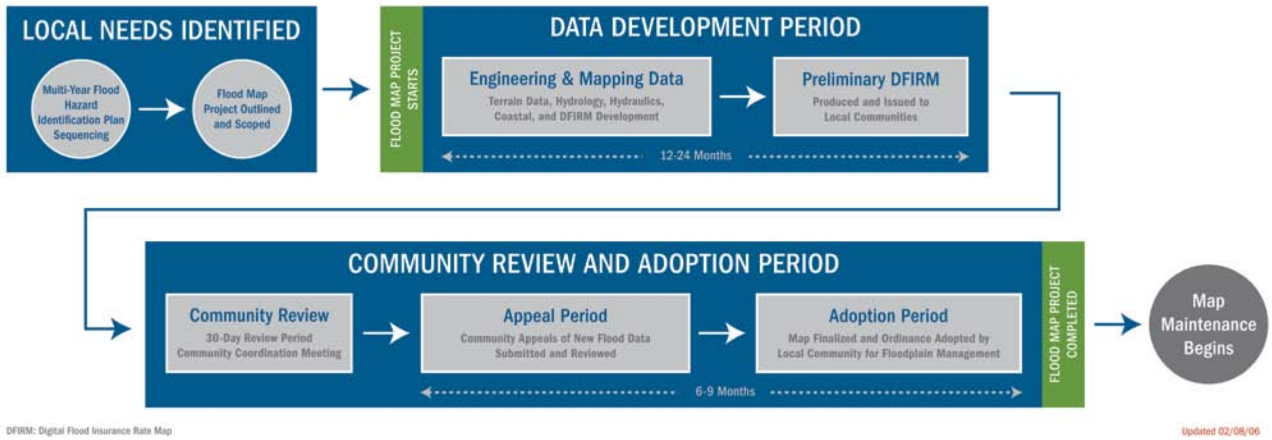
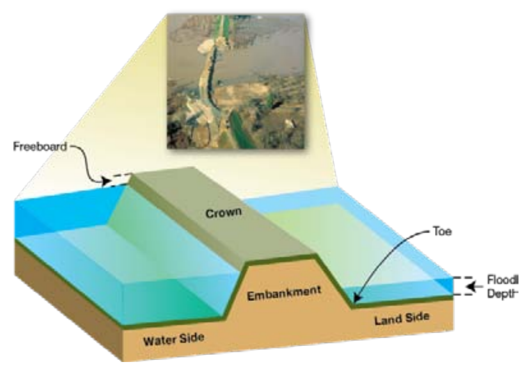


Figure 2-1. Overview of Flood Study Engineering and Mapping Process

2.2 Levee Evaluations During Flood Insurance Study Engineering and Mapping Process



Levees are typically earthen embankments that are designed to contain, control, or divert floodwaters. During the FIS engineering and mapping process, FEMA determines whether a levee system can be accredited.

The accreditation criteria that the levee system must meet are documented in 44CFR65.10. These requirements include such elements as, freeboard, closures, embankment protection, stability, settlement, interior drainage, and operation plans and maintenance. A complete set of the requirements is provided in Appendix D of this public review document. It is the community's or levee owner's responsibility to submit the data, documentation, and analyses required by 44CFR65.10 for FEMA to accredit a levee system.

FEMA's role is to evaluate the information presented by the community/levee owner that documents that a levee system meets the criteria in 44CFR65.10. FEMA's evaluation is used to establish appropriate flood insurance zones on the FIRM. FEMA's review does not constitute a determination as to how a structure or system will perform during a flood.

2.3 Former and Proposed Levee Analysis and Mapping Approaches

Under the former FEMA levee analysis and mapping approach (i.e., the approach that was in effect until March 2011), when FEMA determined that a levee system could not be accredited, FEMA analyzed and represented the flood hazards in leveed areas on the FIRM as if the levee system did not provide any hazard-reduction capability. However, if portions of the levee system satisfied the regulatory requirements of 44CFR65.10 and were hydraulically independent of the portions of the levee system that did not meet the requirements of 44CFR65.10, FEMA may have analyzed them independently. The former approach is discussed in detail in Appendix C of this public review document.

To provide more precise flood hazard information on the FIRM in areas where levee systems are not accredited, FEMA is replacing the former without levee modeling approach with an approach that is made up of a suite of procedures that are technically sound, understandable to stakeholders, and cost effective. The proposed suite of procedures—Sound Reach Procedure, Freeboard Deficient Procedure, Overtopping Procedure, Structural-Based Inundation Procedure, and Natural Valley Procedure—will better meet the needs of community and Tribal officials and citizens nationwide. The proposed procedures will not replace the need for levee owners or the associated community and/or Tribal officials to remain engaged in flood risk management activities or change the existing requirements for them to provide the required levee accreditation data and documentation as outlined in 44CFR65.10.

Additional information on the proposed levee analysis and mapping approach/procedures is provided in Sections 3 and 4 of this public review document. Section 3 provides an overview of the proposed levee analysis and mapping process, including the expanded data collection and stakeholder engagement effort, as documented in flowchart form. Section 4 provides detailed information on the proposed technical procedures.

Section 3. Overview of Proposed Levee Analysis and Mapping Process

3.1 Introduction

Sections 1 and 2 of this public review document provided information on the need to change the former levee analysis and mapping approach, the steps taken to develop the proposed approach and procedures, and the FIS engineering and mapping process. This section discusses the proposed process to categorize a levee system; collect needed data; and engage more extensively with and involve community and Tribal officials, levee owners, and other levee stakeholders.

The flowchart in Figure 3-1 provides an overview of the proposed levee analysis and mapping approach. To explain the steps outlined in Figure 3-1, identification numbers have been assigned to the summaries and the figure elements. The elements in gray boxes are process steps that have not changed. As indicated in Subsection 1.5 of this public review document, Elements 110, 120, and 500 were not within the scope of this project as they concern accredited levee systems and levee systems that are new construction projects that have made adequate progress toward completion, are being restored, or are Provisionally Accredited Levee (PAL) systems. The elements in blue boxes (Elements 200, 300, 400, 410, 420 600, 610, 620, 630, 640, and 650) are process steps that have changed.

> An important part of the proposed levee analysis and mapping approach is engagement with, and involvement from, community and Tribal officials, levee owners, and other levee stakeholders.

This section of the document addresses Elements 10 through 400 and 700 in Figure 3-1. Section 4 describes how the different procedures identified as Elements 610 through 650 in Figure 3-1 (i.e., Sound Reach Procedure, Freeboard Deficient Procedure, Overtopping Procedure, Structural-Based Inundation Procedure, Natural Valley Procedure) are used to analyze levees and map flood hazards in leveed areas.

3.2 Project Includes Potential Levees (Figure 3-1, Element 10)

Whenever FEMA initiates a study/mapping project and a structure is identified, FEMA must determine whether the identified structure is a levee and if it is designed for flood control. See “Structure Designed as a Levee for Flood Control” (Figure 3-1, Element 20). FEMA verifies whether the structure is a levee designed for flood control purposes by coordinating with the community and reviewing available levee documentation.

In making a determination about the structure, FEMA will consider the definitions for flood protection system, levee, and levee system found in Section 59.1, *Definitions*, of the NFIP regulations (44CFR59.1). The definitions of these terms also are found in Appendix B of this public review document. FEMA also recognizes that some levees protect areas below sea level from permanent flooding.

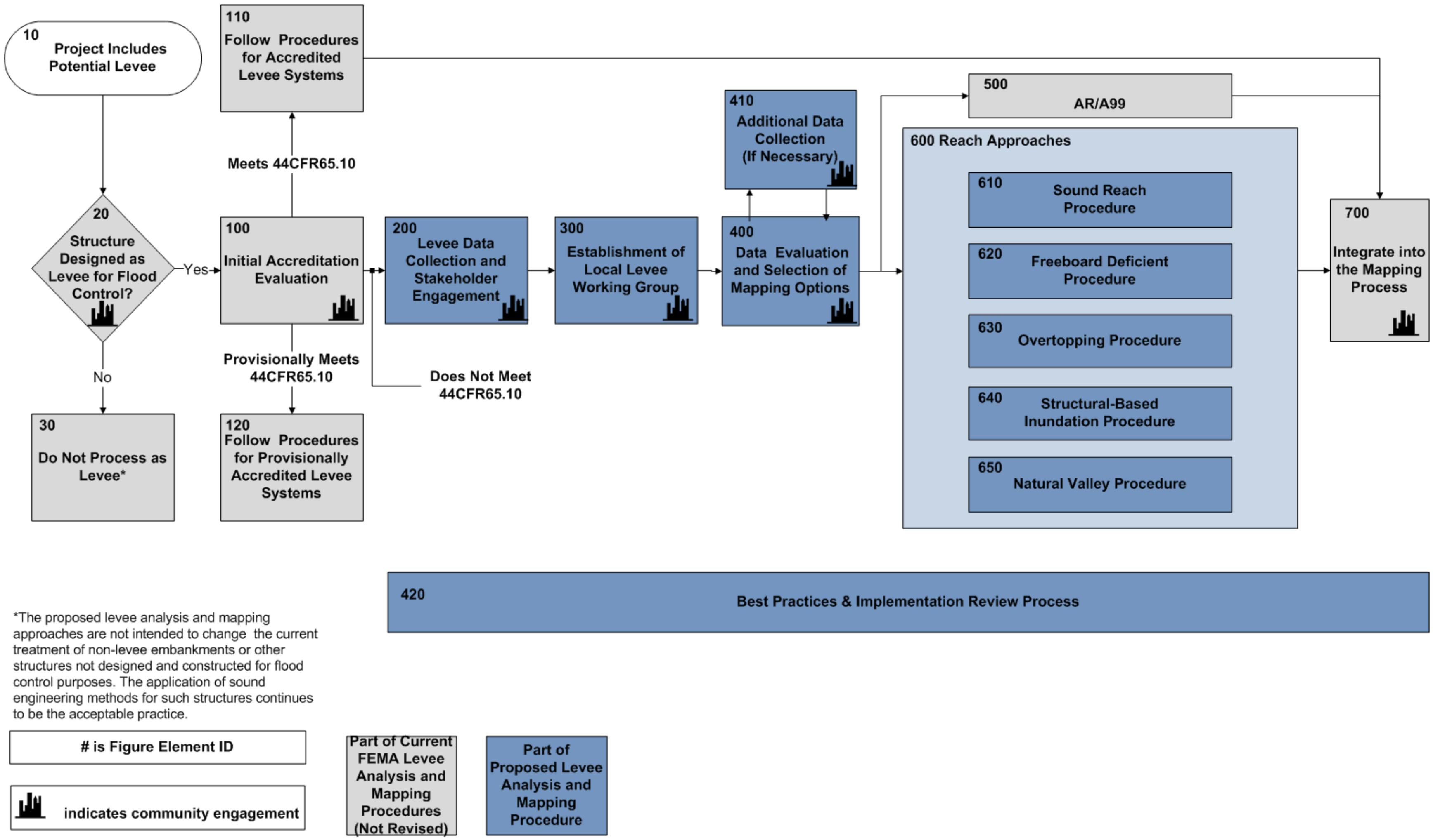


Figure 3-1. Proposed Levee Analysis and Mapping Approach

If FEMA determines that the structure is not a levee designed for flood control based on these regulatory definitions (e.g., it is a road or railroad embankment), then the analysis proceeds to Figure 3-1, Element 30.

3.3 Do Not Process as Levee (Figure 3-1, Element 30)

If FEMA finds that a structure is not a levee designed for flood control purposes, FEMA will not apply the proposed levee analysis and mapping procedures. FEMA will map the structure in accordance with existing procedures for such structures.

3.4 Initial Accreditation Evaluation (Figure 3-1, Element 100)

As mentioned in Subsection 1.5 of this public review document, the proposed levee analysis and mapping process does not change the requirements of 44CFR65.10. If the entire levee system is found to meet the requirements of 44CFR65.10, then FEMA maps the levee as accredited, following existing procedures. The procedural requirements for the accredited levee systems are provided in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (April 2003) and in Procedure Memorandums (PMs) that FEMA has issued to clarify the requirements in Appendix H. Interested parties may access all procedural requirements, including Appendix H and the PMs, from dedicated pages on the FEMA Website.

When evaluating a levee system that does not meet the freeboard requirements in 44CFR65.10 (normally 3 feet), FEMA will assist the levee owner and community/Tribal officials with assessing whether the levee system meets the freeboard exception criteria in 44CFR65.10. If the levee system has at least 2 feet of freeboard, the first step in addressing a freeboard-deficient levee system is to pursue the reduced riverine freeboard exception cited at 44CFR65.10(b)(1)(iii):

> *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.*

An analysis of the Base Flood Elevation (BFE) resulting from the upper 5-percent confidence limit of the 1-percent-annual-chance flood discharge will satisfy the "assessment of statistical confidence limits of the 100-year discharge." The community/levee owner must provide data and documentation to FEMA to show that the levee will remain structurally stable with these additional loading considerations. In addition, the community/levee owner must provide an evaluation of the potential and magnitude of debris, sediment, and ice accumulation to FEMA as specified in

44CFR65.10. The minimum freeboard requirement of 2 feet still applies. All other requirements of 44CFR65.10 must also be met.

Another approach for evaluating the uncertainty in the estimated BFE profile is the risk-based analysis procedure developed by the USACE after the publication of 44CFR65.10. The role of the USACE risk-based procedure in the certification of levee systems for the NFIP is described in USACE Engineer Circular 1110-2-6067 (USACE, 2010).

3.5 Follow Procedures for Accredited Levees (Figure 3-1, Element 110)

For levee systems that can be accredited, FEMA follows existing analysis and mapping procedures, as cited in Subsection 3.4.

3.6 Follow Procedures for Provisionally Accredited Levees (Figure 3-1, Element 120)

As mentioned in Subsection 1.5 of this public review document, the previously established FEMA procedures for Provisionally Accredited Levee (PAL) systems will not change. FEMA will follow the process and procedures documented in the following FEMA documents regarding the mapping of PAL systems:

- PM 43, "Guidelines for Identifying Provisionally Accredited Levees" (FEMA, 2007);
- PM 45, "Revisions to Accredited Levee and Provisionally Accredited Levee Notation" (FEMA, 2008); and
- PM 53, "Guidance for Notification and Mapping of Expiring Provisionally Accredited Levee Designations" (FEMA 2009).

FEMA will then integrate the appropriate flood hazard information for PAL systems into the FIRM, FIS report, and related products. (See Figure 3-1, Element 700.) FEMA will not extend the PAL expiration dates that have already been established in writing with communities/levee owners.

FEMA is **NOT** changing the PAL process or related requirements. FEMA will NOT extend the PAL expiration dates that have already been established.

3.7 Levee Data Collection and Stakeholder Engagement (Figure 3-1, Element 200)

Once FEMA determines that an identified levee system does not meet the requirements of 44CFR65.10, FEMA will make additional efforts to gather data and documentation and to engage levee stakeholders. This process provides FEMA and levee stakeholders with a more comprehensive and holistic understanding of the data available. FEMA will use any additional data or documentation collected during this process to refine the levee analysis and mapping approach to be used and to understand and successfully communicate the flood hazard in leveed areas associated with non-accredited levee systems.

An overview of the levee data collection and stakeholder engagement process is illustrated in Figure 3-2.

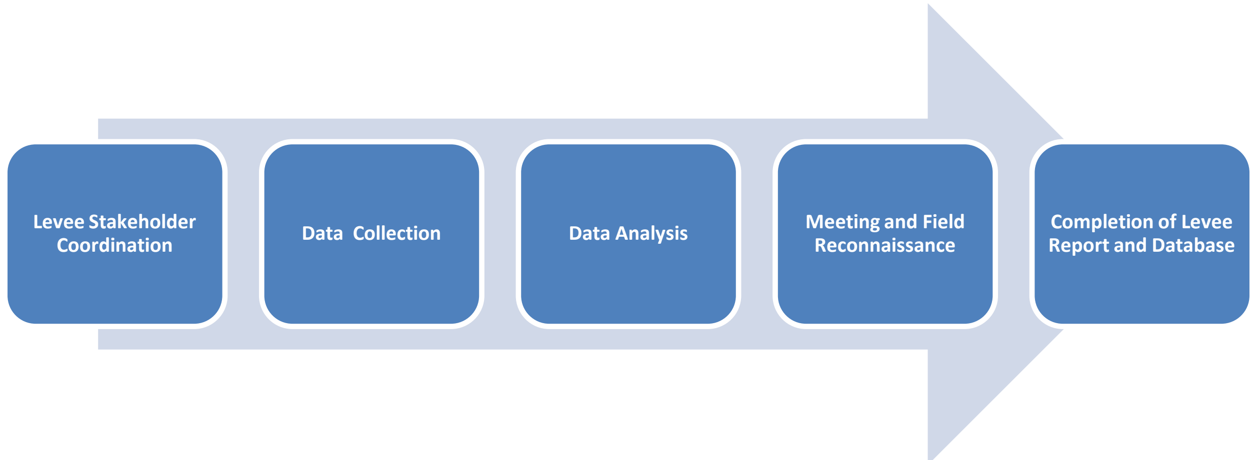


Figure 3-2. Levee Data Collection and Stakeholder Engagement Process

The initial levee stakeholder coordination and data collection steps will be required for all non-accredited levee systems. In some instances, the results of these steps or any subsequent steps may indicate the data and documentation available and community/Tribal officials' and levee owners' needs do not necessitate further discussion of potential mapping procedures. In such instances, FEMA, through coordination with community/Tribal officials and levee owners, will proceed with modeling the levee system and mapping the flood hazards in leveed areas. (See Figure 3-1, Elements 500 and 600.)

3.7.1 Levee Stakeholder Coordination

FEMA will coordinate with levee stakeholders to collect levee-related data and other community/ Tribal information to help streamline and facilitate a meeting with stakeholders. This upfront coordination may take the form of conference calls, Web-based meetings, or other means of two-way communication. The types of levee stakeholders engaged in a levee-related project will vary by State or Region, but may include local community and Tribal officials and agencies; local economic development organizations; members of the local engineering community; State and regional representatives; and other Federal agencies, such as the USACE.

3.7.2 Data Collection

FEMA will obtain available supporting data and documentation for the levee system elements from levee system owners, levee system operators, State and Federal agencies, local agencies, private individuals or corporations, FEMA data repository and online services, and the USACE National Levee Database (NLD), if applicable, before holding an in-person meeting with levee stakeholders. This effort before the meeting will help FEMA facilitate and encourage substantive discussion during the meeting. In addition, FEMA will obtain available supporting documentation regarding historical performance of the levee, considering both successful performance and unsuccessful performance issues.

FEMA will not use any of the data and documentation collected, including past performance data, to change the accreditation determination made in Element 100 on Figure 3-1. The data and documentation collected will help FEMA and the levee stakeholders develop a procedure for mapping the flood hazards in leveed areas.

3.7.3 Data Analysis

FEMA must carefully analyze the data and documentation obtained during the data collection effort to prepare for and conduct the in-person meeting with levee stakeholders. By performing this analysis, FEMA will be prepared for specific discussions with levee stakeholders about levee system characteristics, modeling procedures available, flood hazards, flood hazard communications, and outreach.

During the data analysis stage, FEMA may perform a limited data analysis of the levee system to develop baseline estimates and expected ranges of the SFHA extent and depth. The limited data analysis may include a Natural Valley analysis (described in Section 4.2.5), an evaluation of levee crest elevations, or the use of previously developed preliminary flood hazard zone boundaries. Any Structural-Based Inundation Procedure data that FEMA developed also may be included. FEMA will perform the analysis using readily available data, such as topographic data from the U.S. Geological Survey (USGS) National Elevation Dataset or more detailed data from the community.

FEMA will develop the natural valley elevations either by preparing approximate hydraulic models with the effective hydrologic study or by extending the effective BFEs landward. FEMA will develop these for discussion purposes only and will clearly inform the levee stakeholders that the final SFHA will not exactly match this flood hazard zone boundary delineation.

During this phase, FEMA will select depth profile locations to communicate the variability in expected depths resulting from the various procedures as shown in Figure 3-3. This initial quick analysis will provide stakeholder with an early indication of what the results from various types of analyses might provide.

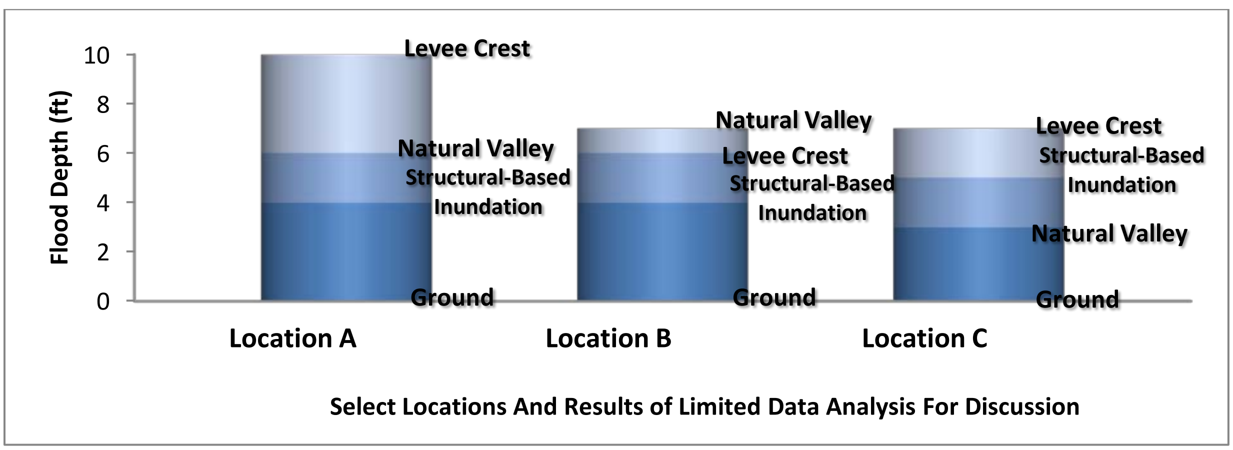


Figure 3-3. Sample of Potential Inundation Extents

FEMA will summarize the findings of the data collection and analysis effort in a draft report, database, and maps before the meeting. FEMA will use the draft report and maps to aid discussions of the data and provide the levee stakeholders with an overview of levee-related data and other known available data.

3.7.4 Meeting and Field Reconnaissance

FEMA will invite all levee stakeholders to the in-person meeting(s). The objectives of the in-person meeting(s) with levee stakeholders are to:

> At meetings with levee stakeholders, FEMA will explain the proposed levee analysis and mapping approach, articulate project goals, review available data, and emphasize stakeholders' responsibility to keep public informed about flood risks.

- Emphasize that the change in mapping approach has shifted from a one-size-fits-all modeling technique, where levee stakeholders were minimally involved, to a process with a variety of options, where the stakeholders are actively engaged in the process.
- Emphasize that the goal of the levee mapping project is to apply the procedure that best reflects the flood hazard in the leveed area based on available resources, data, and community needs.
- Review the available data on the levee system, confirm whether the data are accurate, and obtain stakeholders' perspectives about their flood hazard. This will help determine the appropriate procedure for modeling the levee system.
- Emphasize the importance of the stakeholders' responsibility in keeping the public informed of flood hazards and the relevance of those hazards.
- Discuss the floodplain management and flood insurance implications of the use of Zone D, which is explained in detail in Subsection 4.3 of this public review document.
- Discuss potential members of a Local Levee Working Group, which is explained in Subsection 3.8 of this public review document.

If developed, FEMA will use the draft datasets discussed above to help foster discussion on a possible range in elevations that could be expected after modeling is completed. FEMA will present the inundation range data to the levee stakeholders in the form of both a map to illustrate potential inundation extents and selected depth profile comparisons. Because the data at this stage are draft and were developed by approximate methods, FEMA will clarify that this information could evolve during the life of the project as more data are acquired. It will be a starting point to encourage discussion and set expectations for the resultant flood hazard that could be depicted on the FIRM.

In addition to the meeting(s) with all levee stakeholders, FEMA may choose to host breakout sessions. Breakout sessions could focus on specific issues such as the engineering procedures or could introduce the levee mapping project to the public. FEMA will determine whether breakout sessions are necessary during the initial levee stakeholder engagement discussion. The decision to hold breakout sessions will depend, in part, on the availability of FEMA and mapping partner resources.

If requested by the levee owner or the community, FEMA will conduct a field reconnaissance of the levee system after the in-person meeting. The field reconnaissance effort may be a drive along the levee system or a walk on top of the system to view locations discussed during the in-person meeting. The type and level of field reconnaissance will depend on project needs and available resources.

The field reconnaissance is not an inspection or an attempt by FEMA to make technical conclusions on the quality or substance of the levee system. Its primary purpose is to gain a better understanding of the levee system in order to best reflect the flood hazard information on the FIRM in leveed areas. FEMA analyses for flood hazard mapping do not reflect the performance, reliability, or overall safety of a levee system and are only used to identify the SFHA associated with the levee system.

3.7.5 Completion of Data Collection and Stakeholder Engagement Report and Database

FEMA will finalize a report and a database at the conclusion of the data collection and stakeholder engagement process. The report will include a section listing the data collected, when they were received, data type, and data source. This section will discuss any data that FEMA expects to receive from levee stakeholders, projected timeframe for receipt of the data, and whether funding is available to develop the data. The report will also identify potential stakeholders that could participate in the Local Levee Working Group and a preliminary estimate of the expected reaches for the levee system. (The procedures used to identify reaches are discussed in Subsection 4.1 of this public review document.) In addition to the report, FEMA will catalogue the data collected in alignment with the database structure used for the NLD.

FEMA will provide the final version of the report and database to the levee stakeholders with whom FEMA coordinated during the process. FEMA also will provide the final version to the members of the Local Levee Working Group.

3.8 Establishment of Local Levee Working Group (Figure 3-1, Element 300)

FEMA will establish a Local Levee Working Group when appropriate. The primary function of this group will be to provide feedback and additional data. FEMA's role will be to listen and gather the necessary information to effectively analyze and map the flood hazards in the leveed area. The other working group members will provide input on local conditions and situations. This engagement will enable FEMA to make a better informed final decision, using local input on how the levee system will be analyzed and how the flood hazards in the leveed area will be mapped. The following are individuals who will be invited to participate in the Local Levee Working Group:

- Community CEO or designee (individual with decision-making authority);
- Community FPA (if not the CEO);
- Levee owner (if levee is not owned by community);
- CEO or designee of participating Tribe (individual with decision-making authority);
- Local engineer/technical representative;
- FEMA Regional Office representative;
- USACE and other Federal agency representatives responsible for levee;
- Cooperating Technical Partner representative(s), if a regional entity or State agency other than the community has the interest and capability to be actively involved in the project; and
- Others as determined by the community and FEMA Regional Office representative.

The formation of the Local Levee Working Group will begin during the levee data collection and stakeholder engagement process. FEMA representatives will explain the roles and responsibilities of working group members and the types of individuals recommended for participation. FEMA will provide facilitation and support to working group members to enable them to successfully meet their objectives. The Local Levee Working Group will have met their objective once FEMA decides how the levee system will be analyzed and communicates that decision to the group members.

3.9 Data Evaluation and Selection of Mapping Options (Figure 3-1, Element 400)

The Local Levee Working Group will provide FEMA with input and data that will be used to select and develop the appropriate procedure to analyze and map the levee(s) being considered. FEMA will develop additional guidance on the details of this process, including recommended guidelines on an acceptable schedule to provide this input and data. The process of selecting the procedure and modeling will be open and transparent to stakeholders.

The levee analysis and mapping procedures are flexible, to address each situation. As discussed in Subsection 3.7, one tool that FEMA will use to assist in the initial evaluation will be rough estimates of Natural Valley floodplains. This information can provide an initial sense of where flooding may occur landward of the levee system. If other information is available, such as a rough estimate of a levee breach analysis/map, FEMA will also use that information. Key considerations in selecting the appropriate levee analysis and mapping procedure are as follows:

- Levee system characteristics;
- Data availability;
- 44CFR65.10 deficiency type;
- Length/size of the levee system and/or reach;
- Levee profile vs. BFEs;
- Whether the levee system can be segmented into separate reaches that can be analyzed individually;
- Levee performance history;
- Accreditation status of levee system on current NFIP maps;
- Flooding characteristics;
- Contributing drainage area;
- Duration of flooding;
- Terrain of protected area;
- NLSP Hazard Potential Classification (see Tables 3-1 and 3-2); and
- Community/levee owner willingness to contribute data or analyses.

The classification charts (Tables 3-1 and 3-2) provide input into determining which approaches should be used when analyzing and mapping flood hazards in leveed areas. The more rigorous Structural-Based Inundation Approach may be applied if the risk is high, and the less rigorous Natural Valley Approach may be applied if the risk is low. This input is only one element to be considered when making determinations and should be flexible.

Table 3-1. Hazard Potential Classification (Relation to Procedures)

Hazard Potential Classification	Sound Reach	Freeboard Deficient	Overtopping	Structural-Based Inundation	Natural Valley
High	Y	Y	Y	Y	Y [1]
Significant	Y	Y	Y	Y	Y [1]
Low	Y	Y	N [2]	N [2]	Y

Note: [1]Only when necessary data is insufficient, levee is not hydraulically significant, or community and FEMA determine the Natural Valley Procedure reasonably reflects the flood hazard
[2] May be considered with community contribution of data or identified special need

The USACE-led National Committee on Levee Safety (NCLS) developed the classifications in Table 3-2 as an indicator of the potential hazard associated with a levee. The NCLS classification system can provide users with a standardized measure of the potential hazard associated with their levee compared to that of other levees. This information can be used as one of the factors to be considered when evaluating and selecting modeling and mapping options.

Table 3-2. Hazard Potential Classification (Population)

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

These classifications are intended as rough guidance and should be used to initiate a conversation with local officials about the local perception of the hazard. The inundation mapping used to determine the hazard potential classification may use a tiered approach where the Natural Valley Procedure or another quick method may provide initial results used for determining how the hazard associated with a levee fits into the classifications above.

An important consideration is that the Overtopping and Structural-Based Inundation Procedures require additional data over and above what is required for the Natural Valley Procedure.

FEMA may discover that a restoration project for the levee system is underway through coordination with State, community or Tribal officials; levee owners; and/or USACE and other Federal agencies. As discussed in Subsection 1.5, FEMA has not revised, and does not intend to revise, the regulatory requirements provided in 44CFR61.12 for new construction projects that have made adequate progress toward completion nor the regulatory requirements provided in 44CFR65.14 for de-accredited levee systems that are being restored to 1-percernt-annual-chance or greater flood hazard-reduction capability.

3.10 Additional Data Collection (If Necessary) (Figure 3-1, Element 410)

During the data collection and stakeholder engagement process, FEMA may identify the need for additional data. When reasonable, FEMA will adjust the project schedule to include this activity.

An important consideration will be how the levee analysis and mapping portion of a study impacts the overall study schedule. This additional data activity will not be used to delay a study/project waiting for the data necessary to meet 44CFR65.10 certification and accreditation requirements.

3.11 Best Practices and Implementation Review (Figure 3-1, Element 420)

The proposed levee analysis and mapping process is a new way to address how levees are analyzed and how the resulting flood hazard information is presented on FIRMs. To meet the challenge of providing local flexibility and still maintain a uniform and equitable national approach, FEMA will institute a Best Practices and Implementation Review on an ongoing basis. FEMA will tailor its existing production and monitoring infrastructure to meet these new requirements.

FEMA will integrate the Best Practices and Implementation Review into the existing FIS engineering and mapping process discussed in Section 2 of this public review document to periodically update guidance as needed. This will include using feedback from appropriate subject matter experts and stakeholders.

FEMA will provide training for FEMA and mapping partner staff who will be involved with implementing the proposed levee analysis and mapping approach.

3.12 Integrate Into the Mapping Process (Figure 3-1, Element 700)

FEMA will incorporate the results of the engineering analyses into the affected FIRM panels and FIS report materials as well as non-regulatory products that are required if a study/project is funded by FEMA under the Risk Mapping, Assessment, and Planning (Risk MAP) program. FEMA will issue separate guidance on the application of the proposed levee analysis and mapping procedures to community-initiated map revisions and non-regulatory products, as appropriate.

Section 4. Proposed Levee Analysis and Mapping Technical Procedures

Until March 2011, FEMA used a single method to model and map the SFHA for non-accredited levee systems. FEMA is replacing the former method with five technical procedures described in this section. Through the early steps of the proposed levee analysis and mapping process (described in Section 3), FEMA has added stakeholder engagement and coordination steps to gather data and input from levee stakeholders to develop a situation-specific procedure for each levee system. This procedure uses the concept of dividing the levee system into reaches to assess the flood hazards.

For some situations, FEMA will use the Zone D designation to reflect the possible 1-percent-annual-chance flood hazard that exists because the levee system is not accredited. Zone D is an NFIP flood insurance zone designating an area of undetermined, but possible flood hazards. The Zone D designation represents the uncertainty associated with the potential flood hazards associated with levee systems. The Zone D area will supplement the SFHA identified through the application of the various procedures. The extent of the Zone D areas will be based on the Natural Valley Procedure, detailed in Subsection 4.2.5, and applied to the entire levee system.

Zone D areas are not subject to the Federal mandatory flood insurance purchase requirement. However, homes and buildings landward of levee systems, regardless of the zone designation, may be subject to a lender's flood insurance requirements as part of its overall risk management approach. Because areas designated as Zone D are not considered part of the SFHA, any floodplain management requirements will be applied at the discretion of officials of communities or participating Tribes, as long as the community or Tribe complies with the minimum standards of 44CFR60.3(a), *Flood Plain Management Criteria for Flood-Prone Areas*.

4.1 Segmentation of Levees

A levee reach is defined as any continuous section of a levee system to which a single analysis and mapping procedure may be applied. Analyzing and mapping reaches separately allows credit to be given to those reaches of a levee system that can be shown to provide some level of protection during the 1-percent-annual-chance flood. This subsection details how, under the proposed levee analysis and mapping procedures, a non-accredited levee system may be divided into multiple reaches with each reach being modeled and mapped separately using one of five procedures:

> Under the proposed levee analysis and mapping approach, a non-accredited levee system may be divided into reaches, with each modeled and mapped separately.

1. Sound Reach Procedure;
2. Freeboard Deficient Procedure;
3. Overtopping Procedure;
4. Structural-Based Inundation Procedure; and
5. Natural Valley Procedure.

Figure 4-1 shows an example of a levee system that has been divided into reaches.

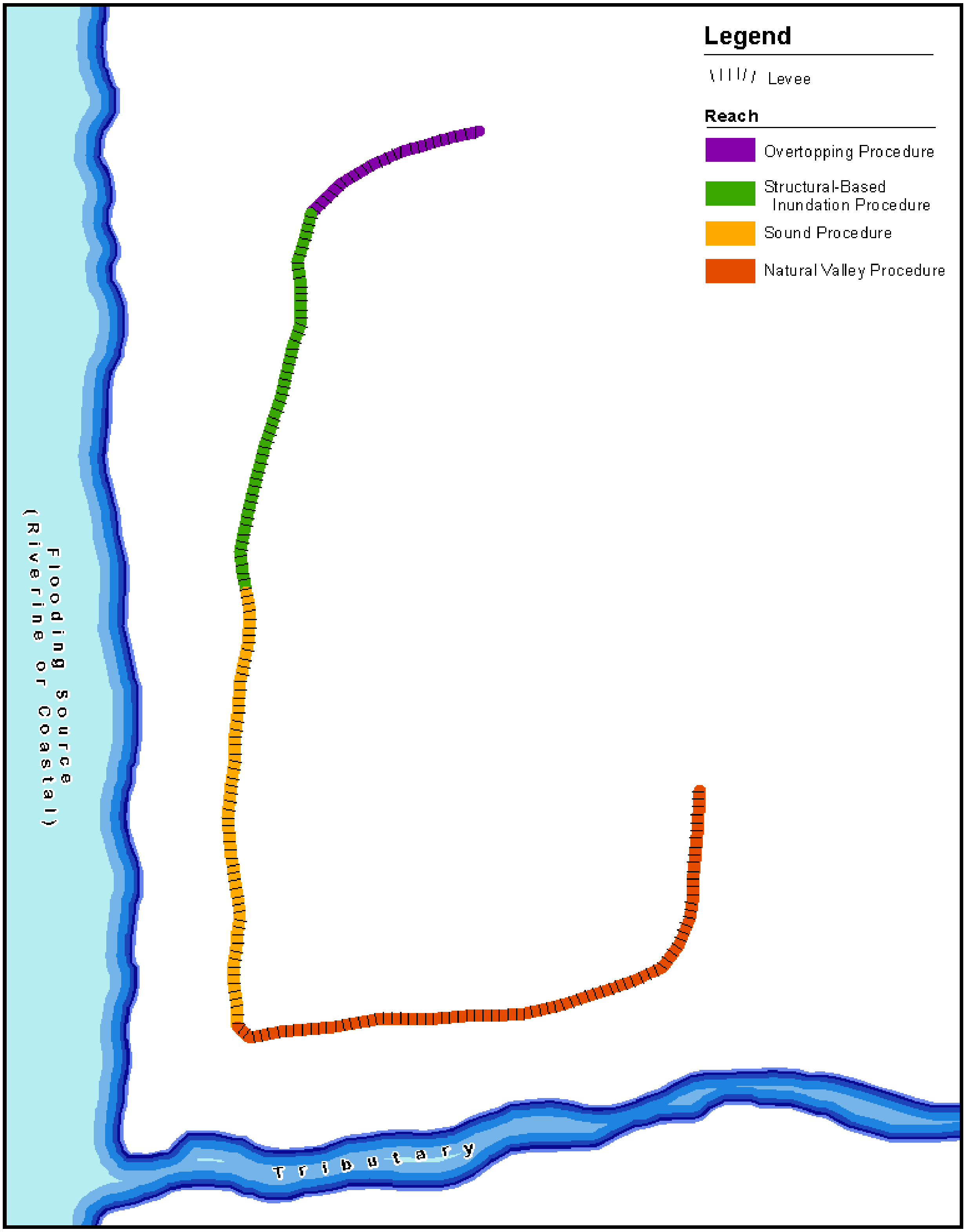


Figure 4-1. Example of Segmentation of a Levee System

Each of the procedures may be applied at both the reach and system levels, and are described in more detail in the subsections that follow. The flooding that results from each individual reach will be merged with that of other reaches within the system, along with any interior drainage flooding of the system, to result in a final SFHA delineation landward of the levee system. Developing the final SFHA delineation for the system is discussed further in Subsection 4.3.4. All engineering data submitted for each of the procedures must be signed and stamped by a Registered Professional Engineer. The Registered Professional Engineer's signature and stamp has the same meaning as the certification required in 44CFR65.2, *Definitions*.

4.2 Non-Accredited Levee Analysis and Mapping Procedures

4.2.1 Sound Reach Procedure

4.2.1.1 Applicability of the Procedure

A Sound Reach is a reach that has been designed, constructed, and maintained to withstand and reduce the flood hazards posed by a 1-percent-annual-chance flood, in accordance with sound engineering practices. To be considered a Sound Reach, the community/levee owner must provide an Operations Plan and Maintenance Plan that discusses closures, interior drainage management and the stability, height, and overall integrity of the levee and its associated structures and systems.

A **Sound Reach** is a reach that has been designed, constructed, and maintained to withstand, and reduce the flood hazards posed by, a 1-percent-annual-chance flood, in accordance with sound engineering practices.

A single reach of a levee within a system cannot be accredited unless that reach can be shown to be a fully functioning, hydraulically independent levee system as defined in 44CFR59.1.

The Sound Reach Procedure is only appropriate for levee systems that have been divided into reaches. If the entire system addresses all elements of 44CFR65.10, the current procedures for accredited levee systems will be followed. Figure 4-2 is an illustration of a cross section view of the Sound Reach conditions.

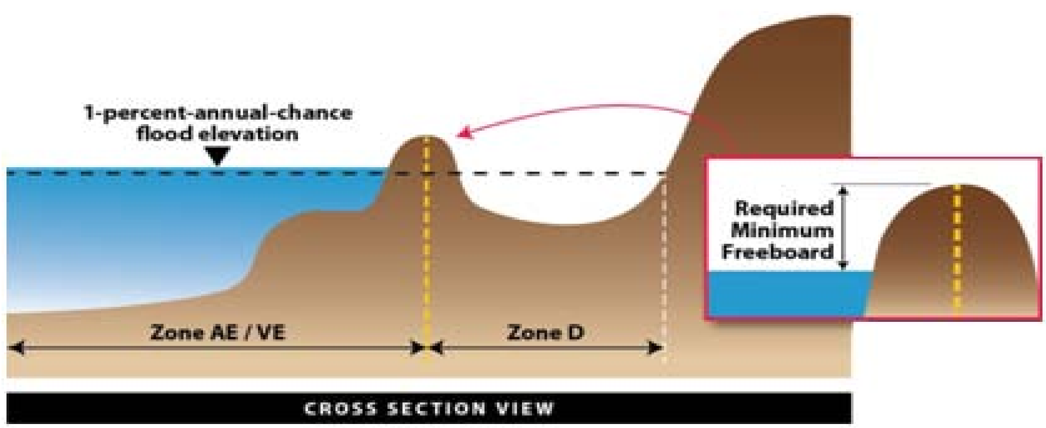


Figure 4-2. Sound Reach Cross Section View

4.2.1.2 Data Requirements

To qualify for the Sound Reach Procedure, the community/levee owner must submit a complete analysis and documentation package to FEMA for the reach. The package must be signed and stamped by a Registered Professional Engineer, and will clearly identify the limits of the Sound Reach and include an interior drainage analysis for the Sound Reach.

The interior drainage analysis will be completed for the entire system, assuming that any adjacent reaches will remain intact. FEMA will check the package submitted by the community/levee owner for completeness.

To qualify for the Sound Reach Procedure, the community/levee owner must submit a complete analysis and documentation package to FEMA for that reach that is signed and stamped by a Registered Professional Engineer.

4.2.1.3 Technical Procedures

Because Sound Reaches are only applicable as reaches of a non-accredited levee system, FEMA will establish a natural valley-based Zone D area landward of the system. It is important to note that the SFHAs from the interior drainage analysis and/or adjacent reaches where different procedures have been applied may still be present behind Sound Reaches. This will depend on the presence of interior ponding areas and other terrain features on the landward side of the levee.

Figure 4-3 shows an example of the Sound Reach Procedure applied to a reach of a non-accredited levee system.

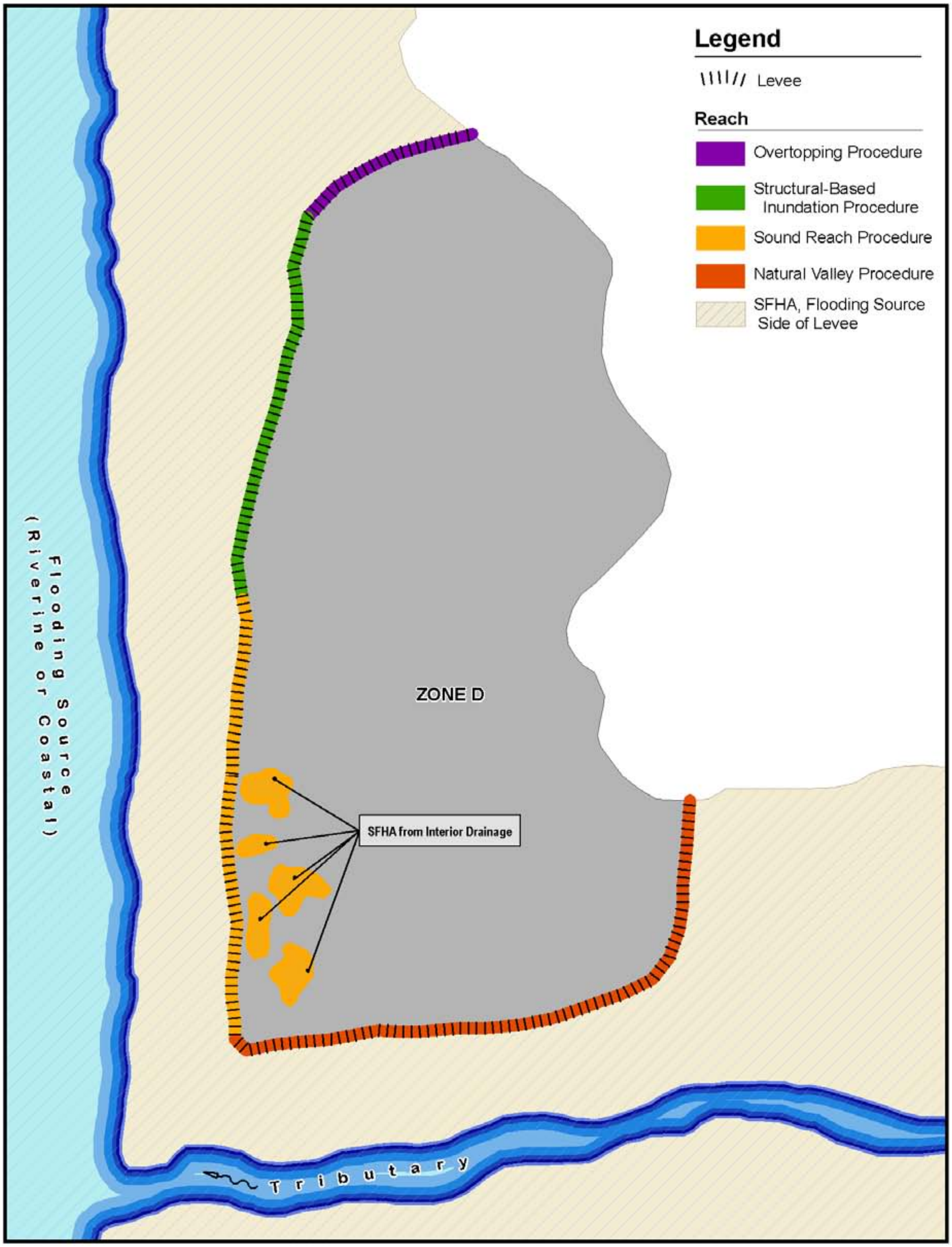


Figure 4-3. Sound Reach Procedure

4.2.2 Freeboard Deficient Procedure

For NFIP purposes, freeboard refers to the vertical distance between the top of the levee and the water level that can be expected during the 1-percent-annual-chance flood. Freeboard requirements are established in acknowledgement of the many unknown realities of flood hazards, including analysis uncertainty, blockage of nearby bridge openings, and potential for unforeseen operational issues.

Given the potentially catastrophic consequences should a levee system suddenly fail, this freeboard is an important tool for floodplain management and public safety. For the purposes of the NFIP, 3 feet of freeboard in riverine situations is an acceptable factor of safety. In coastal areas, freeboard for the purpose of the NFIP is 1 foot above the height of the 1-percent wave or the maximum wave runup (whichever is greater). Some exceptions to these freeboards that depend on additional data and analysis are allowed.

Figure 4-4 is an illustration of a cross section view of the Freeboard Deficient conditions.

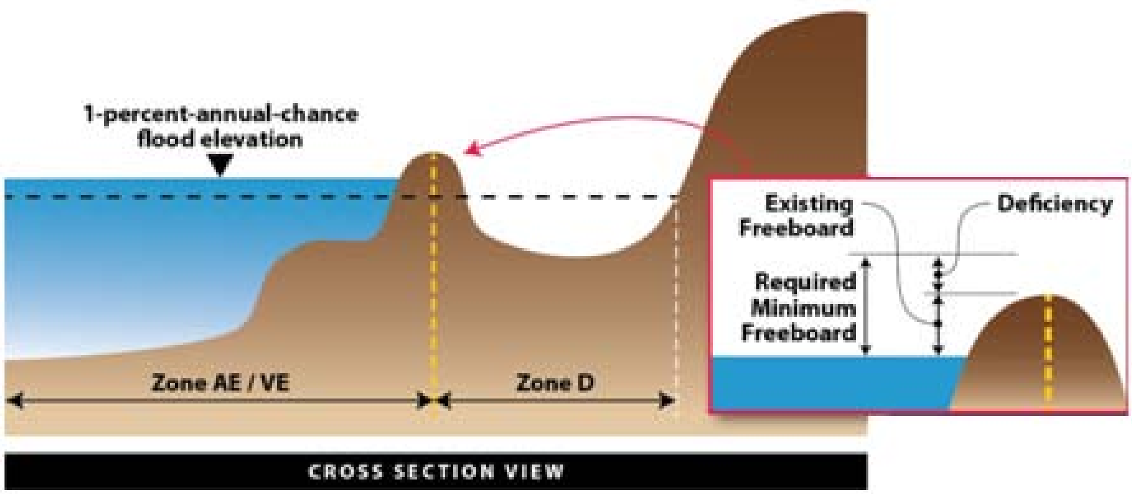


Figure 4-4. Freeboard Deficient Cross Section View

4.2.2.1 Applicability of the Procedure

FEMA will apply the Freeboard Deficient Procedure when a community/levee owner can provide documentation that the levee is structurally sound and the top-of-levee elevation is higher than the 1-percent-annual-chance flood elevation, but cannot provide documentation that an adequate amount of freeboard exists.

4.2.2.2 Data Requirements

The community/levee owner must submit an analysis and documentation package. At a minimum, the package must include an Operations and Maintenance Plan; an analysis, signed and stamped by a Registered Professional Engineer, indicating that the levee can withstand the 1-percent-annual-chance flood; and data on the top-of-levee elevation. Where applicable, the package will include an interior drainage analysis for the reach completed assuming that any adjacent reaches will not breach (i.e., seepage through the levee reach may impact internal drainage, but inundation from breaching does not occur). FEMA will check the package for completeness.

4.2.2.3 Technical Procedures

Similar to Sound Reaches, FEMA will establish a natural valley-based Zone D area landward of Freeboard Deficient levee systems and reaches. (See Subsection 4.2.5 for details.) If applicable, FEMA will show the results of the interior drainage analysis landward of the levee system as well.

4.2.3 Overtopping Procedure

In some instances, levee systems have locations that have been specifically armored to sustain overtopping flows or the rate of overtopping flow is so small or of short duration that the system does not fail during the overtopping event. To recognize this level of hazard reduction capability, FEMA developed a procedure for modeling and mapping reaches within these systems. An example of the use of armoring is shown Figure 4-5. Figure 4-6 is an illustration of a cross section view of the Overtopping conditions.

4.2.3.1 Applicability of the Procedure

The Overtopping Procedure can be applied when the BFE is above the levee crest for a reach, but it can be demonstrated that the 1-percent-annual-chance flood event will not cause structural failure. As distinguished from the Freeboard Deficient Procedure, the Overtopping Procedure is applicable when the 1-percent-annual-chance flood level is higher than the top-of-levee elevation. The Freeboard Deficient Procedure applies if the 1-percent-annual-chance flood is below the top-of-levee elevation, but the levee system has less than the minimum required freeboard.

> The Overtopping Procedure can be applied when the BFE is above the levee crest for a reach, but it can be demonstrated that the 1-percent-annual-chance flood will not cause structural failure.

4.2.3.2 Data Requirements

To proceed with the Overtopping Procedure for a particular reach, the community/levee owner must provide the following:

1. Survey or as-built data for the levee crest.
2. An analysis, signed and stamped by a Registered Professional Engineer, indicating that no appreciable erosion of the levee crest, toes, embankment, or foundation can be expected during the overtopping of the 1-percent-annual-chance flood event as a result of either currents or waves, and that the anticipated erosion will not result in structural failure (i.e., breach of the levee, directly or indirectly, through loss of embankment material due to erosive forces or the reduction of the seepage path or piping and subsequent instability).
3. An Operations and Maintenance Plan.

Figure 4-5. Articulated Concrete Blocks Used for Armoring Purposes

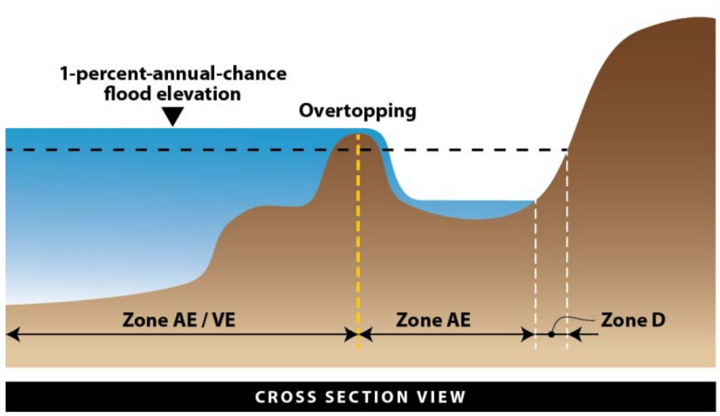


Figure 4-6. Overtopping Cross Section View

The documentation submitted is to include the hydrologic and hydraulic analyses used to determine the duration and extent of overtopping expected during the 1-percent-annual-chance flood event. FEMA will check the package for completeness.

The purpose of this process is not to dictate design standards or strict requirements on backup data required to demonstrate whether the levee reach will appreciably erode. It is the responsibility of the community/levee owner, based on a signed and stamped engineering analysis, to determine if the required armoring will prevent appreciable erosion during the 1-percent-annual-chance flood. However, FEMA has developed the list of possible items discussed below for communities/levee owners and their consulting engineers to consider when developing the data.

Loading Conditions Used for Evaluation

For the loading conditions used for evaluation, the certifying engineer will use the 1-percent-annual-chance flood event plus a factor of safety, such as an elevation freeboard, that takes into account uncertainty in the data. The factor of safety used will depend on the levee reach. For example, the factor of safety will vary when unique tie-in conditions exist or control structures are present.

Determining Need for Armored Surfacing

A community/levee owner, based on the certified engineering analysis submitted, may be able to demonstrate that mechanical armoring is not required for a levee reach to fall within this scenario. However, in most cases, armoring will be required. Some of the reasons for only considering a mechanical means to provide armored surfacing include:

- A lack of proper and continuous maintenance that would result in a continuous uniform surface, including irrigation, fertilization, and annual inspections;
- Some indication that flow along the levee reach may cause some erosion that will initiate levee breaching;
- Concerns about localized irregularities, which lead to flow anomalies, since available survey data may not be indicative of localized conditions along the levee reach;
- Local conditions, on the landward, include the presence of dips, depressions, or protrusions, including trees, posts, or other surface anomalies;
- Traffic rutting along the levee crest that induces non-uniform crest conditions, in terms of both levee profile and condition;
- Difficulty in establishing and properly maintaining a dense and continuous grass cover (in semi-arid and arid regions);
- Debris carried by floodflow may induce damage to the protective surfacing;
- A small amount of damage to a brittle embankment, leading to a catastrophic failure during overtopping; and
- Risk reduction in high-impact areas.

Items to Consider When Determining Viability of an Armored Surface

The items below may be considered when determining the viability of an armored surface.

- *History of Events*. Flood levels, overtopping locations, damage assessments, and maintenance records can be considered to evaluate the damage that occurred during past overtopping events, especially if depth and duration can be established and evidence shows minor to no damage occurred. If the levee has experienced piping or sand boils, the stability of the levee should be questioned. These data will not be used to change the accreditation determination made at the beginning of the levee analysis and mapping process. (See Element 100 in Figure 3-1.)
- *Potential freeboard loss due to subsidence or localized settlement*. Frequent, accurate surveys are critical to ensure that an adequate safety factor is maintained in an area where long-term settlement and regional subsidence are common.
- *Overtopping height and overtopping flow rate (cubic feet per second).* Velocity and tractive-force calculations are key considerations to assess erosion potential. USACE Engineering Circular 1110-2-6067 (USACE, 2010) discusses overtopping flow rates as they apply to grass-covered levees.
- *Overtopping duration*. Levee design discharge or stage hydrographs indicating minutes, hours, or days of anticipated overtopping are especially critical for grass-covered levees.
- *Uplift potential and maximum induced shear stress along the interface between the armored surfacing and the overtopping flow*. Demonstrate adequacy of selected armoring scheme for given site conditions.
- *Resiliency of levee material.* Granular and sandy soils will require surface armoring for small rates and heights of flow.
- *Flow Concentration Potential.* Surface discontinuities and irregularities can lead to irregular hydraulic flow patterns. Armoring should be provided if gullies, tire tracks, access roads, fences, utility poles, animal burrows, cattle paths, roads, and bike trails, or other conditions may exist that will concentrate flow. For grass-lined levees, the downstream slope can be evaluated to determine if it is uniform from crest to toe, with no interruptions or irregularities such as dips, depressions, or protrusions (e.g., trees, posts, or other surface anomalies).
- *Effect of debris on flow patterns.* Armored reaches can be subject to damage from flood-borne debris.
- *Levee toe protection*. This is especially required at the location of eddies, groins, and hydraulic jumps. The depth and thickness of toe protection need to be considered.
- *Levee armoring alternatives*. Alternatives include soil cement, articulated concrete blocks, roller-compacted concrete, gabions, geocells, and rock chutes. Each alternative will have placement thickness recommendations and associated components/feature design considerations (e.g., tieback levees, subdrainage, anchoring requirement).
- *Wind and wave action.* This includes the impact of breaking waves over the levee.
- *Cavitation potential.* This is how it affects armored surfacing.

- *Levee height.* Low levees may be more tolerant to overtopping.
- *Interior side slopes.* Flatter slopes (i.e., > 4H: 1V) are more tolerant. This is especially important for grass-lined levees.
- *Inspections.* Inspection frequency is especially important for grass-lined levees or after historical events where overtopping occurs or the levees have been stressed.
- *Validity of the Operations and Maintenance Plan.* Confidence in emergency planning that minimizes the effects of overtopping, including the impact at overtopping location(s) and interior drainage.
- *Filter capability and free-draining bedding.* Filter materials should be protected from high rates of flow.

Additional Considerations for Coastal Levees

A coastal levee reach will need to include adequate embankment protection, foundation, and embankment stability. The levee reach will need to be designed, constructed, operated, and maintained to resist coastal waves, periodic wave splash, storm surge, and oscillating seiche to resist erosion and prevent flooding of interior areas landward of the levee crest.

For coastal levee reaches with minimal freeboard, armored surfacing will need to be considered on both the seaward and landward sides of the coastal levee, including the crest, to ensure that the coastal levee reach can withstand the wave forces to which the levee is subjected. Further discussion about armoring coastal levees is presented in USACE Coastal Engineering Research Center (CERC) CERC-89-15, *Criteria for Evaluating Coastal Flood Protection Structures* (CERC, 1989).

4.2.3.3 Technical Procedures

If the appropriate data are provided as detailed above, the flooding source hydrograph will be routed over the levee reach. The resulting hydrograph on the landward of the levee reach will be modeled according to the techniques discussed in Subsection 4.3.2 to establish the SFHA. In addition to the overtopping analysis, the SFHA resulting from interior drainage should be computed. To reflect the possible 1-percent-annual-chance flood hazard that exists because the levee system is not accredited, FEMA will apply the Zone D designation to those areas that fall within the natural valley floodplain, but are not designated as an SFHA due to overtopping and interior drainage analysis.

Figure 4-7 shows an example of the Overtopping Procedure applied to a reach of a non-accredited levee system.

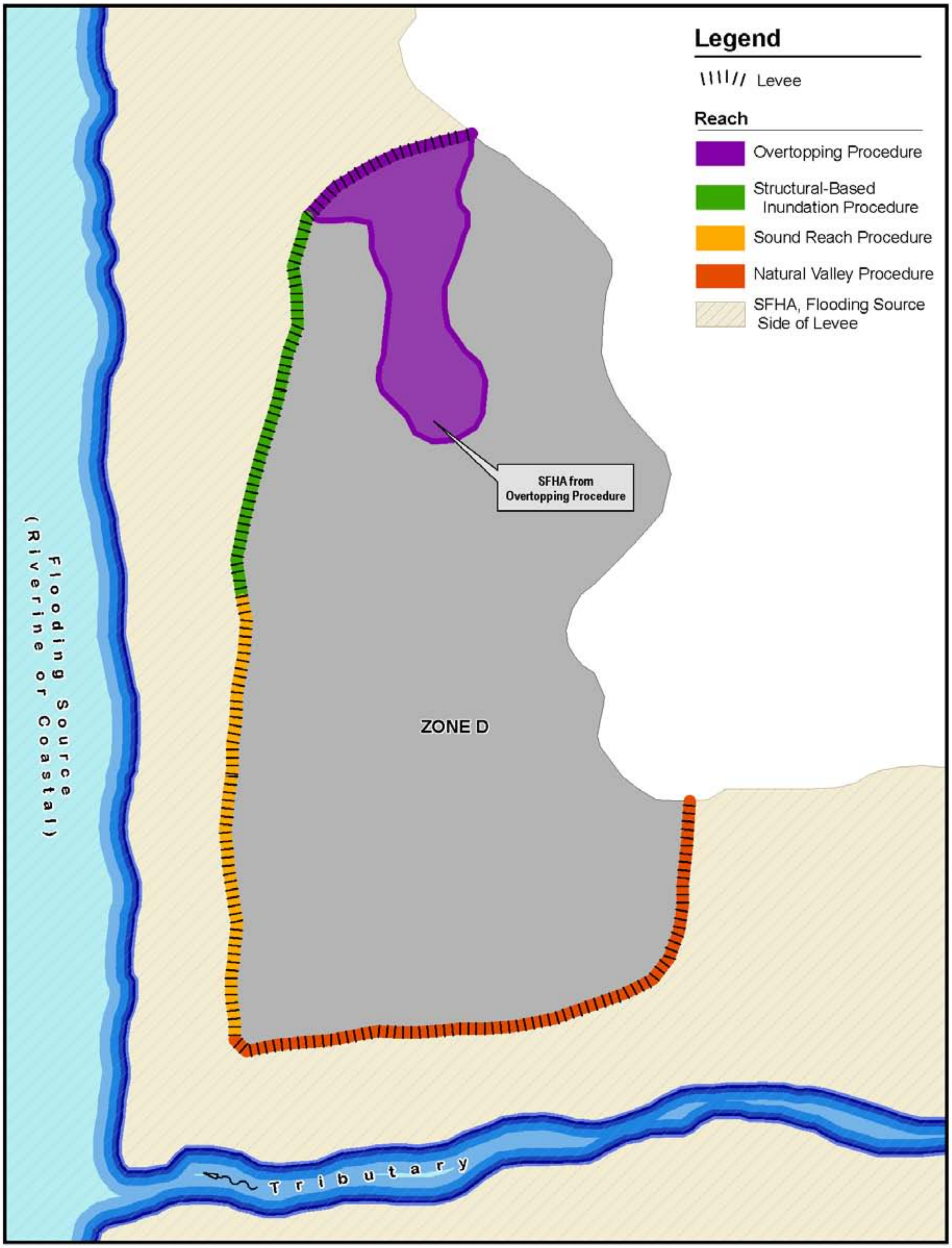


Figure 4-7. Overtopping Procedure

4.2.4 Structural-Based Inundation Procedure

In some instances, levee systems have reaches with either known structural deficiencies or a lack of data to support one of the other procedures. For levee reaches that fall into this category, FEMA developed a standardized procedure to identify the limits of the 1-percent-annual-chance flood that may result from the potential levee failure. This procedure relies on the modeling of levee breaches along the levee reach. Figure 4-8 is an illustration of a cross section view of the Structural-Based Inundation conditions.

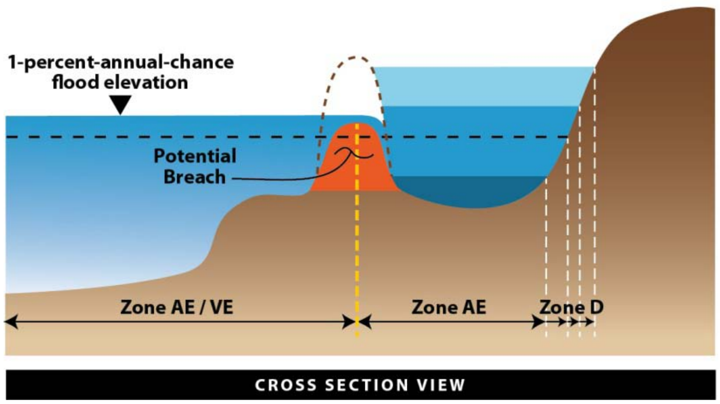


Figure 4-8. Structural-Based Inundation Cross Section View

While there are many different potential failure mechanisms for levees, for the purposes of this procedure failure modes are categorized into two types:

1. Breaches due to overtopping, and
2. Breaches due to underseepage piping, through-seepage piping, stability, and erosion (hereinafter referred to simply as "internal failure").

The second type of breaches is referred to as "internal failure" because, for hydraulic modeling purposes, the exact failure mode is often not important.

Predicting the exact location of levee and floodwall breaches is not possible. This procedure, therefore, does not predict the probability of failure at any breach locations nor does it provide a specific determination or evaluation of the overall levee system performance or require a determination of the likely failure mechanism. The procedure instead develops a floodplain (i.e., SFHA) that might occur due to breaches at any location within the levee reach during the 1-percent-annual-chance flood to which the Structural-Based Inundation Procedure is being applied.

4.2.4.1 Applicability of the Procedure

As indicated in Table 3-2 in Section 3 of this public review document, the Structural-Based Inundation Procedure is applied most appropriately to levees with High and Significant Hazard

Potential Classifications. However, the Structural-Based Inundation Procedure may be applied to any levee for which appropriate data are available.

4.2.4.2 Data Requirements

The data requirements for the Structural-Based Inundation Procedure will vary depending on the final flood hazard zone that will be mapped. In most cases, a flood hydrograph of the flooding source will be required. An accurate depiction of the top-of-levee and toe-of-levee elevations is also required.

4.2.4.3 Technical Procedures

Methods to identify possible locations of system breaches, modes of failure, geometry, failure triggers, and failure duration for use in mapping the 1-percent-annual-chance flood resulting from the breaches are described below.

Subdividing the Reach

After FEMA determines that Structural-Based Inundation Procedure is the appropriate method for a levee reach, further subdivision of the reach will take place. Factors impacting the choice of subdivision of reaches include:

- Hydraulically significant physical barriers, such as bridges, roadway crossings, or tie-ins to natural high ground or other barriers; and
- Confluence of tributary streams. The levee reach providing protection from the main flooding source will be divided from the levee reach providing protection from the tributary source.

Determination of Modeled Breach Locations

The locations of possible levee and floodwall breaches can be determined using the methods described below.

a. Select at least two breach locations for each reach, one representing a breach location near the downstream end of the reach and another near the upstream end of the reach.
b. Model the 1-percent-annual-chance flood through each breach location as though it occurs independently and combine the results into a composite SFHA delineation on the FIRM.
c. Make an initial judgment, through examination of the terrain landward of the levee and/or preliminary modeling results, on whether the selected breach locations will result in a reasonable identification of the flood hazard. The flood hazard will be considered to have been reasonably identified when all potential storage areas and flow paths that can be reached by breach flows reflect the potential flood hazard.
d. Add additional breach locations to the two initial locations if a reasonable SFHA delineation is not produced.

Failure Modes

Based on available data, the appropriate failure mode for hydraulic modeling purposes will be selected at each breach location. An overtopping breach will be used where the levee is overtopped during the 1-percent-annual-chance flood. If the levee does not overtop, a piping breach will be used.

Time of Breach Initiation

The time that a breach is assumed to be triggered will impact the peak flow and volume through the breach. The time that produces the worst reasonable case should be chosen. For an overtopping breach, sensitivity analysis should be conducted as described in the Sensitivity Analysis subsection below to estimate the breach initiation time that produces the largest SFHA. For an internal failure analysis, the breach failure should initiate at the peak flood stage, unless information that suggests a different worse-case breach initiation time is available.

Breach Shape and Development Time

A rectangular shape extending vertically from the levee crest to the flood-side toe elevation will be adequate to describe the breach shape, unless additional analysis determines breach side slopes are important and necessary for accurate modeling of the breach. The minimum breach width will be 100 feet for clay levees and 500 feet for sand levees. The breach width estimates may be based on empirical or physical methods, although empirical methods will likely be far more common. The breach width estimation may consider levee embankment height, levee material, crest width, depth and duration of overtopping, longitudinal river velocity, area protected by the levee, and duration of river stage. The method to estimate breach width will be based on sound engineering judgment, adjusted by comparing to historical documented levee breaches.

Empirical Methods:

*Dam Breach Equations***.** Empirical equations have been developed by a several authors to estimate breach size, shape, and failure time for dam breaches. The equations are based on examination of historical data for dam breaches. Levee failures generally end with much wider breach bottom widths than dams, relative to the height of the levee/dam. The wide breach width may be caused in part by the sheer erosive force of floodflow parallel to levees and in part by the tendency for the hydraulic head over the breach to remain elevated for a longer period of time. Dam breach parameter empirical equations may be applicable to levees in some situations, but justification for their use will be needed if they are chosen for the levee breach width computation.

Historical Levee Breach Information. FEMA has collected and summarized published information of historical levee breaches. This historical information will be consulted and will be a major consideration when choosing levee breach parameters.

Physically Based Models:

Where appropriate information is available to do so, physically based breaching models may be used. These models will be based on erodibility of the levee and levee foundation, levee and levee foundation soil type, levee vegetative cover, flood stage, and flood duration.

Breach Hydrograph Development

Given a flooding source 1-percent-annual-chance hydrograph and breach parameter, a breach hydrograph will be estimated to determine the landward flow. Both basic breach hydrograph methods and advanced breach hydrograph techniques may be used.

Basic Breach Hydrograph Methods:

Basic breach hydrograph methods do not require the data demands or modeling software capabilities of advanced methods, but they may include assumptions that are more conservative than advanced hydrograph methods or assumptions that are not appropriate for some levee failure scenarios.

Advanced Breach Hydrograph Techniques:

Advanced breach hydrograph techniques develop breach hydrographs by modeling the breach within unsteady-state hydraulic models. Unsteady-state hydraulic models, which route hydrographs through the flooding source while modeling the development of breach geometry, are capable of modeling levee breach effects that are not included within all of the basic hydrograph development methods. Breach hydrographs developed from unsteady-state hydraulic models include the impacts of breach development and lowering of flooding source elevations.

Sensitivity Analysis

A sensitivity analysis will be conducted by varying the levee breach width, failure initiation time, and time of breach formation within reasonable limits. The analysis will include widening and narrowing the levee breach width and investigating the impacts of different breach initiation times and times of breach formation. As the parameters are varied, the impacts to the peak discharge, volume through the breach, and SFHA will be noted. In general, the final parameters chosen will maximize the flood hazard area.

To test the impact of failure initiation time, a calculation initiating the breach at the point of overtopping of the levee on the acceding limb of the river flood hydrograph will be conducted. Also, a breach calculation will be performed at the time to peak of the river, but not greater than 2 hours after overtopping begins. This duration of overtopping may be extended if historical evidence or technical calculations are provided by the community/levee owner that indicates the levee can withstand additional overtopping without failure. The breach flows or hydrographs will be compared, and the one that produces the maximum flooding to interior inundation areas will be used.

Mapping

The SFHA shown on the FIRM will be based on a composite of the 1-percent-annual-chance floodplain developed at each breach location. The resulting SFHA will replace the Natural Valley-based Zone D area landward of the levee system. Figure 4-9 shows an example of the Structural-Based Inundation Procedure applied to a reach of a non-accredited levee system.

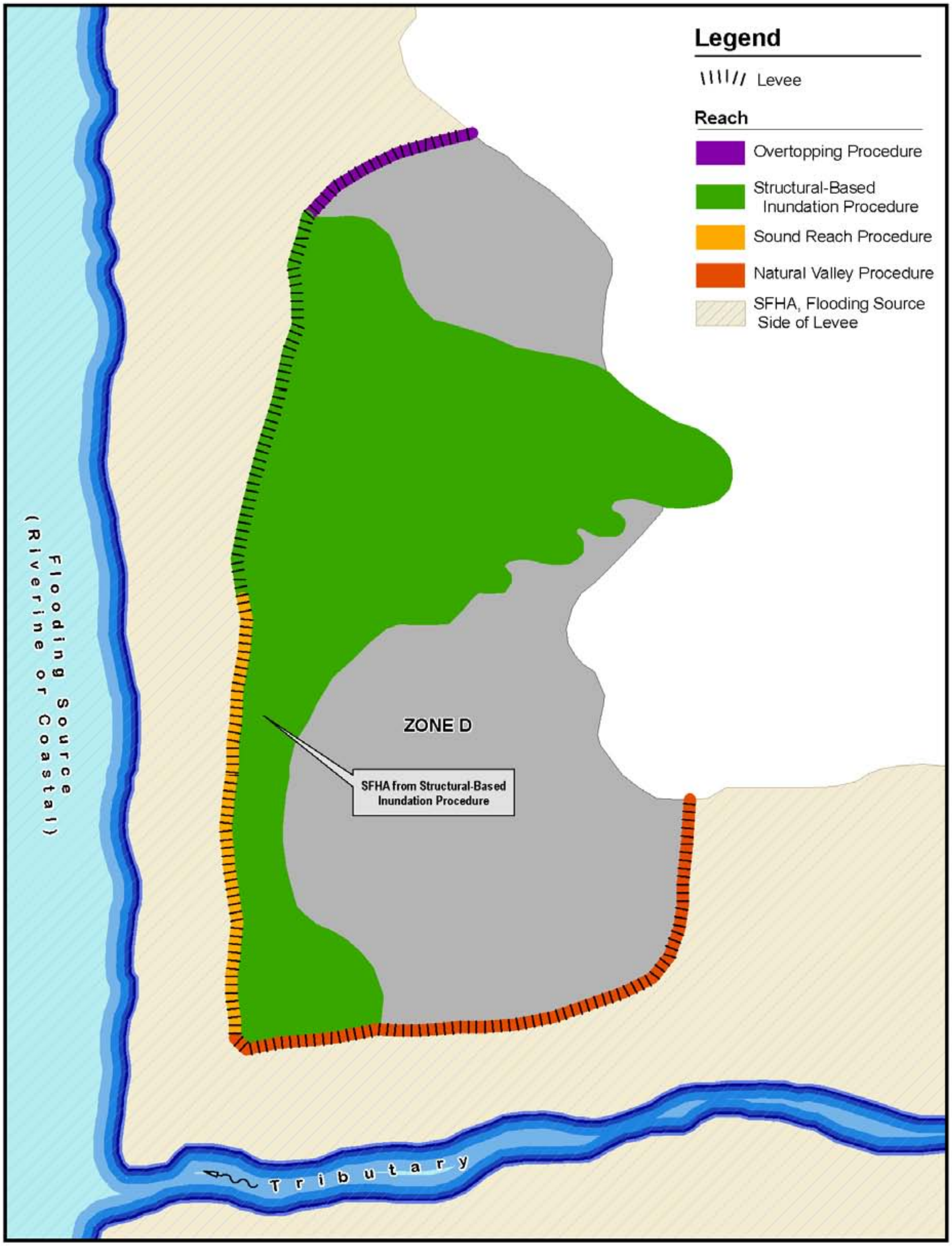


Figure 4-9. Structural-Based Inundation Procedure

4.2.5 Natural Valley Procedure

4.2.5.1 Applicability of the Procedure

The Natural Valley Procedure can be applied to all non-accredited levee reaches. Below are several factors to consider when determining whether to use the Natural Valley Procedure to determine the SFHA.

- *The Hydraulic Significance of the Levee Reach.* In some cases, a levee reach is so significantly overtopped during the 1-percent-annual-chance flood event that the existence of the levee does not have a noticeable effect on the water-surface elevation (WSEL). Techniques and items to consider for this factor are included in the Technical Procedure section below.
- *The Hazard Potential.* Table 3-2 in Section 3 of this public review document identified three different Hazard Potential Classifications, which are the starting point for discussions with the community regarding the Hazard Potential in a leveed area. The Natural Valley Procedure will be considered for levee reaches with a Low Hazard Potential.
- *The Availability of Data.* Because of the minimal data requirements of the Natural Valley Procedure, if no data are available to support the other procedures, the Natural Valley Procedure will be used.
- *The Needs of the Community.* Because of the more limited data requirements and resources required to analyze a levee reach using the Natural Valley Procedure, a community may prefer to use this method.

The Natural Valley Procedure can be applied to all non-accredited levee reaches, but several factors must be considered.

Figure 4-10 is an illustration of a cross section view of the Natural Valley conditions.

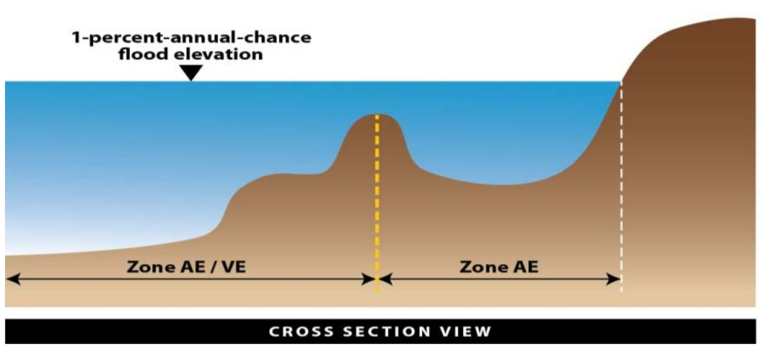


Figure 4-10. Natural Valley Cross Section View

4.2.5.2 Data Requirements

No data are required from the community/levee owner to proceed with the Natural Valley Procedure.

4.2.5.3 Technical Procedures

Testing the Hydraulic Significance of the Levee Reach for Riverine Levees

Characteristics of the levee reach that may indicate the levee is not hydraulically significant include:

- Constant WSEL and energy grade line exist for the full floodplain within approximately 0.5 foot on average.
- Levee/floodwall is fully submerged and landward conveyance is in the direction of the river flow.
- Lateral exchange of flow across the levee crest is insignificant or does not exist.
- Height of the levee/floodwall is low compared to the WSEL over the crest of the levee/floodwall for the majority of the length of the levee/floodwall, as outlined in the following section.

Modeling the Natural Valley Procedure on a Riverine Flooding Source

The Natural Valley Procedure will be modeled for riverine levee reaches by leaving the topographic features of the levee in the model, but allowing the discharge to flow on either side of the levee. The levee will not be impeding conveyance in the model.

Figure 4-11 shows an example of the Natural Valley Procedure applied to a reach of a non-accredited levee system.

Modeling the Natural Valley Procedure on a Coastal Flooding Source

Non-accredited coastal levees will be included in the storm surge model setup to determine peak storm-surge elevations seaward of the levees. A steady-state condition will then be assumed landward of the levee, and the 1-percent-annual-chance The WSEL will be extended landward of the non-accredited levee until it intersects the ground elevation. A similar procedure may be applied when a detailed storm surge model is not available. Wave conditions landward of the non-accredited levees will not need to be assessed for the Natural Valley Procedure.

A similar procedure may be applied when a detailed storm surge model is not available. Wave conditions landward of the non-accredited levees will not need to be assessed for the Natural Valley Procedure.

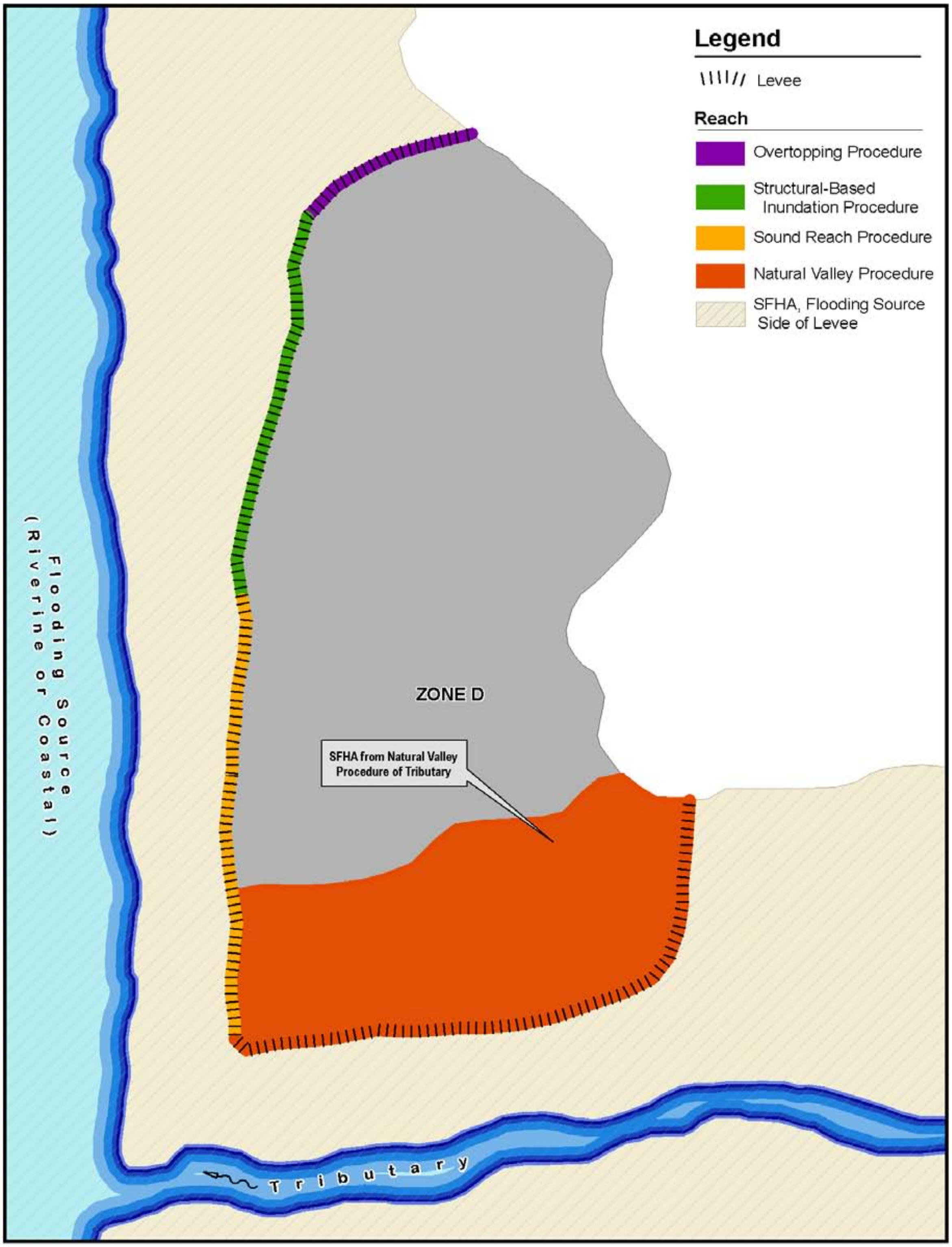


Figure 4-11. Natural Valley Procedure

4.3 Additional Analysis and Mapping Considerations

4.3.1 Hydrograph Development

4.3.1.1 Riverine Hydrograph Development

Traditionally, studies conducted for flood insurance purposes have only calculated peak-flow or peak-surge elevation. Both Structural-Based Inundation and Overtopping Procedures will often require a 1-percent-annual-chance flood hydrograph[4] to complete the modeling, making the development of a flood hydrograph necessary. Computing and selecting a representative hydrograph shape with an appropriate volume is an important step. For many systems, the hydrograph shape and volume will be a key parameter influencing the resultant SFHAs. A cost-effective method is needed to estimate flood hydrographs for studies where only peak discharges/surge elevations are currently available or where funding is not sufficient to develop a calibrated rainfall-runoff or storm surge model. Procedures discussed below will use the 1-percent-annual-chance flood hydrograph for the levee analysis, but other percent chance floods could be used if required.

The FEMA method is based on both the availability of existing data and the type of flooding. For flooding sources with gaging stations near the study reach, two methods for developing desired-percent-chance flood hydrographs may be taken:

- Scale a major (10-percent-annual-chance peak discharge or larger) observed flood hydrograph by multiplying the ordinates by a factor to create the desired-percent-chance flood hydrograph; or
- Develop a balanced synthetic flood hydrograph using peak discharges and N-day volumes.

The balanced synthetic flood hydrograph will be used when no major (10-percent-annual-chance peak discharge or larger) observed flood hydrograph is available for scaling to obtain the desired-percent-chance hydrograph, or the volume under the observed flood hydrograph is not considered representative of the desired-percent-chance hydrograph

To scale a smaller hydrograph to a larger hydrograph, several observed flood hydrographs will be plotted to determine a representative hydrograph shape that can be scaled to become a desired-percent-chance flood hydrograph. Unit discharge data are available from the USGS Instantaneous Data Archive for many gaging stations beginning in the late 1980s.

The discharge ordinates of the representative observed hydrographs can be scaled by multiplying them by a ratio of the desired-percent-chance peak discharge to the observed peak discharge (or the reverse ratio if scaling down the observed hydrograph). If the gaging station drainage area is within 50 percent of the drainage area of the study reach, the desired-percent-chance hydrograph can be transferred upstream or downstream by multiplying the discharge ordinates by a ratio of the drainage areas of the gage and the reach raised to an exponent. Often, the exponent on the drainage area value in the applicable USGS regression equation is used. If needed, the time scale of the desired-percent-chance hydrograph can be adjusted using a ratio of basin lag times at the gaging station and the study reach.

[4] The term hydrograph is used in this public review document to denote both a time series of flow rate (for riverine analysis) and the time series of water-surface elevation associated with a storm surge event (for coastal analysis).

The balanced synthetic hydrograph can be constructed using desired-percent-chance flood volumes for different durations (e.g., 1-day, 3-day, 7-day). The N-day flood volumes can be obtained from daily discharge data in the USGS National Water Information System. Some of the available computer programs for estimating the desired-percent-chance N-day flood volumes include the USACE Hydrologic Engineering Center Statistical Software Package (HEC-SSP) and USGS Surface-Water Statistics (SWSTAT) computer program. The balanced synthetic hydrograph is shaped using an observed major flood hydrograph. More information on this method is provided in the U.S. Bureau of Reclamation *Flood Hydrology Manual* (Cudworth, 1989) and in USACE Engineer Manual EM 1110-2-1415 (USACE, 1993).

For ungaged watersheds, if the FIS was based on a rainfall-runoff model, that model can be used to obtain the appropriate flood hydrograph. If a rainfall-runoff model was not developed for the FIS, a rainfall-runoff model may have been developed for other purposes, such as a master drainage plan. If available, the flood hydrographs from that model can be scaled to be consistent with the peak discharges developed for the FIS.

If a continuous simulation rainfall-runoff model is available, then several simulated flood hydrographs are available. The simulated flood hydrograph with largest volume and peak discharge can be scaled to get the desired-percent-chance flood hydrograph.

If no rainfall-runoff model is available, it may be feasible to develop a simplified rainfall-runoff model for a single watershed area with no subdivision and no channel/reservoir routing or model calibration. The flood hydrographs from this model could be scaled to be consistent with peak discharges determined from other methods.

Otherwise, dimensionless unit hydrograph procedures will be applied. Examples of dimensionless unit hydrographs are provided in Figure 4-12, where the vertical ordinate is a ratio of discharge (Q) to the peak discharge (Qp) and the horizontal ordinate is a ratio of time (t) to basin lag time (T_L) to time to time (T_P).

The “Statewide” hydrograph in Figure 4-12 was developed by Inman (1987) using data for 80 gaging stations in Georgia. This dimensionless hydrograph is implemented in the USGS National Streamflow Statistics (NSS) computer program (Ries, 2007). The “Stricker-Sauer” hydrograph was theoretically developed from Clark unit hydrograph procedures (Stricker-Sauer, 1982). The “SCS” hydrograph is described in Chapter 16, Part 630, Hydrology of the *National Engineering Handbook* (NRCS, 2007).

The USGS dimensionless hydrographs shown in Figure 4-12 can be converted to desired-percent-chance flood hydrographs by multiplying the discharge ratio by the desired-percent-chance peak discharge and the time ratio by basin lag time. The resultant flood hydrograph is assumed to be a typical flood hydrograph for a desired-percent-chance peak discharge. There is no implication that the volume under the hydrograph has a desired-percent chance of being exceeded.

In addition to the Georgia dimensionless hydrograph available in the USGS NSS program, the USGS has developed dimensionless hydrographs for several other States (e.g., Bohman, 1990; Dillow, 1998; Gamble, 1989). The dimensionless hydrographs in other States agree reasonably well with the Georgia dimensionless hydrographs, but the State-specific hydrographs are to be used if available. For ungaged streams that are not regulated by flood control structures, the dimensionless hydrograph method may be used to estimate the desired-percent-chance hydrograph.

The desired-percent-chance peak discharge for rural and urban ungaged watersheds may be estimated from USGS regression reports or from other regression equations developed for the study area. The basin lag time may be estimated by regression equations given in USGS reports on dimensionless hydrographs, many of which are summarized in Appendix B of Ries (2007), and other regression equations developed for basin lag time. The basin lag time as used in the USGS dimensionless hydrograph approach is the time from the center of mass of rainfall excess to the center of mass of runoff.

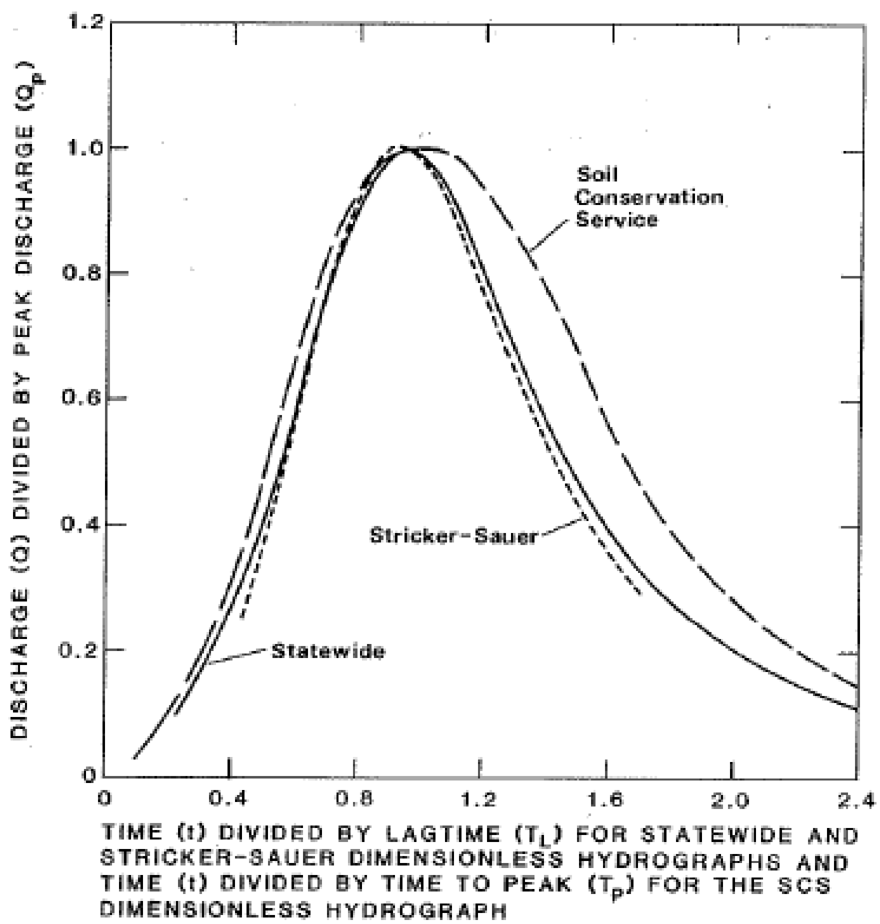


Figure 4-12. Sample Dimensionless Unit Hydrographs

Using rainfall-runoff data for 81 watersheds in Maryland, Thomas and others (Transportation Research Board, 2000) demonstrated that the basin lag time used to define the USGS dimensionless hydrograph was, on average, only 5 percent less than the watershed time of concentration. Therefore, basin lag time as defined above may be approximated by the time of concentration as estimated by the NRCS (1986) travel time method.

The balanced synthetic hydrograph method described earlier for gaged streams may also be applied to ungaged streams by:

- Estimating N-day volumes (e.g., 1-day, 3-day, 7-day) at gaging stations in the vicinity of the ungaged stream;
- Developing regression equations for estimating the desired-percent-chance N-day volumes for ungaged stream; and
- Constructing a balanced synthetic hydrograph with the desired-percent-chance N-day volumes.

This method is more time consuming, but it may be used if the dimensionless hydrograph method does not provide reasonable results or in areas where the dimensionless hydrograph method may not be applicable.

4.3.1.2 Coastal Hydrograph Development

For coastal analyses, one way to create a synthetic storm surge hydrograph is using procedures in the Federal Highway Administration (FHWA) publication, *Highways in the Coastal Environment* (FHWA, 2008) if data from a detailed coastal model are not available. The required variables for the method are the peak surge elevation (S_p), forward speed of the storm (f), and the radius of maximum winds (R). S_p is given directly from the published 1-percent-annual-chance water level noted in the FIS, while a range of values for both R and f are possible for a given location.

Coastal FISs based on modern methods involving Joint Probability Method (JPM) analysis contain enough information about the range of storm parameters that a representative R and f to associate with the value of S_p can be calculated directly. For studies where the FIS does not employ a JPM approach for determining the 1-percent-annual-chance water level, these values may need to be estimated by examining historical storms in the region.

Pilot tests suggest that the ultimate extent of flooding landward of a breached or overtopped coastal levee is not highly sensitive to the shape of the synthetic hydrograph, and so the exact choice for f and D may not be a critical factor. The peak surge and width of failure in a breaching condition is of primary importance within this analysis

4.3.2 Hydraulic Modeling Landward of the Levee

This subsection presents recommended guidance to be used for the mapping of the landward flood hazard area for levee and floodwall reaches that fit within the Overtopping or Structural-Based Inundation Procedures. For these procedures, often an unsteady flow will be required. While FEMA's current *Guidelines and Specifications* discusses both one- and two-dimensional unsteady-flow modeling, this subsection provides additional guidance specific to levees.

The flood hazard area created by levee overtopping or breach is assumed to be subject to the same annual-chance flooding as the exterior flooding source. For example, if a levee is breached by the 1-percent-annual-chance flood, the inundated area will be assigned a 1-percent-annual-chance exceedance probability and delineated as an SFHA on the FIRM.

Hydrologic or hydraulic analyses are necessary to compute the flood elevations created by the inflow. Reservoir routing and pump operation will be the features generally applied to determine flood elevations for hydrologic analyses.

One-dimensional (1D), two-dimensional (2D) steady flow, and unsteady flow solution methods are the hydraulic analysis methodologies applicable to compute flood elevations. The applicability and data requirements for these methodologies are summarized below.

4.3.2.1 Hydrologic Flow Routing

Hydrologic flow routing is applicable when floodplain storage, not conveyance, is the dominant factor determining the flood elevation. This will generally be applicable if the inflow is for a limited duration and the interior floodplain has the capability to store the volume of flow entering the protected area. A stage-inflow hydrograph of the exterior flooding source is essential to determine the duration and rate of the inflow, and to conduct a hydrologic flow routing. Depending on the mode of failure, inflow hydrographs can be computed by applying appropriate hydraulic computations. Most hydrologic flow routing models also have the capability to reflect flow evacuation features, such as pumping stations.

4.3.2.2 Hydraulic Modeling

A hydraulic approach is applicable when an alternate flow path is created landward of the levee for floodwater to flow downstream. Conveyance and floodplain storage along the flow path are the dominant factors controlling the flood elevations. For general floodplain analyses based on the formulation of basic equations of motion, four types of solutions procedures are available. They are categorized as 1D steady flow, 1D unsteady flow, 2D steady flow, and 2D unsteady flow solutions. Where groundwater is close to ground level, it may be appropriate to account for groundwater interaction.

Any hydraulic analysis software accepted by FEMA for flood hazard area boundary development can be selected for hydraulic modeling. General data requirements and applicability of the different types of hydraulic flow modeling are listed below.

One-Dimensional Steady Flow Analysis

One-dimensional steady flow analyses are applicable where flow is limited to defined flow paths. Inflow would be peak flow rates generated from the subject levee failure conditions – overtopping, segment failure, dynamic breach, or final breach condition. Weir and split flows are two commonly used options.

Inflow discharges due to overtopping can be computed by applying lateral weir flow computations. For weir flow assumptions to be applicable, the flow crossing the crest profile of the levee or flood wall must not be submerged landward of the levee. The weir flow method is also applicable if the final breach geometry creates weir flow conditions.

When overtopping flow accumulated on the floodplain creates a fully submerged condition landward of the levee, split flow becomes applicable. When a breached levee fails to the ground, inflow may be computed as split flow conditions in the vicinity of the breach location. The breach or overtopping flow may return to the same river downstream, join another flooding source, or flow into a large water body whose WSEL will not noticeably change despite receiving the inflow from levee failure.

In addition, most steady flow analyses can also reflect constant pumping rates.

One-dimensional steady flow models are generally not applicable in coastal situations.

One-Dimensional Unsteady Flow Analysis

Unsteady flow analyses are most suitable if the flow is limited to defined flow paths and defined storage areas are present in the overbank. However, unsteady flow models using link-node concepts to represent flow have the capability to model a larger number of flow paths and offline floodplain storage. Unsteady flow analyses have the capability to simulate online floodplain storage and dynamic impacts of pumping activities.

Unsteady flow analyses can be applied to a variety of downstream boundary conditions. Flow may rejoin the same river downstream, at other flooding sources, travel to storage/ponding areas, or reach an ocean impacted by daily tide level variations.

Unsteady 1D numerical models also may be applied to model the hydraulics for coastal levee overtopping and breach scenarios. In selecting an appropriate model, consideration is to be given to models that include modules for incorporating flow-control structures and supercritical flow. Models developed with modules accounting for dam-break scenarios may also be applied to levee breach scenarios. Models that are applicable to coastal flooding sources and include wave overtopping also exist.

Two-Dimensional Flow Analysis

Two-dimensional flow routing is most applicable to natural floodplains with flat terrain or urban floodplains where flow directions are dictated by streets, storm drain alignments, and obstructions caused by buildings. When levee breach or overtopping occurs, inflow from the channel may be modeled as 1D flow near the breach and develop into 2D flow, either forming flow paths or remaining as sheet flow to spread over the floodplain. A typical 2D model can model levee, flow paths, street flow, or shallow flow conditions.

Generally, 2D models have the capability to provide unsteady flow solutions. Inflow is defined as a hydrograph and can be generated outside of the 2D model and provided as input. Inflow hydrographs can be computed using methodologies described for 1D unsteady flow analysis. Some 2D software accepted for flood study development can also model levee overtopping, piping, and slope stability failure as well as flow routing on the adjoining floodplain.

Two-dimensional analyses provide a convenient method to simulate multiple modes of failure at different locations without significant additional efforts. Two-dimensional analysis is also applicable to simulate flood ponding in areas between two levees or areas protected by ring levees. When a breach occurs in one of the levees, areas between two levees will be inundated until the ponding elevation reaches the equivalent elevation of the flooding source side or overtops the other levee. In the latter situation, the ponding elevation is to be mapped as the elevation of levee being overtopped. Pumping and other flood mitigating features may be reflected in most 2D models through rating curves.

The storm surge modeling system most prevalently used in coastal flood hazard studies includes the ADCIRC 2D circulation model, which is then coupled with a 2D wave model (STWAVE or UnSWAN).

A 2D model will have varying levels of complexity. A simple 2D model using terrain data may be easily produced. In comparison, a complex 2D model that includes detailed hydraulic structures and streets may be time-consuming to prepare.

Combination of One-Dimensional and Two-Dimensional Models

Increasingly, 1D unsteady flow and 2D software developers have provided the capability to link 1D and 2D solutions as needed. Users have the capability to use the appropriate solutions for appropriate locations. Some such models also have options to model the levee breach process. The channel flow is typically modeled as 1D, using cross sections. Landward flow from a levee breach or overtopping is routed using 2D grids or finite element mesh.

The selected analysis methodology should be able to reflect flow conditions adequately and develop reliable flood elevations and flood hazard area boundaries for the area landward of a levee that does not meet the 44CFR65.10 criteria. Decision factors include the consequences of levee failure, nature of the terrain, complexity of the levee systems, mode of failure mechanisms, data availability, and availability of funds.

Levees and floodwalls protecting heavily populated areas and critical facilities warrant more detailed analyses before final flood hazard areas are delineated. For agricultural levees and those protecting sparsely populated areas where the consequence of failure is smaller, simpler and less costly methods can be selected for analysis.

4.3.3 Impacts to Modeling and Mapping the Flooding Source

The proposed methods for levee analysis and mapping generally do not impact the modeling and mapping of the flooding source on the flooding source side of the levee. Existing procedures for determining the BFEs on the flooding source side of the levee are to be followed.

When the Structural-Based Inundation Procedure is used, the flow in the flooding source is not to be reduced by the amount that is computed as lost through a breach. However, the flow in the flooding source can be reduced by the amount of flow lost during overtopping of the levees.

The equal-conveyance method will continue to be the default methodology for performing an encroachment analysis. Typically, FEMA will not map the regulatory floodway on the landward side of the levee. Exceptions to this situation include when the levee reach is determined to be hydraulically insignificant and a Natural Valley procedure is used. If this occurs, the regulatory floodway boundary may fall on the landward side of the levee, depending on the results of the equal-conveyance analysis.

However, for flooding sources with a levee along one side, the encroachment analysis will need to consider alternative methods to equal conveyance, because the levee impedes flow along one side of the flooding source, but not the other side. Therefore, for flooding sources with levees along one side, the surcharge limit should be set to one-half of the NFIP surcharge limit of 1.0 foot or, if a more restrictive floodway surcharge limit is established within the State or local jurisdiction of the study, one-half of the State or local surcharge limits. For flooding sources with levees on both sides, the regulatory floodway limit may be set to 0.0, as the floodplain may be considered fully encroached.

Exceptions to this method are possible. For example, if a levee on one side of a flooding source is not adjacent to the bank, than it is possible that more than one-half the normal limit would be available on the non-leveed side. Also, when the State and local jurisdictions along either side of a flooding source are different, coordination among those State and local jurisdictions and the FEMA Regional Office(s) will need to take place before options are chosen.

4.3.4 Flood Hazard Mapping

The final mapped flood hazard boundaries behind non-accredited levee systems will be a combination of three main sources:

1. The composite SFHA resulting from the reaches evaluated by the Overtopping, Structural-Based Inundation, or Natural Valley Procedures for each levee reach (Sound and Freeboard Deficient reaches will not have a SFHA associated with the individual reach analysis);
2. The SFHA resulting from the interior drainage analysis; and
3. The Zone D flood zone boundary developed using the Natural Valley Procedure, which will be used to depict the potential 1-percent-annual-chance flood hazard that exists landward of a non-accredited levee system in areas where an SFHA has not been identified.

This concept is illustrated in Figure 4-13. If BFEs are to be shown on the FIRM, they will be based on the highest elevation of the composite mapping.

4.3.4.1 Special Flood Hazard Area Resulting from Reach Procedures Chosen

For each individual levee reach, the SFHA extent will be determined by the procedure chosen. These individual polygons will be merged to produce the final SFHA.

When the Structural-Based Inundation Procedure is used, the SFHA for that reach will be a composite of each independently analyzed breach location. In addition, the final SFHA will reflect that a breach could occur at any location along the reach. To achieve this, it may be acceptable to extrapolate breach analysis results to areas that were not analyzed separately. This will most often occur in situations where breach flows seek a flow path or storage area that is not directly adjacent to the levee. The SFHA for these areas can be mapped as Zone A, AE, or AO, depending on the flooding conditions and level of detail used. (Explanations of the flood zones can be found on the FEMA Website.) The analyzed breach locations are not to be evident on the final mapping.

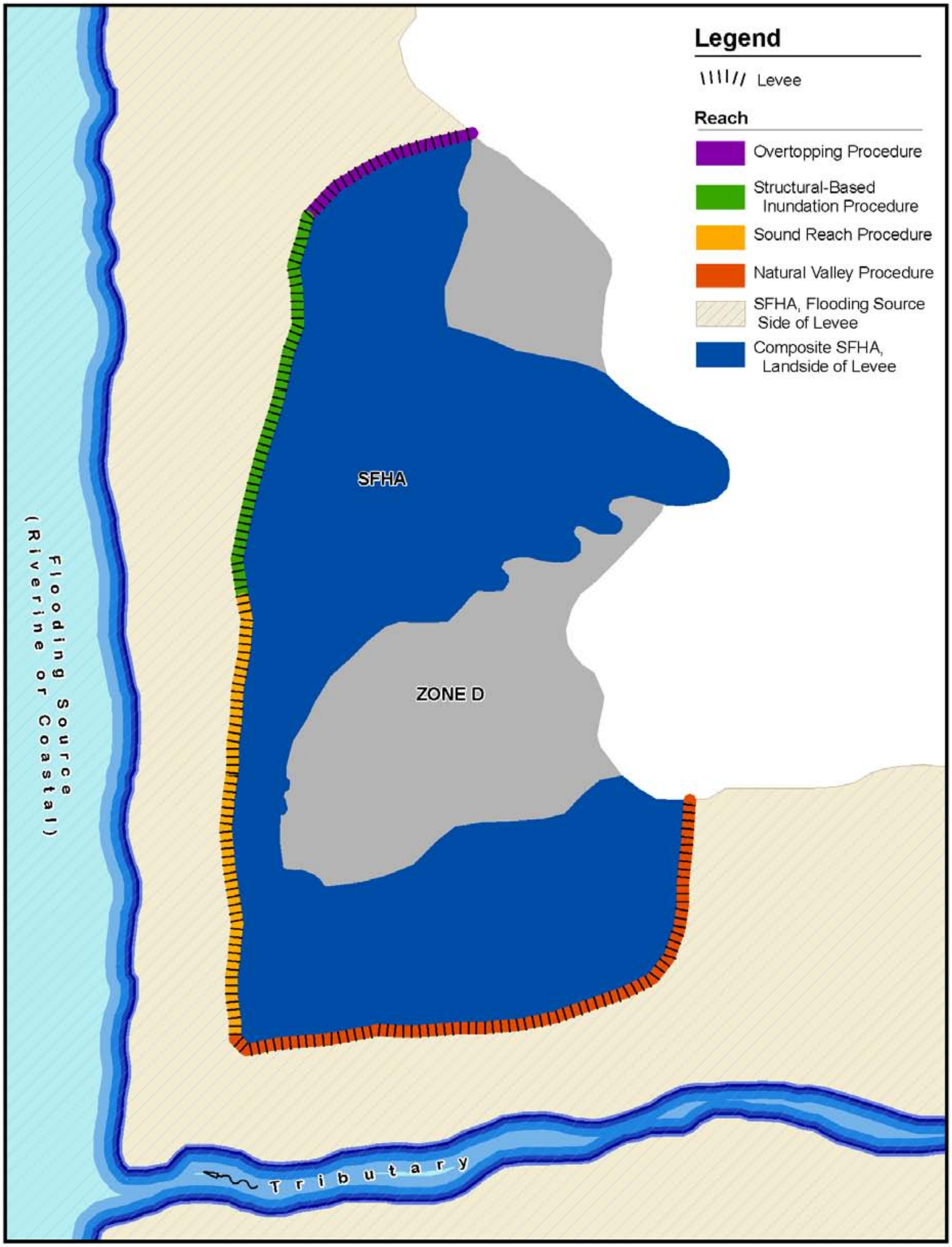


Figure 4-13. Composite Flooding for the Levee System

The input data requirements to map BFEs on the FIRM for the Overtopping and Structural-Based Inundation Procedures follow existing FEMA guidelines outlined in FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners*. Therefore, field-surveyed cross sections and field-surveyed hydraulic structures will be required on the landward side of the levee if BFEs will be shown on the FIRM. For the Natural Valley Procedure, BFEs can be shown as long as the flooding source was studied with the required level of detail.

4.3.4.2 Special Flood Hazard Area Resulting from Interior Drainage Flooding

For non-accredited levee systems, the adequacy of the interior drainage systems will be evaluated and an SFHA will be mapped for the 1-percent-annual-chance flood in these locations. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof.

The level of effort required for the analysis of the interior drainage systems will depend on the procedure chosen for the reaches within the system. For example, if the Natural Valley Procedure is used for a reach, it might not be necessary to evaluate flooding associated with the interior drainage system. However, if the reach is considered sound, then an analysis of the 1-percent-annual-chance flood hazard associated with the interior drainage system will be necessary to adequately reflect the flood hazard landward of the levee.

Engineering judgment will be used to determine if the interior drainage systems need to be analyzed. The SFHA used to depict this hazard will depend on the depth and type of flooding that occurs.

4.3.4.3 Reflecting the Possible Flood Hazard of a Non-Accredited Levee System

For areas that fall within the natural valley floodplain of the levee system but are not designated as an SFHA, the Zone D designation will be used to reflect the possible 1-percent–annual-chance flood hazard that exists because the levee system is not accredited. As mentioned earlier in this public review document, Zone D is used by FEMA to designate areas with possible, but undetermined flood hazards. Zone D areas are not subject to the Federal mandatory flood insurance purchase requirement. Homes and buildings located landward of levee systems, regardless of the zone designation, may be subject to lender-required flood insurance. Communities are expected to exercise judgment in issuing permits in Zone D areas. Flood insurance premium rates are commensurate with the uncertainty of the flood hazard.

For pre-FIRM structures, the rates for Zone D are the same as those for Zones A and AE. For post-FIRM structures, the rates for Zone D are similar to those for Zone AE if the structure's lowest floor is at the BFE, but significantly more expensive than a Zone AE rate for structures elevated 1 foot or more above the BFE. This occurs because properties located in Zone D are not eligible for discounted rates based on structure elevation, as is the case for properties located in Zone AE with established BFEs. Further, because areas designated as Zone D are not considered part of the SFHA, the application of any floodplain management requirements are at the discretion of a community or participating Tribe, provided those requirements comply with the minimum standards of 44CFR60.3(a).

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Appendix A. List of Levee-Related Acronyms

The acronyms below have been used in this report or will be encountered in other levee-related FEMA resources. A more comprehensive list of levee-related acronyms and abbreviations is available from the FEMA Library.

- ADCIRC – Advanced Circulation (computer model)
- BFE – Base Flood Elevation
- BIA – Bureau of Indian Affairs
- CCO – Consultation Coordination Officer
- CEO – Chief Executive Officer (community official)
- CERC – Coastal Engineering Research Center (USACE)
- CFR – Code of Federal Regulations
- CTP – Cooperating Technical Partner
- DHS – Department of Homeland Security
- EC – Engineer Circular (USACE)
- EM – Engineer Manual (USACE)
- EP – Engineer Pamphlet (USACE)
- ER – Engineer Regulation (USACE)
- FEMA – Federal Emergency Management Agency
- FHWA – Federal Highway Administration
- FIMA – Federal Insurance and Mitigation Administration
- FIRM – Flood Insurance Rate Map
- FIS – Flood Insurance Study
- FPA – Floodplain Administrator
- G&S – Guidelines and Specifications
- GIS – Geographic Information System
- HEC – Hydrologic Engineering Center (USACE)
- HEC-SSP – HEC Statistical Software Package (USACE)
- ISB – Independent Scientific Body
- JPM – Joint Probability Method
- LFD – Letter of Final Determination

- NCLS – National Committee on Levee Safety
- NED – National Elevation Dataset
- NFIP – National Flood Insurance Program
- NIBS – National Institute of Building Sciences
- NLD – National Levee Database
- NLSP – National Levee Safety Program
- NRCS – Natural Resources Conservation Service
- NSS – National Streamflow Statistics (computer program)
- O&M – Operations and Maintenance (Plan)
- PAL – Provisionally Accredited Levee
- PM – Procedure Memorandum
- Risk MAP – Risk Mapping, Assessment, and Planning (Program)
- SFHA – Special Flood Hazard Area
- STWAVE – Steady State Irregular WAVE (computer model)
- SWSTAT – Surface-Water Statistics (U.S. Geological Survey computer program)
- USACE – U.S. Army Corps of Engineers
- USBR – U.S. Bureau of Reclamation
- USGS – U.S. Geological Survey
- WSEL – Water-Surface Elevation

Appendix B. Glossary of Levee Terms

The terms below have been used in this public review document and will be encountered in other levee-related FEMA resources. Additional terms are provided in the glossary of frequently used terms available from the FEMA Library.

0.2-Percent-Annual-Chance Flood – The flood that has a 0.2-percent chance of being equaled or exceeded in any given year (also known as the 500-year flood).

1-Percent-Annual-Chance Flood – The flood that has a 1-percent chance of being equaled or exceeded in any given year (also known as the 100-year flood).

44CFR65.10 Requirements – See Section 65.10 Requirements**.**

Accredited Levee System– A levee system that FEMA has shown on a FIRM as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood. This determination is based on the submittal of data and documentation as required by 44CFR65.10 of the NFIP regulations. The area landward of an accredited levee system is shown as Zone X (shaded) on the FIRM except for areas of residual flooding, such as ponding areas, which are shown as Special Flood Hazard Area (SFHA).

ADCIRC Coastal Circulation and Storm Surge Model – A system of computer programs for solving time-dependent, free surface circulation and transport problems in two and three dimensions. These programs utilize the finite element method in space allowing the use of highly flexible, unstructured grids.

Appeal – A formal objection to FEMA's proposed flood hazard determinations (i.e., addition or modification of Base Flood Elevations [BFEs], base flood depths, SFHAs, zone designations, and regulatory floodways) shown on a new or revised FIRM and/or a new or revised FIS report subject to the NFIP due process requirements cited at Title 44, Chapter I, Part 67 of the Code of Federal Regulations (44 CFR Part 67).

Appeal Period – The period, beginning on the date of second publication of FEMA's proposed flood hazard determination notice in a local newspaper with wide circulation, during which community officials or owners or lessees of real property within the community may submit formal objections to the proposed flood hazard determinations (i.e., additions or modification of BFEs, base flood depths, SFHAs, zone designations, regulatory floodways) shown on a new or revised FIRM and/or a new or revised FIS report by submitting data to show that the proposed flood hazard determinations are scientifically or technically incorrect.

Approximate Study – An engineering study that results in the delineation of floodplain boundaries for the 1-percent-annual-chance flood, but does not include the determination of Base Flood Elevations or base flood depths.

Base Flood – The flood that has a 1-percent chance of being equaled or exceeded in any given year.

Base Flood Elevation (BFE) – The elevation of a flood having a 1-percent chance of being equaled or exceeded in any given year.

Berms – Horizontal strips or shelves of material built contiguous to the base of either side of levee embankments for the purpose of providing protection from underseepage and erosion, thereby increasing the stability of the embankment or reducing seepage.

Chief Executive Officer (CEO) – The official of a community who has the authority to implement and administer laws, ordinances, and regulations for that community.

Closure Devices – Any movable and essentially watertight barriers, used during flood periods to close openings in levee systems, securing but not increasing the levee systems' design level of protection.

Code of Federal Regulations (CFR) – The codification of the general and permanent rules published in the FEDERAL REGISTER by the Executive Departments and agencies of the Federal Government. NFIP regulations are published in Parts 59 through 77 of Title 44 of the CFR.

Community – Any State or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has the authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

Consultation Coordination Officer (CCO) – The individual on the FEMA Regional Office staff who is responsible for coordinating with a community on activities related to the NFIP.

CCO Meeting/Open House – The term used to describe a formal meeting with community officials and select stakeholders and subsequent open house for the public for flood risk projects carried out under the FEMA Risk Mapping, Assessment, and Planning Program. The CCO Meeting/Open House focuses on the release of the Preliminary version of the FIRM and FIS report and the process for reviewing and adopting the FIRM prior to the FIRM effective date.

Cooperating Technical Partner (CTP) – A participating NFIP community, regional entity, or State agency that has the interest and capability to become a more active participant in the FEMA Flood Hazard Mapping Program and has signed a Partnership Agreement with FEMA under the Cooperating Technical Partners Program.

De-Accredited Levee System – A levee system that was once shown on the FIRM as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood, but is no longer accredited with providing this flood hazard reduction because FEMA has not been provided with sufficient data and documentation to determine that the levee system continues to meet the NFIP regulatory requirements cited at 44CFR65.10. The impacted area landward of a de-accredited levee system is shown on a new FIRM as an SFHA, labeled Zone A or Zone AE, depending on the type of engineering study that was performed for the area.

Detailed Study – An engineering study that, at a minimum, results in the delineation of floodplain boundaries for the 1-percent-annual-chance flood and the determination of BFEs and/or base flood depths.

Effective Base Flood Elevations (BFEs) – The BFEs that are shown on the FIRM that is in effect for a community for flood insurance and floodplain management purposes.

Effective Date – The date on which the NFIP map for a community becomes effective and all sanctions of the NFIP apply.

Effective Map – The NFIP map issued by FEMA, usually a FIRM, that is in effect as of the date shown in the title block of the map as "Effective Date," "Revised," or "Map Revised" and is to be used by the community and others for flood insurance and floodplain management purposes.

Erosion – The process by which floodwaters lower the ground surface in an area by removing upper layers of soil.

Federal Emergency Management Agency (FEMA) – The component of the U.S. Department of Homeland Security that oversees the administration of the NFIP.

Federal Insurance and Mitigation Administration (FIMA) – The component of FEMA Headquarters that, among other responsibilities, administers the NFIP. FIMA works with partners at the Federal, State, and local level to facilitate efforts toward achieving resilience from natural hazards. FIMA works to reduce risk to life and property damage through a variety of grant programs.

FEDERAL REGISTER – The document, published daily by the Federal Government, that presents regulation changes and legal notices issued by Federal agencies.

Flood – A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters or (2) the unusual and rapid accumulation or runoff of surface waters from any source.

Flood Insurance Rate Map (FIRM) – The insurance and floodplain management map produced by FEMA that identifies, based on detailed or approximate analyses, the areas subject to flooding during a 1-percent-annual-chance flood event in a community. Flood insurance risk zones, which are used to compute actuarial flood insurance rates, also are shown. In areas studied by detailed analyses, the FIRM shows BFEs and/or base flood depths to reflect the elevations of the 1-percent-annual-chance flood. For many communities, when detailed analyses are performed, the FIRM also may show areas inundated by 0.2-percent-annual-chance flood and regulatory floodway areas.

FIRM Effective Date – The date on which the NFIP map for a community becomes effective and all sanctions of the NFIP apply.

Flood Insurance Study (FIS) Report – A document, prepared and issued by FEMA, that documents the results of the detailed flood hazard assessment performed for a community. The primary components of the FIS report are text, data tables, photographs, and Flood Profiles.

Floodplain Administrator (FPA) – The community official who is responsible for implementing and enforcing floodplain management measures and for monitoring floodplain development.

Flood Protection System – Those physical works for which funds have been authorized, appropriated, and expended and which have been constructed specifically to modify flooding in order to reduce the extent of the area subject to a “special flood hazard” and the extent of the depths of the associated flooding. These systems typically include hurricane tidal barriers, dams, reservoirs, levees, or dikes.

Floodwall – Concrete wall constructed adjacent to streams for the purpose of reducing flooding of property on the landward of the wall. Floodwalls are normally constructed in lieu of or to supplement levees where the land required for levee construction is too expensive or not available.

Floodway – See regulatory floodway.

Freeboard –The vertical distance between the top of a levee and the water level that can be expected during the 1-percent-annual-chance flood.

Geographic Information System (GIS) – A system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems.

Hazard – An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, and other types of loss or harm.

Hydraulic Analysis – An engineering analysis of a flooding source carried out to provide estimates of the elevations of floods of selected recurrence intervals**.**

Hydraulic Computer Model – A computer program that uses flood discharge values and floodplain characteristic data to simulate flow conditions and determine flood elevations.

Hydraulic Methodology – Analytical methodology used for assessing the movement and behavior of floodwaters and determining flood elevations and regulatory floodway data.

Hydrograph – A graph showing stage, flow, velocity, or other properties of water with respect to time.

Hydrologic Analysis – An engineering analysis of a flooding source carried out to establish peak flood discharges and their frequencies of occurrence.

Hydrology – The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground.

Independent Scientific Body (ISB) – An independent group composed of recognized experts and, convened by the National Institute of Building Sciences to review and provide comments on the proposed levee mapping approach developed by FEMA.

Interior Drainage – Natural or modified outflow of streams within a leveed area for the conveyance of runoff.

Interior Drainage Systems – Systems associated with levee systems that usually include storage areas, gravity outlets, pumping stations, or a combination thereof.

Letter of Final Determination (LFD) – The letter in which FEMA announces its final determination regarding the flood hazard information presented on a new or revised FIRM and FIS report, including (when appropriate) new or modified BFEs, base flood depths, SFHAs, zone designations, or regulatory floodways. By issuing the LFD, FEMA finalizes the flood hazard information, begins the adoption/compliance period, and establishes the effective date for the new or revised FIRM and FIS report.

Levee – 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 reduce flood hazards posed by temporary flooding.

Levee Breach – A rupture, break, or gap in a levee system that causes flooding in the adjacent area and whose cause has not been determined.

Leveed Area – The portion of the floodplain from which waters are excluded by a levee/floodwall.

Levee Failure Breach – A rupture, break, or gap in a levee system that causes flooding in the adjacent area and for which a cause of failure is both known and occurred without overtopping. An investigation is usually required to determine the cause.

Levee Overtopping – Floodwater levels that exceed the crest elevation of a levee system and flow into leveed areas landward of the levee system.

Levee Overtopping Breach – A rupture, break, or gap in a levee system that causes flooding in the adjacent area and whose cause is known to be a result of overtopping.

Levee Owner – A Federal or State agency, a water management or flood control district, a local community, a levee district, a nonpublic organization, or an individual considered the proprietor of a levee.

Levee Reach – Any continuous section of a levee system to which a single analysis and mapping procedure may be applied.

Levee Saturation – Soil saturation that has occurred in an earthen levee because of floodwaters remaining above flood stage for extremely long periods of time. This condition can lead to catastrophic failure of the levee.

Levee System – A flood hazard-reduction system that 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**.**

Local Levee Working Work Group – A group established by FEMA when a non-accredited levee system in a community or project area will be analyzed and the leveed areas will be mapped. The primary function of this group is to provide input on how the levee system should be modeled and how the leveed area should be mapped.

Mitigation – A sustained action taken to reduce or eliminate long-term risk to people and property from flood hazards and their effects. Mitigation distinguishes actions that have a long-term impact from those are more closely associated with preparedness for, immediate response to, and short-term recovery from specific events.

Mitigation Planning– A ***process*** for State, local, and Indian Tribal governments to identify policies, activities, and tools to implement sustained actions to reduce or eliminate long-term risk to life and property from a hazard event. The mitigation planning process has four steps: (1) organizing resources; (2) assessing risks; (3) developing a mitigation plan; and (4) implementing the plan and monitoring progress.

National Elevation Dataset (NED) – The primary elevation data product of the U.S. Geological Survey. The NED is a seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands.

National Flood Insurance Program (NFIP) – Federal Program under which floodprone areas are identified and flood insurance is made available to the owners of the property in participating communities.

Non-Accredited Levee System – A levee system that does not meet the requirements spelled out in the NFIP regulations at Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44CFR65.10), *Mapping of Areas Protected by Levee Systems*, and is not shown on a FIRM as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood.

Participating Community – Any community (including any Indian tribe, authorized tribal organization, Alaska Native village, or authorized native organization) that voluntarily elects to participate in the NFIP by adopting and enforcing floodplain management regulations that are consistent with the standards of the NFIP. The sale of flood insurance under the NFIP is authorized in a participating community.

Partnership Agreement – An agreement signed by FEMA and a community, regional entity, or State agency that wishes to participate in the FEMA Cooperating Technical Partners Program. The Partnership Agreement is a broad statement of principle, emphasizing the value of the NFIP's three components of insurance, floodplain management, and mapping.

Piping – The phenomenon where seeping water progressively erodes and washes away soil particles, leaving large voids in the soil. Removal of soil through sand boils by piping or internal erosion damages levees, their foundations, or both, which may result in settlement and has the potential to cause catastrophic failures of levees.

Ponding – The result of runoff or flows collecting in a depression that may have no outlet, subterranean outlets, rim outlets, or manmade outlets such as culverts or pumping stations. Impoundments behind manmade obstructions are included in this type of shallow flooding as long as they are not backwater from a defined channel or do not exceed 3.0 feet in depth.

Post-FIRM Structure – A structure that was built after the first FIRM was adopted for the community in which he structure is located.

Pre-FIRM Structure – A structure that was built before December 31, 1974, or before the first FIRM was adopted for the community in which he structure is located, whichever is later.

Preliminary FIRM – The NFIP map that reflects the initial results of a FEMA study/mapping or flood risk project. The Preliminary FIRM is provided to CEOs and FPAs of all affected communities before a 90-day appeal period is initiated.

Preliminary FIS Report – The report that reflects the initial results of a FEMA study/mapping or flood risk project. The Preliminary FIS report is provided to CEOs and FPAs of affected communities before the 90-day appeal period is initiated.

Procedure Memorandum (PM) – A memorandum issued by FEMA to clarify mapping-related procedures, particularly procedures documented in FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners*.

Provisionally Accredited Levee (PAL) – A designation for a levee system that FEMA has previously accredited with reducing the flood hazards associated with a 1-percent-annual-chance or greater flood on an effective FIRM, and for which FEMA is awaiting data and/or documentation that will demonstrate the levee system's compliance with the NFIP regulatory criteria cited at 44CFR65.10.

Public Sponsor – A public entity that is a legally constituted public body with full authority and capability to perform the terms of its agreement as the non-Federal partner of the U.S. Army Corps of Engineers for a project, and able to pay damages, if necessary, in the event of its failure to perform. A public sponsor may be a State, county, city, town, federally recognized Indian Tribe or tribal organization, Alaska Native Corporation, or any political subpart of a State or group of states that has the legal and financial authority and capability to provide the necessary cash contributions and lands, easements, rights-of-way, relocations, and borrow and dredged or excavated material disposal areas necessary for the project.

Regional Offices (ROs) – The FEMA offices located in Boston, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Atlanta, Georgia; Chicago, Illinois; Denton, Texas; Kansas City, Missouri; Denver, Colorado; San Francisco, California; and Bothell, Washington.

Regulatory Floodway – A floodplain management tool that is the regulatory area defined as the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the base flood discharge can be conveyed without increasing the BFEs more than a specified amount. The regulatory floodway is not an insurance rating factor.

Residual Flooding Area – The area of 1-percent-annual-chance flooding that is shown as an SFHA on a FIRM in the impacted area behind an accredited or provisionally accredited levee system; the source of residual flooding is usually local drainage or flooding from a source that is not controlled by the levee system.

Risk Mapping, Assessment, and Planning (Risk MAP) – A program developed by FEMA to leverage the successes of earlier flood map modernization efforts and further enhance the usability and value of flood hazard mapping. The Risk MAP program combines flood hazard mapping, risk assessment tools, and mitigation planning into one seamless program. The intent of this integrated program is to encourage beneficial partnerships and innovative uses of flood hazard and risk assessment data in order to maximize flood loss reduction.

Sand Boils – The volcano-like cones of sand that that are formed on the landward side of a levee system when the upward pressure of water flowing through soil pores under a levee (underseepage) exceeds the downward pressure from the weight of the soil above it.

Scientifically Incorrect Base Flood Elevations/Depths – Those BFEs and base flood depths determined through analyses in which the methodologies used and/or assumptions made are inappropriate for the physical processes being evaluated or are otherwise erroneous.

Section 65.10 Requirements – The NFIP regulatory criteria for the evaluation and mapping of areas impacted by levee systems, which are presented at Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations.

Soil Saturation – A condition in soil in which all spaces between the soil particles are filled with water. Such conditions normally occur after prolonged periods of rainfall and/or snowmelt.

Sound Reach – A reach that has been designed, constructed, and maintained to withstand, and reduce the flood hazards posed by, a 1-percent-annual-chance flood, in accordance with sound engineering practices.

Special Flood Hazard Area (SFHA) – The area delineated on a FIRM as being subject to inundation by the 1-percent-annual-chance flood. SFHAs are determined using statistical analyses of records of riverflow, storm tides, and rainfall; information obtained through consultation with a community; floodplain topographic surveys; and hydrologic and hydraulic analyses.

Stillwater Flood Elevation – The projected elevation that floodwaters would reach in the absence of waves resulting from wind or seismic effects.

Technically Incorrect Base Flood Elevations/Depths – Those BFEs and base flood depths determined through analyses in which the methodologies used have not been applied properly, are based on insufficient or poor-quality data, or do not account for the effects of physical changes that have occurred in the floodplain.

Underseepage – The upward pressure on the land behind a levee system that is exerted by groundwater, under pressure from the flooding source, when the elevation of the floodwaters is higher than the elevation of the land.

Unnumbered A Zones – Flood insurance risk zones, designated "Zone A" on an FHBM or FIRM, that are based on approximate studies.

Water-Surface Elevations (WSELs) – The heights of floods of various magnitudes and frequencies in the floodplains of coastal or riverine areas, in relation to a specified vertical datum.

Appendix C. Former Non-Accredited Levee System Evaluation and Mapping Approach

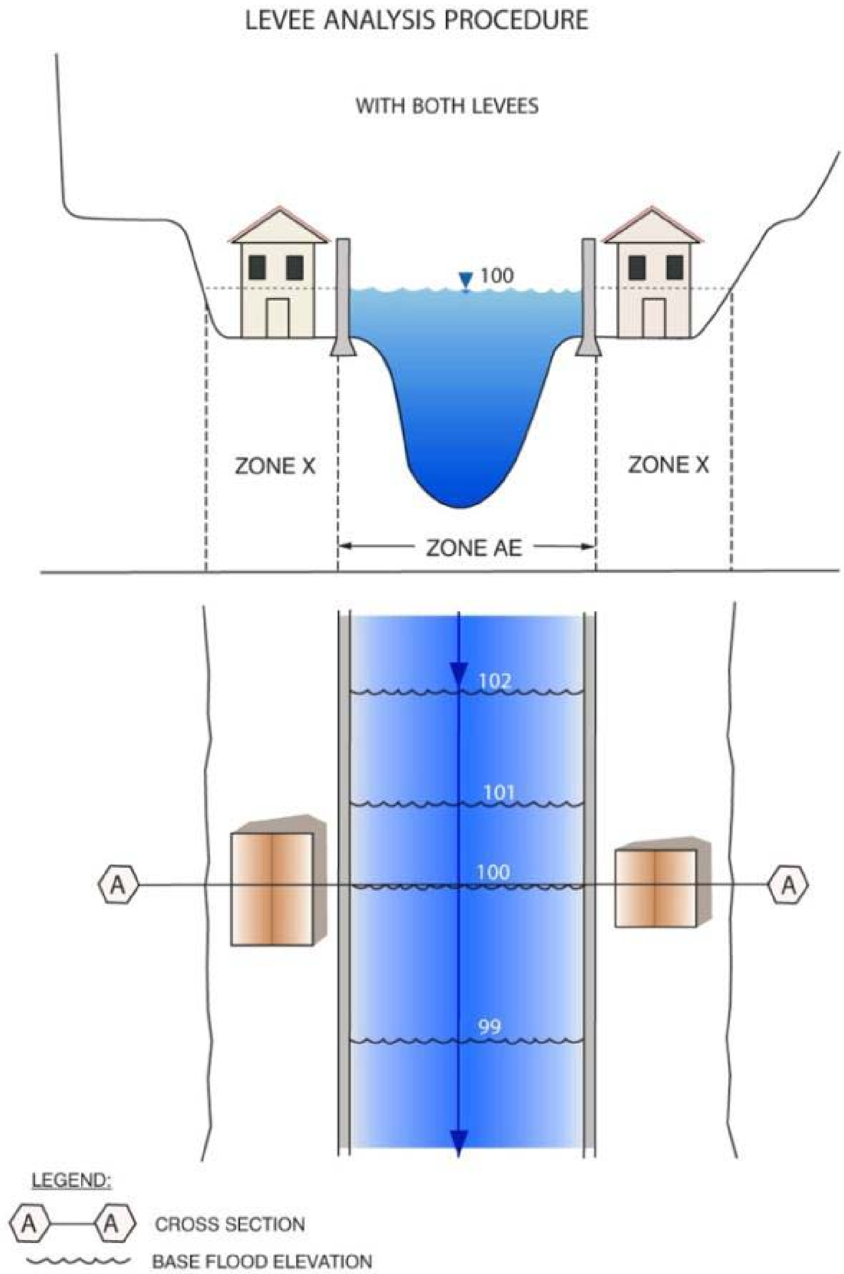
FEMA is proposing replacing the former approach to evaluating levee systems and mapping leveed areas that is specified in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners (Guidelines and Specifications* (FEMA, 2003). Under the former approach, when a levee system did not meet the National Flood Insurance Program (NFIP) requirements cited in the Code of Federal Regulations (CFR) at Title 44, Chapter 1, Section 65.10 (44CFR65.10), FEMA analyzed the flood hazards and represented the flood hazards in leveed areas on the Flood Insurance Rate Map (FIRM) as if the levee system does not exist. In these instances, the FIRM did not reflect the levee system as providing any hazard-reduction capability unless portions of the levee system satisfied the regulatory requirements of 44CFR65.10 and were hydraulically independent of the portions of the levee system that did not meet the requirements of 44CFR65.10.

Use of the former approach to evaluating and mapping areas with non-accredited levees generated considerable concern from community and Tribal officials and their representatives in the U.S. Congress. Some believe the former approach to be too broad a stroke when determining an area's flood risk. Therefore, in response to correspondence from the U.S. Congress, in March 2011, FEMA suspended the processing of all FIRMs and Flood Insurance Study reports for communities and Tribes with levee systems that could not be accredited because they did not meet the requirements of 44CFR65.10.

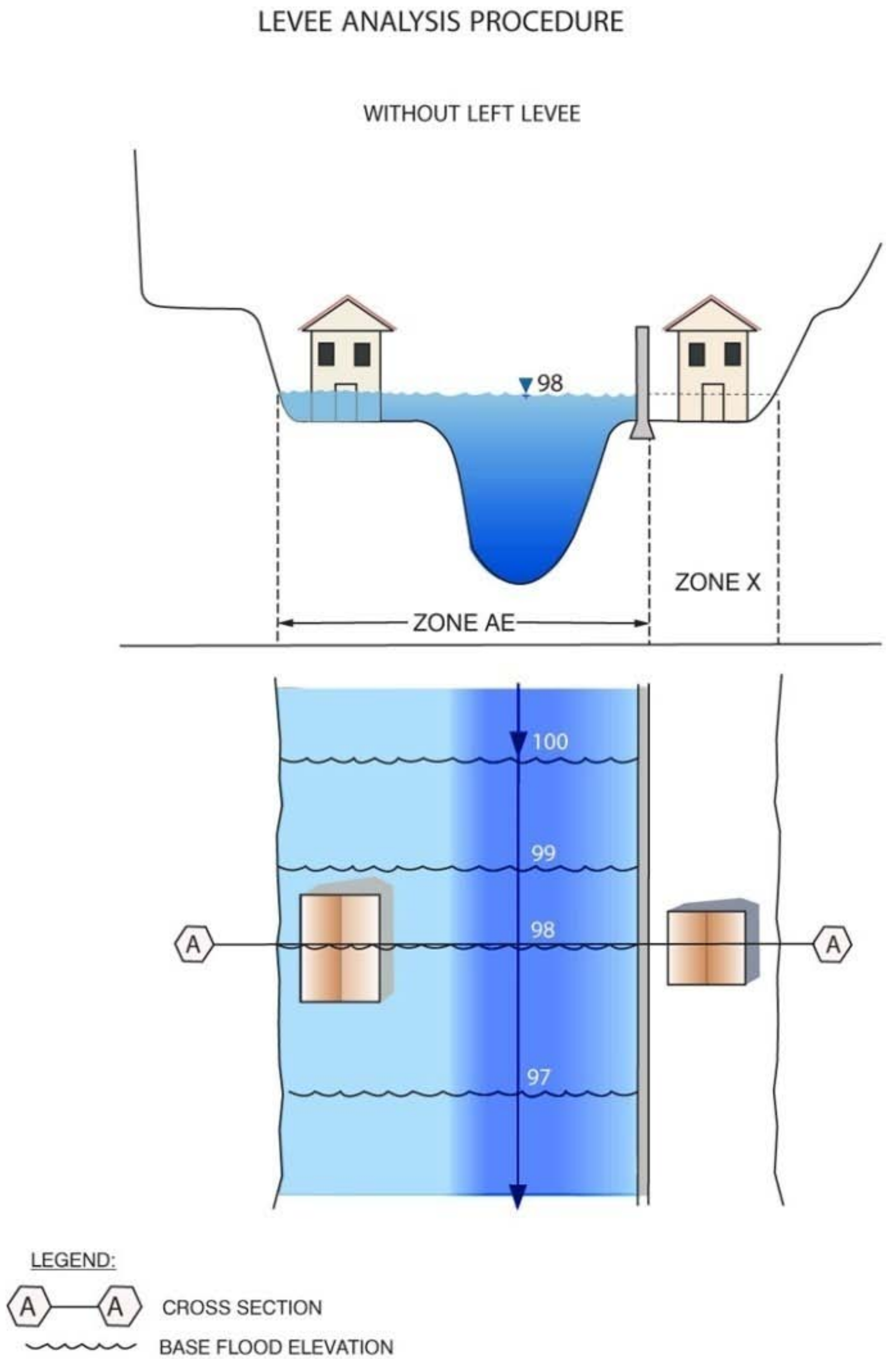
Because FEMA establishes and maps only the 1-percent-annual-chance and 0.2-percent-annual-chance floods, a non-accredited levee system can only be considered as having no hazard-reduction capability under existing policies and procedures. However, FEMA recognized that even if a levee system cannot be accredited, it may still disrupt the flow of floodwater, preventing the deepest and fastest floodwater from reaching the landward side of the levee system.

Below is a step-by-step graphical depiction of how FEMA typically mapped Base Flood Elevations (BFEs) and Special Flood Hazard Areas using the former approach when levees on both sides of a river or other flooding source could not be accredited with reducing the flood hazards posed by a 1-percent-annual-chance or greater flood.

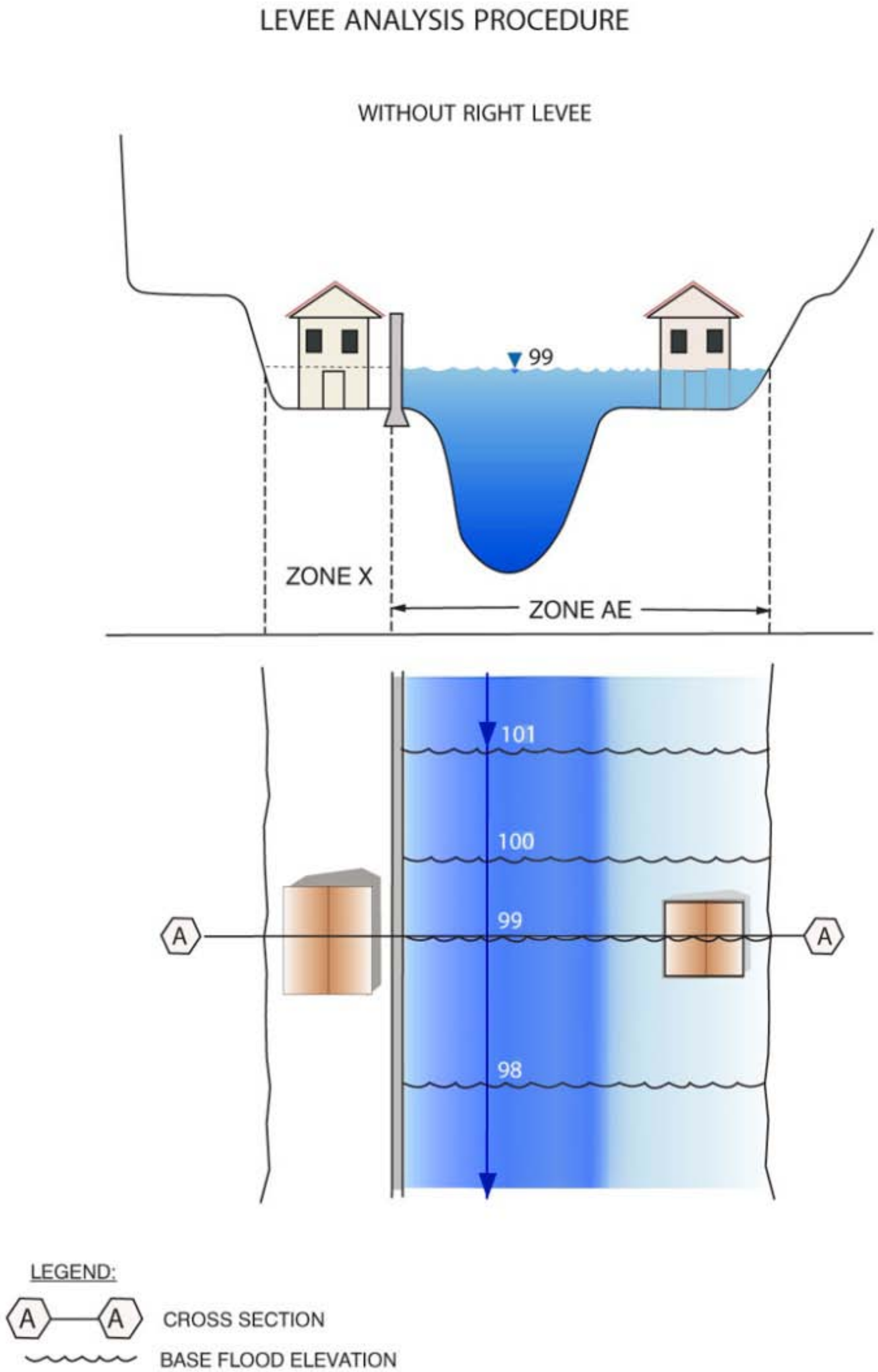
Step1: Compute the riverward BFE with both levees in place.



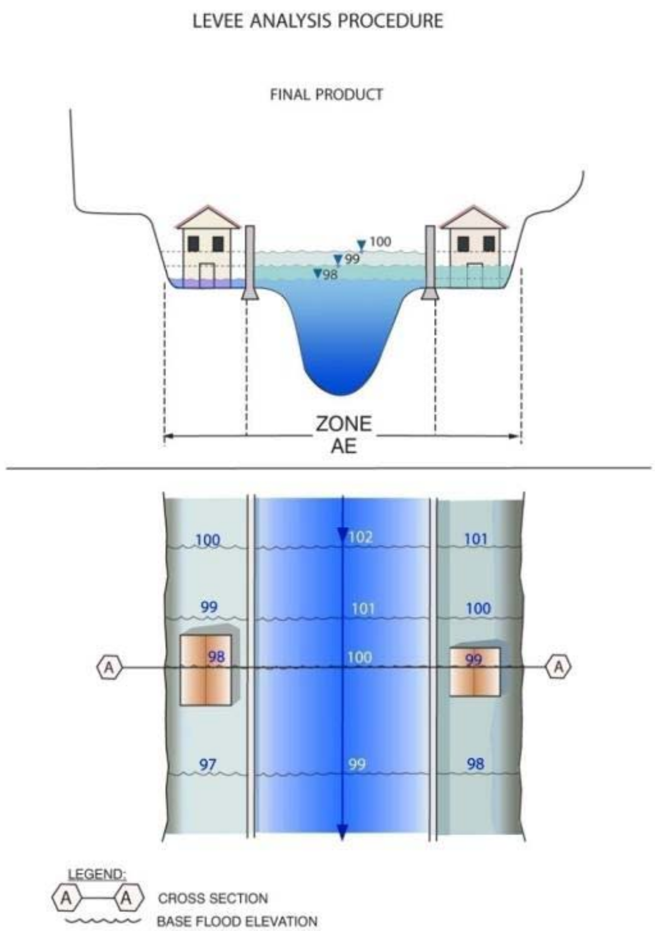
Step 2: Compute the left-side BFE by removing the levee on the left side of the river from the analysis.



Step 3: Compute the right-side BFE by removing the levee on the right side of the river from the analysis.



Step 4: Map the results of Steps 1, 2, and 3.



Appendix D. Section 65.10 of the NFIP Regulations

The National Flood Insurance Program (NFIP) regulatory criteria for the evaluation and mapping of areas protected by levee systems are presented in the Code of Federal Regulations at Title 44, Chapter 1, Section 65.10. These NFIP regulatory criteria are provided in their entirety below as they appear in the FEDERAL REGISTER.

Sec. 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 Sec. 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 Sec. 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.