Operating Guidance 12-13

Non-Accredited Levee Analysis and Mapping Guidance

September 2013

FEMA

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Operating Guidance 12-13

Operating guidance documents provide best practices for the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. These guidance documents are intended to support current FEMA standards and facilitate effective and efficient implementation of these standards. However, nothing in Operating Guidance is mandatory, other than **program and working level standards, bolded in this document,** that are defined elsewhere and reiterated in the Operating Guidance document. Alternate approaches that comply with standards that effectively and efficiently support Risk MAP program objectives and meet standard engineering practices are also acceptable.

1. Introduction

This document provides guidance to Federal Emergency Management Agency (FEMA) Regional Office staff, contractors, and Cooperating Technical Partners (CTPs) that perform Flood Risk Projects where non-accredited levee systems have been identified. The FEMA, contractor, and CTP staff involved in these "non-accredited levee projects" are hereinafter referred to as "Project Teams." An overview of the process described in this document is shown in Figure 1 on page 6.

Section 59.1, Definitions, of the National Flood Insurance Program (NFIP) regulations (44CFR59.1) includes several definitions applicable to this document. The definitions of these terms are provided below.

> **Flood Protection System** – Those physical structural 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. Such a system typically includes hurricane tidal barriers, dams, reservoirs, levees, or dikes. These specialized flood-modifying works are those constructed in conformance with sound engineering standards.
>
> **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 provide protection from temporary flooding.
>
> **Levee System** – A flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices**.**

Other terms that are used throughout this document and are not defined at 44CFR59.1 are defined below.

> **Non-Accredited Levee System -** A levee system that has not been shown to meet the requirements outlined in 44CFR65.10 and is not shown on a Flood Insurance Rate Map (FIRM) as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood.
>
> **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.
>
> **Levee Reach -** A continuous section of a levee system to which a single analysis and mapping procedure may be applied.

Unless specified, the procedures in this document use the term "levee" to be inclusive of both levees and floodwalls that reduce the risk of flooding from inland or coastal flooding sources.

2. System Identification

Accreditation for the purposes of a FIRM can only be applied to an independent levee system. If a portion of the system cannot be accredited, then the entire system is considered non-accredited. To be accredited, **levee systems must be hydraulically independent whereby if one system fails, the area behind another system is not inundated.**

3. Non-Accredited Levee Identification

When a Flood Risk Project is initiated and the Project Team identifies a levee system, the Project Team must determine whether the identified levee system is subject to the procedures described in this Operating Guidance. **A structure shall only be considered a levee when it can be demonstrated that the structure was designed and has been operated and maintained as a levee. Structures that cannot meet these requirements cannot be considered for accreditation under 44 CFR 65.10.** FEMA verifies whether a structure meets this definition of a levee by coordinating with community official and levee owners, and by reviewing available levee data and documentation.

This process for non-accredited levee systems will not be applied to non-levee embankments, levees that are not hydraulically significant, or coastal structures that protect areas below sea level from permanent flooding. The technical procedures described in Section 11 may be used for these structures, but the process as a whole is not applicable. For mapping purposes, a structure is considered hydraulically insignificant if, during a 1-percent –annual-chance flood event, the peak water-surface elevations landward of the structure may be the same regardless of whether the structure was in place.

For coastal structures such as seawalls, revetments, and bulkheads, the U.S. Army Corps of Engineers (USACE) Coastal Engineering Research Center (CERC) prepared Technical Report CERC-89-15, *Criteria for Evaluating Coastal Flood Protection Structures*, in December 1989. Coastal structures primarily are designed to reduce the impacts of waves, while levees are generally designed to prevent a certain frequency of floodwater from advancing inland.

4. Other Considerations

The subsections below provide information regarding the submission of data through the Letter of Map Revision (LOMR) process, coastal considerations, tribal considerations, expiring Provisional Accredited Levee (PAL) system designations, projects involving multiple levee systems, and projects involving levee systems that are in the process of being restored.

4.1. Submission of Data through the Letter of Map Revision Process

A LOMR shall not be used to revise a community's FIRM panels to reflect a de-accredited or non-accredited levee system. If technical data are submitted in support of a map revision through the LOMR process, FEMA will review those data and then process the request as a Physical Map Revision (PMR). This will ensure that all stakeholders are included in the map revision process.

4.2. Coastal Considerations

Flood Risk Projects involving non-accredited levee systems in coastal areas may have a longer timeline for completion than a "typical" levee-related Flood Risk project in riverine or lacustrine settings. FEMA guidance for the RiskMAP Discovery process outlines the extended timeline for pre-Discovery and Discovery efforts related to coastal Flood Risk Projects; the levee data collection and stakeholder engagement effort may follow a similar extended timeline. It may be necessary to assess and discuss the transition zones between coastal and riverine levees. Additional information regarding coastal considerations is provided in the discussion of each of the technical procedures in Section 11.

4.3. Tribal Considerations

When Tribal lands of federally recognized Tribes are included in the areas impacted by a non-accredited levee system, the FEMA Regional Tribal Liaison and designated Risk Analysis (RA) and Floodplain Management and Insurance (FMI) Branch staff members are to consult with affected Tribal Nations. The assigned FEMA Regional Office staff will consult with the affected Tribal Nations regarding their desire to be included in other, non-tribal community engagement efforts or if separate, Tribal Nation-specific meetings would be more appropriate. Tribal Nations are welcome to attend and participate in both non-Tribal and Tribal Nation-specific meetings. Meeting participation will depend in part on the established working relationships between the Regional Office staff and Tribal officials.

Unless specific arrangements have been made to authorize other Project Team members to contact and coordinate directly with Tribal officials, only the FEMA Regional Tribal Liaison and designated RA and FMI Branch staff members are to work directly with Tribal officials. When these special arrangements are made, the assigned Project Team member(s) are to distribute copies of written correspondence exchanges with Tribal officials as well as records of any telephone conversations that may occur in accordance with requirements established by FEMA Regional Tribal Liaison and designated RA and FMI Branch staff members.

For the remainder of this document, when the term "communities" is used, it includes Tribal Nations as appropriate.

4.4. Expiring Provisionally Accredited Levee Designations

Because extensive coordination may have been performed as part of the PAL process, some outreach and data collection steps may not be required for levee systems where PAL designations are expiring. Where outreach and data collection are necessary, Project Teams are to perform these tasks in conjunction with the remaining parts of the PAL process. For example, the Stakeholder Coordination and Data Collection Meeting discussed in Subsection 5.3 may be combined with a meeting held to discuss the levee system where the PAL designation is expiring. FEMA Regional Office staff will make this determination through coordination with other Project Team members.

4.5. Projects Involving Multiple Levee Systems

If there are levee systems on both sides of a flooding source, or multiple systems that overlap, the extents of the natural valley area and reach specific Special Flood Hazard Areas (SFHAs) for each system will be analyzed independently assuming the other systems remain in place.

4.6. Levee Restoration and Adequate Progress

Situations may occur where FEMA determines, through coordination with community officials, levee owners, and/or other Federal agencies (OFAs), that a restoration (44CFR65.14) or adequate progress (44CFR61.12) project for the levee system is underway. In these instances, levee reaches are not used. Rather, the regulatory requirements provided in 44CFR61.12 for new construction projects that have made adequate progress toward completion or the regulatory requirements provided in 44CFR65.14 for de-certified levee systems that are being restored to provide 1-percent-annual-chance flood event design, or greater, would apply. Section 100230 of the Biggert-Waters Flood Insurance Reform Act of 2012 (Public Law 112-141) provides additional guidance on reconstruction or improvement of flood protection systems.

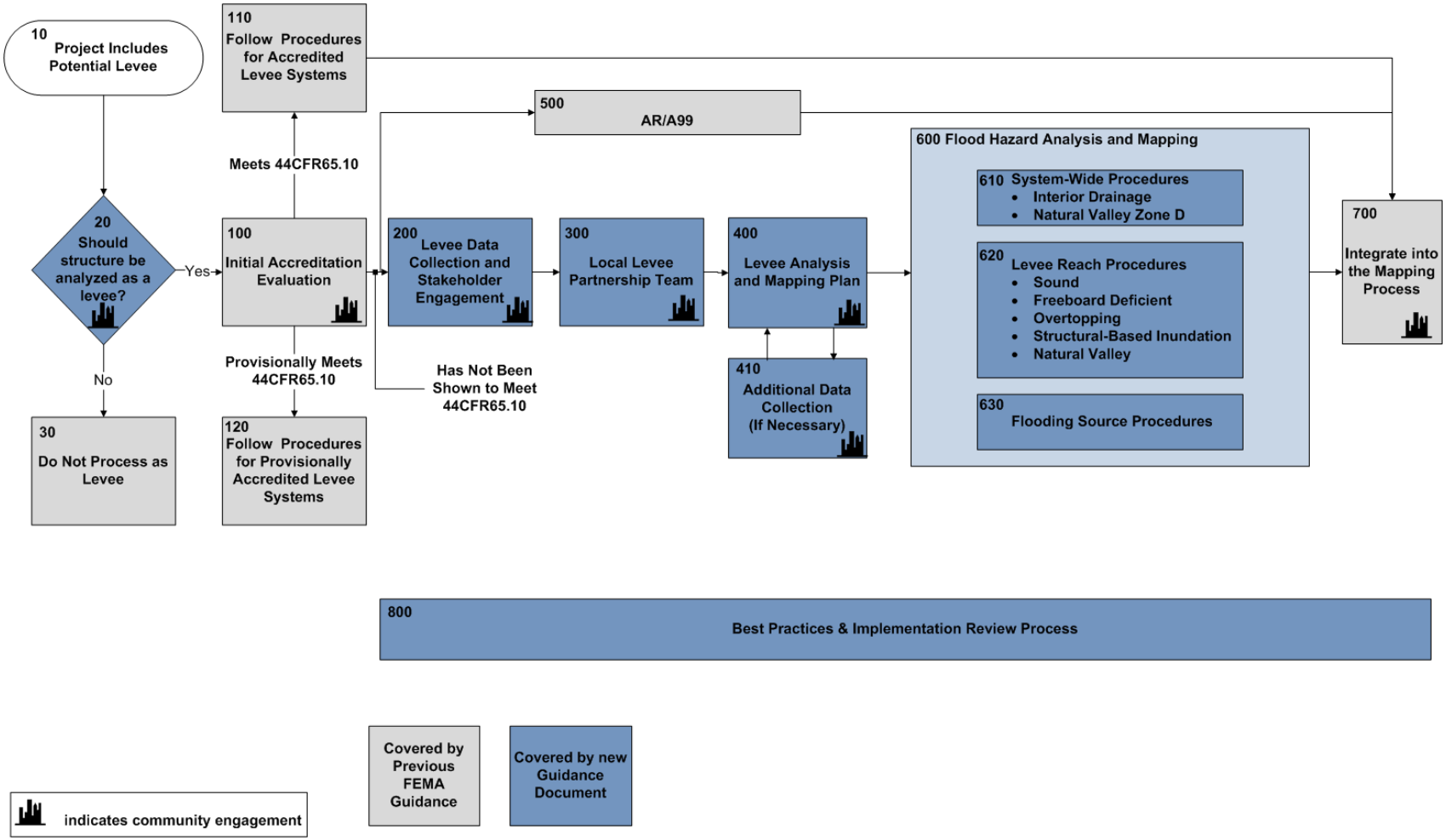

Figure 1 - Levee Analysis and Mapping Process

5. Levee Data Collection and Stakeholder Engagement (Figure 1, Element 200)

The first goal of the levee data collection and stakeholder engagement phase is to ensure stakeholders have an understanding of the new levee analysis and mapping process. The second goal is to assure that the Project Team has a comprehensive understanding of the levee system(s) in project areas so that informed decisions may be made by FEMA regarding the procedures to be used to model and map flood hazards for non-accredited levee systems. FEMA will provide tools and templates (e.g., meeting invitations, announcements, agendas) for use by Project Team members in conducting required and recommended meetings.

The FEMA Regional Office staff are to plan, and budget for, stakeholder coordination, data collection, and establishment of a Local Levee Partnership Team (LLPT) for all Flood Risk Projects involving non-accredited levee systems. Each step is discussed further later in this document. If little or no data are available, or if the Natural Valley Procedure discussed in Subsection 11.5 is preferred by the affected communities and that preference is documented, the scope may be limited. This stakeholder coordination step should typically occur during the Discovery process for the watershed that is the focus of the Flood Risk Project.

The levee data collection and stakeholder engagement process is shown in Figure 2 and discussed in more detail in Subsections 5.1 through 5.4.

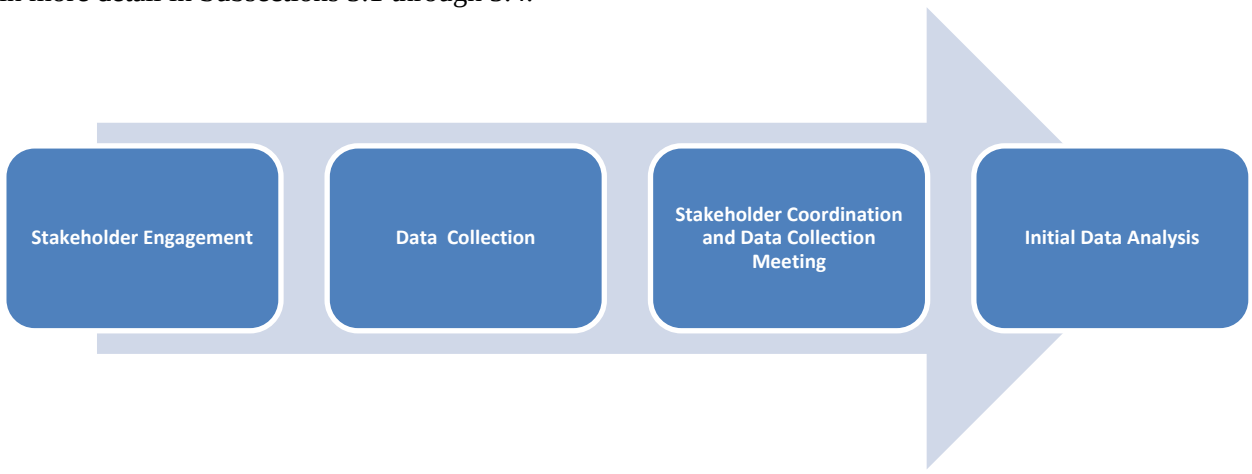

Figure 2 - Levee Data Collection and Stakeholder Engagement Process

5.1. Stakeholder Engagement

The FEMA Regional Office staff must engage impacted communities and levee owners/operators during the stakeholder engagement process. The purpose of this initial engagement is twofold: (1) to discuss the levee analysis and mapping process and (2) to collect initial community/levee-related information and data to help streamline and facilitate future meetings. This upfront

coordination may take the form of conference calls, Web-enabled meetings, or other means of two-way communication.

For Flood Risk Projects involving non-accredited levee systems, the Project Teams will need to engage with a different array of community, county, regional, and State officials and other stakeholders than may be engaged for Flood Risk Projects that do not involve such systems. The stakeholders to be engaged include, but are not limited to, the following:

- Community and State emergency management officials;
- Levee owners/operators;
- Officials from communities upstream of, downstream of, and across the flooding source from the levee system;
- State or regional groups with a vested interest in water resources, such as levee boards, conservation districts, and watershed/river basin commissions;
- Dam safety officials;
- Members of Tribal communities, as defined through consultation and coordination with Tribal Officials;
- Geographic Information System (GIS) managers and specialists, community and regional planners, and county land use departments;
- Representatives of district offices of OFAs with responsibility for levee systems in the project area, including USACE District Offices;
- Economic development and commerce representatives; and
- Members of the local engineering community.

5.2. Data Collection

Collecting data and information early in the process will help FEMA facilitate and encourage substantive discussion during the LLPT meetings. Data collection efforts may vary based on the uniqueness of the levee system. Levee owners may choose to perform additional data collection activities, but must do so at their own expense. FEMA will work with various stakeholders as appropriate in an effort to obtain supporting data and documentation.

Depending on the complexity of the levee system, data collected may include (if available and applicable), but are not be limited to, the following:

- Design reports/memorandums;
- Construction documentation reports/memorandums, specifications, or plans;
- Post-construction plans and specifications (e.g., bridges, roads, utility construction that occurred since levee construction);
- Survey data;
- Geotechnical reports;
- Structural analyses;
- Interior drainage analyses;

- Operations and Maintenance plans;
- Inspection reports;
- Historical news articles or data regarding levee breaches and flood fighting efforts and levee distress;
- USACE National Levee Database (NLD) data, Levee Screening, or Risk Assessment Reports;
- Flood records and streamflow data;
- Current orthophotography and topographic data;
- Related data from the FEMA Mapping Information Platform (MIP), the FEMA Library, and other FEMA archives/databases;
- Building footprint/parcel data;
- Master drainage plans and/or flood modeling; and
- PAL or accreditation review documentation.

If the levee is included in the NLD, Project Team members are to use the NLD as a first resource. The data and information collected will help FEMA and the levee stakeholders develop an approach for modeling and mapping the flood hazard in areas landward of non-accredited levees.

Typically, the FEMA Regional Office will make the initial contact with district offices of OFAs to obtain data and information regarding levees. The Regional Office will determine the appropriateness of followup contacts with OFAs by other Project Team members. Data and information collection efforts may also vary based on the potential uniqueness of each area landward of a levee system. The FEMA Regional Office and other Project Team members will work with various stakeholders in these areas in an effort to obtain the best available supporting data, information, and documentation. Levee owners may choose to perform additional data and information collection activities, but must do so at their own expense.

During this phase, the Project Team should develop and maintain a distribution list for disseminating information to all stakeholders involved in the process.

5.3. Stakeholder Coordination and Data Collection Meeting

5.3.1. Meeting Objectives

The overarching objectives of the Stakeholder Coordination and Data Collection Meeting are (1) to introduce stakeholders to each other and (2) to discuss areas of flood risk, available data, and the FEMA process for analyzing and mapping flood hazards landward of non-accredited levees. To accomplish these objectives, the Project Team performed the upfront research and data and information collection activities described in Subsection 5.2. This first meeting is a working meeting, so it is important that attendees are prepared to contribute and that the meeting facilitator and other Project Team members encourage participation.

A comprehensive list of the meeting objectives is included below. It may not be possible to cover all of these objectives at every meeting. However, this list includes the array of topics that may be discussed depending on the levee system.

- Introduce the Project Team to the community officials, Tribal officials, and other stakeholders with areas of influence within the areas potentially impacted by a new levee analysis and mapping project.
- Emphasize that the goal of the levee analysis and mapping project is to apply the technical procedure that best reflects the flood hazard in the area landward of the levee based on available resources, data, and community needs.
- Review available data on the levee system, confirm whether the data are accurate, and obtain stakeholders' perspectives about their flood hazards. This will help determine the appropriate procedure for modeling the levee system.
- Emphasize the importance of the stakeholders' responsibility in providing necessary data and keeping the public informed of flood hazards and the relevance of those hazards.
- Discuss floodplain management and flood insurance implications of the use of Zone D as the flood hazard designation on the FIRM.
- Discuss potential members of an LLPT (See Section 6).

5.3.2. Meeting Timing

The Project Team is to hold the Stakeholder Coordination and Data Collection Meeting after Project Team members have collected available data and information and have had initial discussions with identified stakeholders. The Project Team will plan the Stakeholder Coordination and Data Collection Meeting in coordination with the affected community officials, Tribal officials, and levee owner(s).

5.3.3. Meeting Attendees

All stakeholders contacted by the Project Team during the levee data collection and stakeholder engagement process are to be invited to the Stakeholder Coordination and Data Collection Meeting. It may not be possible for all stakeholders to attend all meetings. However, their input is important, and Project Team members should attempt to coordinate with these stakeholders in advance of the meeting if their attendance is not feasible or to arrange for remote participation when necessary. Additionally, it is important that Project Team members ask stakeholders for suggestions of other stakeholders who should be included in the meetings. Project Team members must follow up on meeting outcomes and actions with those stakeholders who are not able to attend in person or remotely.

5.3.4. Meeting Messages

Messages that are to be emphasized during the Stakeholder Coordination and Data Collection Meeting include the following:

- 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.

- It is important for community officials to keep the public informed of flood hazards and associated risks and the relevance of those risks, and identifying the public as a stakeholder in the process.
- Some risk of flooding will always exist landward of levees.
- "Living with Levees – It's a Shared Responsibility."

5.3.5. Pre-Meeting Activities

Meeting-related actions and materials that the Project Team must compile before the Stakeholder Coordination and Data Collection Meeting include, but are not limited to, the following:

- Coordinate with stakeholders upfront to obtain data; understand the levee system being evaluated and its history; and to learn about a community's or Tribe's resources, assets, future plans, vision, etc.
- Confirm best available data (including the timing of such data) and discuss data-sharing agreements.
- Prepare talking points to discuss the levee system, the levee analysis and mapping approach, and the project lifecycle.
- Prepare NFIP compliance/adoption information as appropriate.
- Arrange for a field reconnaissance visit during the Stakeholder Coordination and Data Collection Meeting if appropriate.
- Prepare and distribute a meeting invitation, meeting agenda appropriate for the levee system, and map for discussion purposes.

Designated FEMA Regional Office staff will identify any additional items that may be needed when Tribal Nations are affected through consultation and coordination with Tribal Officials.

5.3.6. Meeting Activities

Stakeholder Coordination and Data Collection Meeting activities include, but are not limited to, the following:

- An interactive, collaborative discussion. Project Team members should facilitate discussions between community officials and other stakeholders, offer suggestions, and manage the time.
- Review of available data. A map providing a system-wide view of available data gathered to date should be available in GIS format. The GIS format allows a Project Team member to zoom in and out to specific, targeted areas for discussion purposes during the meeting.
- Identification of gaps in data collected. Project Team members should work with meeting participants to identify data gaps that need to be filled and formulate a reasonable plan, or alternatives, to fill the gaps especially if filling the gap is critical to project completion.
- Discussion of the procedures for analyzing and mapping the levee system(s) that are the focus of the project. Project Team members should present the information in a logical way that illustrates the levee system(s) and the currently available and potentially available

data. This will allow the majority of the meeting time to be focused on gaining a better understanding of the next steps for all participants.

5.3.7. Field Reconnaissance

In some instances, the Project Team may participate in a field reconnaissance of the levee system after the Stakeholder Coordination and Data Collection Meeting. The FEMA Regional Office will decide the type and level of field reconnaissance based on project needs and available resources.

Field reconnaissance generally is recommended along reaches where the Overtopping Procedure (see Subsection 11.3) or the Structural-Based Inundation Procedure (see Subsection 11.4) could potentially be used to model and map a levee reach. The field reconnaissance effort may be a drive along the levee system or a walk on top of the levee system to view areas of interest. The Project Team should document the field reconnaissance using notes, markups, sketches, and/or photographs.

The field reconnaissance is not an inspection or an attempt by the Project Team to make technical conclusions on the quality, substance, or performance of the levee system. The primary purpose of the field reconnaissance is to gain a better understanding of the levee system to reflect the flood hazard information on the FIRM in areas landward of the levee system. FEMA analyses for flood hazard mapping do not predict or guarantee the performance, reliability, or overall safety of a levee system and are used only to identify the flood hazards landward of the levee system.

5.4. Initial Levee Data Analysis

The Project Team will analyze the collected data, information, and documentation to prepare for the LLPT Meeting(s). By performing this data analysis, the Project Team will be better prepared for specific discussions with the LLPT members about levee system history, characteristics, modeling procedures available, flood hazards, flood hazard communications, and outreach. The FEMA Regional Office staff will determine the appropriate level of effort for this activity; the level of effort should be commensurate with the level of risk to the community, the complexity of the levee system, and the available data. Three main efforts may occur during this step.

First, the Project Team will analyze currently available and potentially available data to determine what reach-specific procedures could potentially be applied to the levee system(s) being analyzed. For example, if data to meet the structural requirements is not available and not expected to be available, the LLPT Meeting discussion should be focused on both the Natural Valley and Structural-Based Procedures.

Second, the Project Team should conduct an analysis to determine baseline estimates and expected ranges of the SFHA extent and depth. This will usually include a Natural Valley analysis, evaluation of levee crest elevations, or the use of previously developed preliminary flood hazard zone boundaries. A rough analysis using the Structural-Based Inundation Procedure may be included as well. The Project Team 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.

As part of this initial Natural Valley analysis, the Project Team will develop 1-percent-annual-chance flood elevations by using the effective analysis or preparing an approximate analysis that applies the effective or a proposed flood discharge with an approximate level hydraulic model or by extending the effective Base Flood Elevations (BFEs) landward of the levee. In most situations, extending BFEs landward of the levee represents a worst-case scenario for defining the limits of the SFHA. The Project Team will develop water-surface elevations for discussion purposes only and will clearly inform the LLPT members that the final BFEs and SFHA delineations that will be shown on the FIRM may not match the results of this initial data analysis.

To show the results of this analysis, the Project Team will select depth profile locations to communicate the variability resulting from the various procedures as shown in Figure 3. For example, in Figure 3, the initial data analysis indicates that no single approach results in the shallowest depths landward of the levee. At the upstream end, the red area is the area where a Natural Valley analysis results in the deepest depths. In the central part of the levee (yellow area), however, the Natural Valley analysis results in the lowest depths and instead the Structural-Based Inundation Analysis results in the deepest depths. This initial analysis will provide the LLPT with an early indication of what the results from various types of analyses might provide.

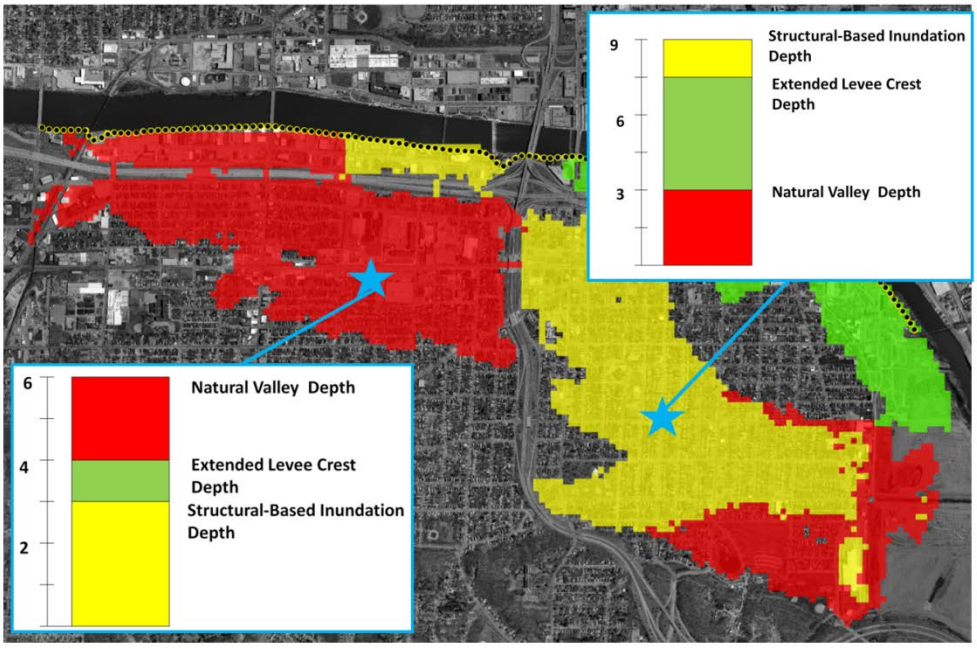

Figure 3 – Sample of Potential Inundation Extents

Third, the USACE Levee Screening Tool can be a useful tool to run during this Initial Data Analysis step. This USACE tool combines inspection data with a preliminary engineering

assessment. The tool helps users to understand the level of risk behind the levee system and thereby suggests an appropriate analytical approach to employ. The tool may also provide a way for FEMA to develop a more comprehensive understanding of risk landward of non-accredited levees at the national level.

The Project Team will present the results through maps and a draft report summarizing the methods used and results. The Project Team will use the draft maps and draft report to aid discussions with the LLPT regarding the available data and the range of potential outcomes. FEMA will provide templates for the draft maps and report.

6. Local Levee Partnership Team (Figure 1, Element 300)

6.1. Introduction and Mission

The new levee analysis and mapping process includes an interactive coordination effort with stakeholders, especially the key stakeholders that are invited to participate in the LLPT. **An LLPT must be established with participation of diverse stakeholders based on the complexity and scope of the levee system under evaluation. The options discussed by the LLPT members and FEMA's decisions regarding the appropriate analysis and mapping procedures to be used, must be documented and made available to stakeholders.** Participants in the LLPT will vary, depending on the scope and complexity of the levee system that is being analyzed and mapped.

The primary function of the LLPT will be to provide feedback and, if necessary, additional data, information, or documentation. The FEMA Regional Office representative's role as the facilitator of the LLPT will be to present results of the initial (and any subsequent) levee data analysis, solicit and consider input from other LLPT members, and make the final decision on the technical procedures to be applied to effectively analyze and map the flood hazards in the area landward of the levee.

The LLPT may meet and/or coordinate more than one time. The FEMA Regional Office representative, in consultation with the other LLPT members, will determine the number and format for these meetings and coordination activities.

6.2. Transparency

The LLPT membership and activities must be transparent. To maintain this transparency, the LLPT must create an attendance sheet documenting invitees and members attending meetings (in person, by telephone, or via the Internet). In addition, the Project Team must prepare meeting minutes that document important discussions, action items, and decisions made by FEMA. These documents will be made available to stakeholders by mail, e-mail, or postings to publicly accessible websites.

6.3. Membership

As discussed in Section 5, the formation of the LLPT will begin during the levee stakeholder coordination and data collection process. During the Stakeholder Coordination and Data Collection Meeting, the FEMA Regional Office will explain the need for the LLPT and the types of individuals who could be members. A representative from the FEMA Regional Office must always be a member of the LLPT but may not always attend meetings in person.

Once established, FEMA will provide outreach and training materials to enhance the ability of the LLPT members to meet their objectives successfully. For most projects, LLPT members will be a subset of those stakeholders that participated in the Stakeholder Coordination and Data Collection Meeting.

At minimum, all communities affected by flooding related to how the levee is analyzed and mapped will be provided the opportunity to have a participating member on the LLPT. In addition, levee owners (if a community does not own the levee in question) will also have an opportunity to participate.

The following are the types of groups and individuals that could be invited to participate in the LLPT:

- Community Chief Executive Officer (CEO) or designee (individual with decision-making authority, if not the CEO);
- Community floodplain administrator (FPA);
- State NFIP Coordinator;
- Levee owner (if levee is not owned by a community);
- CEO or designee of participating Tribe (individual with decision-making authority);
- Local engineer/technical representative invited by the community;
- FEMA Regional Office representative;
- Representatives of OFA district offices that could provide additional input;
- Other Project Team members.(i.e., CTPs, FEMA contractors); and
- Others as determined jointly by the community and FEMA Regional Office representative.

6.4. Roles and Responsibilities

FEMA Regional Office staff will have the responsibility for coordinating with the LLPT, obtaining LLPT members' input, and making final decisions on the way to analyze and map the flood hazards in the areas landward of the levee system. This responsibility will include the determination of how reaches of the levee system are analyzed and mapped.

The Project Team will perform the levee analyses and mapping activities as directed by the FEMA Regional Office representative. This may include preparing the initial data analysis, as well as developing intermediate non-regulatory products.

As previously stated, the non-FEMA LLPT members' primary role is to provide data and input to FEMA, including commenting on the creation of levee reaches and the procedures to be used for analyzing and mapping the reaches based on local levee conditions.

In some circumstances, State agencies other than the State agency represented by the State NFIP Coordinator may be an active participant in the LLPT. Their roles will vary based on the specific agency's mission and relationship to the impacted communities and levee owners.

In many situations, a USACE District Office will have a history of providing support to impacted communities and levee owners. FEMA Regional Office staff should coordinate with USACE District Office staff before establishing the LLPT to discuss what role USACE District Office(s) will assume on the LLPT. Likewise, FEMA Regional Offices will coordinate with OFAs other than USACE in determining their role when it is appropriate for them to participate.

7. Local Levee Partnership Team Meetings

7.1. Meeting Objectives

In addition to the general Risk MAP objectives, the LLPT has the following specific objectives:

- Provide all members the opportunity to explain the unique conditions that will influence the analysis and mapping associated with the non-accredited levee system;
- Allow for discussion on information and data obtained, and results of any analyses presented;
- Allow for comment on methods for levee reaches, analyses, and mapping within the allowable guidelines; and
- Develop, if necessary, a reasonable schedule for obtaining input or additional data.

7.2. Meeting Timing and Format

Depending on the complexity of the levee system under consideration, more than one LLPT Meeting may be necessary. The initial LLPT Meeting will take place after the stakeholder coordination, data collection, and initial data analysis have taken place. As discussed in Subsection 5.4, FEMA and other Project Team members will use the initial data analysis to help explain alternatives to the LLPT members and get their input.

In many instances, at least an initial field reconnaissance will have already occurred. However, as discussed in Subsection 5.3.7, this reconnaissance activity could follow the LLPT Meeting, depending on the local situation.

The LLPT Meetings may be held in-person, via conference call, or via the Internet. Decisions regarding where and when to hold meetings will be based on the local logistical situation, availability of members, and the complexity of the levee system being evaluated.

7.3. Meeting Attendees

The FEMA Regional Office representative is to assure that all LLPT members are invited to all LLPT Meetings. (See Subsection 6.3 for a list of potential LLPT participants).

7.4. Meeting Messages

The message continues to be "Living with levees – It's a shared responsibility." The specific message to the LLPT is that FEMA recognizes that there are unique local levee conditions, and the FEMA Regional Office representative will work with the other LLPT members and use local data and input. An additional message is that, while FEMA has the final decision-making authority on how the flood hazards landward of the non-accredited levee system will be analyzed and mapped, the process for reaching that decision will emphasize an interactive exchange of information and ideas among the LLPT members.

7.5. Pre-Meeting Activities

The following activities will occur before the first LLPT Meeting:

- The FEMA Regional Office representative will send an invitation to the first LLPT Meeting (and all subsequent meetings) to each LLPT member.
- The FEMA Regional Office representative will provide LLPT members with introductory briefings and training materials on the new procedures for analyzing and mapping non-accredited levees.
- The Project Team will conduct an initial data analysis, discussed in Subsection 5.4, to provide an overview of alternative approaches for various levee reaches. This could include any draft maps or other results that would be helpful to communicate the impact of different approaches.
- The Project Team will develop a summary of data and information obtained during the data collection and reconnaissance efforts.

7.6. Meeting Activities

During the LLPT Meeting(s), the FEMA Regional Office representative will:

- Explain the LLPT Meeting objectives and the need for transparency.
- Inform the LLPT members that meeting minutes to document who attended and what happened at the meeting will be produced and made available to other stakeholders.
- Provide a summary of the background of the Flood Risk Project.
- Provide a summary of the levee analysis and mapping process.
- Answer any questions about the levee analysis and mapping process and the briefing and training information previously provided.
- Summarize the following information:
  - Meeting messages;
  - Results from the data collection efforts;

- Results from the initial data analysis, including any draft map and USACE Levee Screening Tool results; and
- Possible alternative approaches for analyzing and mapping flood hazards landward of the levee(s).

8. Levee Analysis and Mapping Plan (Figure 1, Element 400)

Once the LLPT has completed its deliberations, the Project Team will produce a Levee Analysis and Mapping Plan. The Plan will include sections covering the following:

- Copies of the data developed, including agendas, meeting minutes, attendance sheets, and correspondence;
- Summary of the data and information collected, when they were received, type, and source;
- Summary of data and information FEMA expects to receive from stakeholders, including the recommended timeframe for delivery; and
- Flood hazard analysis and mapping options based on data that are already available and timeframe for when data to be collected by stakeholders is to be provided to FEMA.

In addition to the Levee Analysis and Mapping Plan, FEMA may catalogue the data and information collected in the database structure used for the NLD if data collected during this phase came from sources other than the NLD. FEMA will provide the final version of the Levee Analysis and Mapping Plan and database to the levee stakeholders with whom FEMA coordinated during the data collection and stakeholder engagement process, including all LLPT members.

9. Additional Data Collection (Figure 1, Element 410)

As previously noted, in some cases the Levee Analysis and Mapping Plan may include a summary of data FEMA expects to receive from stakeholders that may affect the reach approaches used and the recommended timeframe for delivery of the additional data. The timeframe for the community providing additional data will depend on many factors, including:

- Whether the levee system was previously provisionally accredited;
- Type of data being collected;
- Planned project schedule if the levee is part of a larger watershed or countywide Flood Risk Project;
- Contractual timeframes between the FEMA Regional Office and other Project Team members (i.e., CTPs, FEMA contractors); and
- Size and complexity of the levee system.

Table 1 presents suggested ranges of timeframes for supplying additional data. Because the appropriate timeframe for supplying additional data will depend on many factors, the chosen timeframe should fit the actual project conditions, but should generally not exceed the upper limits of the listed ranges.

Table 1 – Timeframe for Additional Data

	Timeframe Range	
Data Type	**Previous PAL**	**No Previous PAL**
Elevation Information for the Levee Crest and Toe	up to 2 months	up to 6 months
Operations and Maintenance Plan	up to 3 months	up to 3 months
Structural Design Requirements	up to 6 months	up to 18 months
Inspection Reports	up to 2 months	up to 2 months
Evaluation of Overtopping Erosion Potential	up to 18 months	up to 18 months

10. System-Wide Analysis and Mapping Procedures (Figure 1, Element 610)

10.1. Interior Drainage Analysis

For non-accredited levee systems, the Project Team will evaluate the adequacy of the interior drainage systems and map an SFHA for the 1-percent-annual-chance flood where applicable. Interior drainage associated with levee systems usually include storage areas, gravity outlets, pumping stations, and other residual flooding, or a combination thereof. Interior drainage analyses will assume that all sections of the levee and associated structures will remain intact in their current condition.

Judgment will be required to determine if the interior drainage systems need to be analyzed. The FEMA Regional Office representative will decide how to analyze and map interior drainage after consultation with community officials, levee owner, and/or local project sponsor, and the Project Team. If the potential for mappable flooding exists on the landward side of the levee system due to interior flooding, the Project Team will perform an interior drainage analysis. If the Project Team used the Natural Valley Procedure (see Subsection 11.5) or Structural-Based Inundation Procedure (see Subsection 11.4) for the entire system, no additional interior drainage analysis may be required if those flooding conditions would result in flooding more extensive than the interior drainage analysis.

USACE Engineer Manual *EM 1110-2-1413, Engineering and Design- Hydrologic Analysis of Interior Drainage Areas* provides guidance and criteria for performing an interior drainage analysis for levee systems, including joint probability analyses.

10.2. Natural Valley Zone D

Any area within the Natural Valley footprint that is not SFHA will be depicted as Zone D. The Project Team shall use the Zone D designation to identify the area of possible 1-percent–annual-chance flood hazard that exists because the levee system is not accredited. The Project Team will determine this area using the Natural Valley Procedure (see Subsection 11.5). This is similar to the process used to determine the Zone X (shaded) areas for accredited levee systems.

The Zone D designation is used for non-accredited systems instead of the Zone X (shaded) designation used for accredited levee systems because the flood hazard potential is higher and more uncertain than with accredited levee systems. Zone D is used by FEMA to designate areas with possible, but undetermined flood hazards.

If levee systems exist on both sides of a flooding source, or multiple systems that overlap exist, the Project Team will determine the extents of the Zone D area for each system independently assuming the other systems remain in place.

11. Levee Reach Analysis and Mapping Procedures (Figure 1 Element 620)

In addition to the system-wide hazard mapping, the levee system is divided into reaches to develop additional SFHA. A levee reach is defined as any continuous length of a levee system to which a single technical procedure may be applied. A levee reach has no minimum or maximum length requirement. Individual reaches can be analyzed using the Sound, Freeboard Deficient, Overtopping, Structural-Based Inundation, or Natural Valley Procedures.

Each procedure, except for the Sound Reach Procedure, may be applied at both the reach and system levels. Analysis of a single reach must be conducted with all other levee reaches intact. The Project Team will merge the flood hazard information that results from the analyses of the individual levee reaches within the system along with any interior drainage flood hazards. The result will be a final SFHA delineation landward of the levee system. As mentioned in Subsection 10.2, any area within the Natural Valley footprint that is not SFHA will be designated as Zone D.

There are no stakeholder data/documentation requirements for applying the Natural Valley Procedure. In situations where FEMA is not provided with the data/documentation required for use in the reach analysis procedures, the Natural Valley Procedure will be applied at the reach or system level.

The reach analysis procedures and corresponding stakeholder data requirements shown in Table 2 shall be used when analyzing non-accredited levee systems.

Table 2 - Summary of Stakeholder Data Requirements for Reach Analysis Procedures

		Reach Analysis Procedures				
Data Element	**Applicable Portion of CFR**	**Sound Reach**	**Freeboard Deficient**	**Overtopping Approach**	**Structural-Based Inundation**	**Natural Valley**
Elevation Information for the Levee Crest and Toe	N/A	Required	Required	Required	Required	N/A
BFE + Freeboard Less than Levee Crest	44CFR65.10(b)(1)	Required	N/A	N/A	N/A	N/A
BFE Less than Levee Crest	N/A	Required	Required	N/A	N/A	N/A
Operations and Maintenance Plan	44CFR65.10(c)	Required	Required	Required	Recommended	N/A
Structural Design Requirements	44CFR65.10(b)(2) - 44CFR65.10(b)(7)	Required	Required	Required	N/A	N/A
Inspection Reports	44CFR65.10(c)(2)(iv)	Required	Required	Required	Recommended	N/A
Evaluation of Overtopping Erosion Potential	N/A	N/A	N/A	Required	N/A	N/A

Surveyed elevation data for the levee crest and levee toe, if required, must meet FEMA standards. All engineering data submitted for each of the procedures must be signed and sealed by a registered professional engineer. The registered professional engineer's signature and seal have the same meaning as the certification required by the NFIP regulations as cited at 44CFR65.2 and 44CFR65.10(e).

FEMA will not fund any efforts solely related to certifying data for levee accreditation or making determinations of the levee's structural conditions.

11.1. Sound Reach Procedure

A Sound Reach is a levee reach that has been designed, constructed, and maintained, in accordance with sound engineering practices, to withstand and reduce the flood hazards posed by a 1-percent-annual-chance flood even if the entire system does not.

11.1.1. Data Requirements

Sound Reaches are part of a levee system that cannot meet accreditation requirements as a whole. Because they are only a component of a levee system, they cannot be accredited as a hydraulically independent system.

To designate a reach as sound, technical data must be provided to FEMA to demonstrate that the levee reach will withstand the forces of the 1-percent- annual-chance flood event, and reasonably

account for uncertainty. To accomplish this, documentation to meet the following standards from 44CFR65.10 must be submitted to FEMA:

- *Freeboard*. The levee reach must meet the minimum freeboard standards in 44CFR65.10(b)(1).
- *Operations and Maintenance Plan*. Details of the operations and maintenance standard are provided in 44CFR65.10(c).
- *Structural design standards*. Structural design must meet minimum design standards, including data regarding closures in 44CFR65 (b)(2), embankment protection in 44CFR65.10(b)(3), embankment and foundation stability in 44CFR65.10(b)(4), settlement in 44CFR65.10(b)(5), and any other design standards as detailed in 44CFR65.10(b)(7). The structural design documentation should also include a discussion if the structural integrity could be affected by the failure of an adjacent levee reach if that adjacent levee reach is not categorized as Sound or Freeboard Deficient.
- *Inspection reports*. The standard for documentation of inspection is provided in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).
- Elevation information for the levee.
- All items must be certified and sealed by a registered professional engineer.

FEMA will review the submittal in accordance with the appropriate sections of FEMA Procedure Memorandum No. 63 (PM 63), "Guidance for Reviewing Levee Accreditation Submittals," issued on November 2, 2010.

11.1.2. Technical Procedures

No levee reach-specific modeling is required for a Sound Reach, but the Project Team will map the system-wide Zone D landward of the levee for these reaches. The SFHAs from the system-wide interior drainage analysis and/or adjacent levee reaches may still be present on the landward side of Sound Reaches. This will depend on the presence of interior ponding areas and other terrain features on the landward side of the levee. The SFHAs that form these areas will supersede the system-wide Zone D areas, as applicable.

11.2. Freeboard Deficient Procedure

The Freeboard Deficient Procedure can be applied to reaches where the levee meets the structural requirements of 44CFR65.10, lacks adequate freeboard, and has a documented Operations and Maintenance Plan.

11.2.1. Data Requirements

To designate a levee reach as a Freeboard Deficient Reach, documentation to meet the following standards from 44CFR65.10 must be submitted to FEMA:

- The top of the levee crest and closure structures along the entire reach must be above the BFE.
- *Operations and Maintenance Plan*. Details of the operations and maintenance standard are provided in 44CFR65.10(c).
- *Structural design standards*. Structural design must meet minimum design standards, including data regarding closures in 44CFR65 (b)(2), embankment protection in 44CFR65.10(b)(3), embankment and foundation stability in 44CFR65.10(b)(4), settlement in 44CFR65.10(b)(5), and any other design standards as detailed in 44CFR65.10(b)(7). The structural design documentation should also include a discussion of whether the structural integrity could be affected by the failure of an adjacent levee reach if that adjacent levee reach is not categorized as a Sound or Freeboard Deficient Reach.
- *Inspection reports*. The standard for documentation of inspection is provided in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).
- Elevation information for the levee crest and toe.
- All items must be signed and sealed by a registered professional engineer.

FEMA will review the submittal in accordance with the appropriate sections of PM 63.

11.2.2. Technical Procedures

No reach-specific modeling is required for a reach evaluated using the Freeboard Deficient Procedure, but the Project Team will map the system-wide Zone D area landward of the levee system for these reaches. The SFHAs from the system-wide interior drainage analysis and/or adjacent levee reaches where different procedures have been applied may still be present on the landward side of the levee with Freeboard Deficient Reaches. This will depend on the presence of interior ponding areas and other terrain features on the landward side of the levee.

11.3. 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 small enough or of short enough duration that the system would not fail during the 1-percent-annual-chance event. 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.

11.3.1. Data Requirements

For the Overtopping Procedure to be used for a reach , an analysis, signed and sealed by a registered professional engineer, must be submitted to FEMA. This analysis must indicate that no appreciable erosion of the levee crest, toe, embankment, or foundation occurs during the

overtopping of the 1-percent-annual-chance flood event because of either currents or waves. The analysis must also demonstrate that the anticipated erosion will not result in structural failure. Failure is defined as breach of the levee, directly or indirectly, through loss of embankment material due to erosive forces, the reduction of the seepage path, or piping and subsequent instability. In addition, documentation to meet the following standards from 44CFR65.10 must be submitted to FEMA:

- *Operations and Maintenance Plan*. Details of the operations and maintenance standard are provided in 44CFR65.10(c).
- *Structural design standards*. Structural design must meet minimum design standards, including data regarding closures in 44CFR65 (b)(2), embankment protection in 44CFR65.10(b)(3), embankment and foundation stability in 44CFR65.10(b)(4), settlement in 44CFR65.10(b)(5), and any other design standards as detailed in 44CFR65.10(b)(7). The structural design documentation should also include a discussion if the structural integrity could be affected by the failure of an adjacent levee reach if that adjacent levee reach is not categorized as Sound or Freeboard Deficient.
- *Inspection reports*. The standard for documentation of inspection is provided in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).
- Elevation information for the levee crest and toe.
- All items must be signed and sealed by a registered professional engineer.

In addition to the standards detailed in 44CFR65.10, more expansive structural documentation as well as operations and maintenance documentation will be required for these reaches to certify the overtopping analysis. These are detailed further in the subsections below.

11.3.1.1 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 and engineering judgment. For example, the factor of safety will vary when unique tie-in conditions exist or control structures are present. Because of the uncertainty in depth and duration of the overtopping flows, a factor of safety will typically be applied when considering the structural stability of the levee reach.

11.3.1.2 Armored Surfacing

Based on the certified engineering analysis submitted, a community, levee owner, and/or local project sponsor may be able to demonstrate that armoring is not required for a levee reach to fall within this scenario. However, in most cases, armoring will be expected. Some of the reasons for armored surfacing include:

- Some indication that flow along the levee reach may cause some erosion that will initiate levee breaching;

- A lack of proper and continuous maintenance that would result in a non-continuous, non-uniform surface, including the lack of irrigation, fertilization, and annual inspections;
- Concerns about localized irregularities, which lead to flow anomalies, because available survey data may not be indicative of localized conditions along the levee reach;
- Local conditions, on the landward side of the levee, 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 structural condition;
- Difficulty in establishing and properly maintaining a dense and continuous grass cover (in semi-arid and arid regions);
- Debris carried by floodflow that could induce damage to the protective surfacing;
- A small amount of damage to a dry or cracked embankment, leading to a catastrophic failure during overtopping; and
- Risk reduction in high-impact areas.

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.
- *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 Engineer Circular (EC) 1110-2-6067, *USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*, 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*. Adequacy of the selected armoring scheme must be demonstrated for given site conditions.
- *Resiliency of levee material.* Granular and sandy soils will require surface armoring for small rates and depths 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, 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, sub-drainage, anchoring requirement).
- *Wind and wave action*. The impact of breaking waves over the levee should be evaluated.
- *Cavitation potential.* How overtopping flows will affect armored surfacing should be evaluated.
- *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-covered levees.
- *Inspections*. Inspection frequency is especially important for grass-covered levees or after historical events where overtopping occurs or the levees have been stressed.
- *Validity of the Operations and Maintenance Plan.* The Operations and Maintenance Plan should provide 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.

11.3.1.3 Additional Considerations for Levees Subject to Coastal Flood Forces

A levee reach subject to coastal flood forces 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 wave effects (potentially including wave overtopping and storm surcharge to resist erosion) and prevent flooding of interior areas landward of the levee crest.

For levee reaches subject to coastal flood forces 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 levee reach can withstand the wave forces to which the levee is subjected. Further discussion about armoring coastal levees is presented in USACE CERC-89-15, *Criteria for Evaluating Coastal Flood Protection Structures*.

11.3.2. Technical Procedures

If the appropriate data are provided as detailed in the preceding subsections, the flooding source hydrograph will be routed over the levee reach with the levee remaining intact. The flooding will then be modeled landward of the levee system to determine the SFHA.

11.4. 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, the Structural-Based Inundation 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.

Predicting the exact location of a future breach to a levee or floodwall is not possible. The Structural-Based Inundation Procedure, therefore, does not predict the probability of failure at any breach location 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 an SFHA based on the flood hazard due to potential breaches along a particular levee reach during a 1-percent-annual-chance flood event.

11.4.1. Data Requirements

The only mandatory data requirement is an accurate determination of the top-of-levee and toe-of-levee elevations. However, in certain circumstances, FEMA may require the following information to apply the Structural-Based Inundation Procedure, which should follow the standards from 44CFR65.10:

- *Operations and Maintenance Plan*. Details of the Operations and Maintenance Plan standard are provided in 44CFR65.10(c).
- *Inspection reports*. The standard for documentation of inspection is provided in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).

No water-surface elevation requirements apply to the Structural-Based Inundation Procedure. Therefore, this procedure can be used when the levee crest is lower than the 1-percent-annual-chance flood level, but high enough to impede flow.

11.4.2. 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. Given the number and nature of assumptions inherent in this procedure, FEMA will allow flexibility in the use of the Structural-Based Inundation Procedure to enable the use of engineering judgment. In rural settings, where levee systems protect primarily agricultural lands, yet the levees are hydraulically significant, simplification of the approach may be warranted to limit analysis costs that would not result in significantly different flood hazard mapping.

11.4.2.1 Determination of Modeled Breach Locations

The locations of possible levee breaches could be determined using the method described below.

1. Select initial breach locations for each levee reach, one representing a breach location near the downstream end of the levee reach and another near the upstream end of the levee reach.
2. Determine the hydrograph through each breach, also known as "the breach hydrograph," and independently analyze the hazard for the 1-percent-annual-chance flood landward of the levee for each breach.
3. Combine the resulting flood hazard boundary delineations into a composite SFHA delineation.
4. 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 are reflected in the flood hazard mapped. The final SFHA on the landside of a reach using the Structural-Based Inundation Procedure must reflect the fact that a breach may occur at any location along the reach.
5. Add additional breach locations to the initial locations if additional breaches can change the flood elevations or the extent of the composite flood hazard area significantly.

The breach locations generally should be placed to capture the full flood hazard on the landward side of the levee. Exact locations should be based on breach potential indicators, such as greatest overtopping depth, past breach locations, encroachment or known seepage locations, or changes in levee material or shape. For coastal areas, levee exposure to waves and potential wave runup should also be considered.

11.4.2.1.1 Time of Breach Initiation

The time that a breach is assumed to be triggered will influence the peak flow and volume through the breach. The time that produces the most reasonable case should be chosen using sound engineering judgment. For an overtopping breach, a sensitivity analysis should be conducted to estimate the breach initiation time that produces the most reasonable SFHA. For an internal failure analysis, the breach failure should initiate at the peak flood stage, unless information that suggests a different breach initiation time is appropriate.

Another option to consider when determining at what point to initiate the breach is the point in time when the water rises to an elevation at which the levee fails to meet all standard engineering criteria. This will be before peak stage in most cases.

11.4.2.1.2 Breach Shape

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. These minimum accepted breach widths are based on a qualitative review of the historic breach width information available.

Based on an evaluation of historic breach widths, typically breach widths should be larger than these minimum accepted values. The breach width estimation may consider levee embankment height, levee material, crest width, depth and duration of overtopping, longitudinal velocity, area protected by the levee, distance from the flooding source, and duration of flooding event. The method to estimate breach width will be based on sound engineering judgment, adjusted by comparing to historical documented levee breaches where available. The assigned Project Team member should provide adequate justification for the choice of breach parameters. Unless other information is available, it should be assumed that the breach will extend vertically to the bottom of the levee.

Empirical Methods for Estimating Breach Shape:

*Dam breach equations***.** Empirical equations have been developed by 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 erosive shear 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. If available, historic levee breach information is an important tool in determining breach shape and development time. No nationwide compendium of historic breach information is available, but the engineer performing the analysis should search for historical breach information.

Physically Based Models for Estimating Breach Shape:

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

When floodwalls fail, it is typically a partial breach as one or more sections (e.g., monolith) formed during the floodwall construction are forced apart by escaping water. When conducting a breach analysis on a floodwall, the assigned Project Team member will need to determine the number of sections that might fail as the breach width is based on the particular structure, available documentation, and engineering judgment. The minimum expected breach width for a floodwall is one section (i.e., monolith).

11.4.2.1.3 Development Time

Typically, the time for breach formation (the time from breach initiation to the time full breach width is realized) can be set to zero to simplify the analysis. If it is determined that the breach formation time would have a significant impact on the breach hydrograph, the variable may need to be considered in the analysis.

11.4.2.2 Sensitivity Analysis

A sensitivity analysis will be conducted to evaluate the effects that varying the levee breach width and failure initiation time will have on the resulting flood hazards, within reasonable limits. This sensitivity analysis will include widening and narrowing the levee breach width within reasonable bounds and investigating the impacts of different breach initiation times. As the parameters are varied, the impacts to the peak discharge, volume through the breach, and the SFHA will be noted. In general, the final parameters chosen will represent the most reasonable flood hazard that result from the parameters evaluated.

To test the impact of failure initiation time, a calculation initiating the breach at the point of overtopping of the levee on the ascending or rising limb of the flood hydrograph will be conducted. Also, a breach calculation will be performed at the time to peak flood stage, but not greater than 2 hours after overtopping begins. This duration of overtopping may be extended if technical calculations, prepared by a registered professional engineer, are provided by the community, Tribe, levee owner, and/or local project sponsor to indicate that the levee can withstand additional overtopping without failure. The breach flows or hydrographs will be compared, and the one that produces the most reasonable flood hazard landward of the levee will be used.

For coastal levees, the sensitivity analysis should include testing related to the duration of a storm surge hydrograph.

11.4.2.3 Mapping Breach Analysis Results

The SFHA shown on the FIRM will be based on a composite of the 1-percent-annual-chance event flood hazard developed at each breach location. The final SFHA must reflect the fact that a breach may occur at any location along the Structural-Based Inundation Reach. The modeled breach locations should not be apparent in the final SFHA delineation or BFEs.

11.5. Natural Valley Procedure

The Natural Valley Procedure can be applied to all non-accredited levee reaches to determine the SFHA. Factors to consider when determining whether to use the Natural Valley Procedure to determine the SFHA for a reach are provided below.

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 applied using FEMA funds. In some locations, the SFHA shown on the effective FIRM for the flooding source side of the non-accredited levee system is based on an approximate study and, therefore, the

SFHA is designated as Zone A or Zone V. In these locations, FEMA will evaluate the need for new modeling of the flooding source for performing the Natural Valley Procedure. If the need does not exist, the SFHA shown for the effective flooding source mapping will continue to be designated Zone A. If the need exists, the SFHA for the flooding source may be designated Zone A or Zone AE, depending on the modeling method(s) used.

Needs of the community. Because of the limited data requirements and resources required to analyze a levee reach using the Natural Valley Procedure, a community may prefer to use this method. Therefore, the community may also request that FEMA use the Natural Valley Procedure.

The natural valley floodplain behind non-accredited levee systems shall be modeled and depicted as an SFHA, except when additional analysis indicates an alternate treatment. The natural valley floodplain behind non-accredited levee systems shall only be depicted as Zone D when freeboard deficient, sound reach, overtopping, and structural-based inundation procedures are implemented.

11.5.1. Data Requirements

No data are required from community officials, levee owners, and/or local project sponsors to proceed with the Natural Valley Procedure.

11.5.2. Technical Procedures

Using the Natural Valley Procedure, the Project Team will model the flooding along the levee reach by allowing the discharge to flow freely on either side of the levee for the entire levee reach. The levee will not be impeding conveyance in the model. For riverine levee reaches using one-dimensional models, topographic features of the levee will be in-place in the model, but not allowed to obstruct lateral flow.

Non-accredited levees subject to coastal flood forces will be intact within the storm surge model setup to determine peak storm-surge elevations seaward of the levees. In these situations, consideration will be given to how the levee system will influence wave propagation. A steady-state condition will then be assumed landward of the levee, and the 1-percent-annual-chance water-surface elevation will be extended landward of the non-accredited levee until it intersects the ground elevation, or the levee on the opposite side, in the case of a ring levee. The potential of waves reforming landward of the levee should be evaluated. A similar procedure may be applied when a detailed storm surge model is not available.

12. Flood Hazards Evaluated by Flooding Source (Figure 1, Element 630)

12.1. Flooding Source Modeling and Mapping

The BFEs on the flooding source side of the levee will be analyzed and mapped assuming that all levee reaches remain intact. If a levee is overtopped and flow would be lost to the landward side of

the levee, those losses may be considered and flow in the main flooding source may be reduced in accordance with current FEMA guidance.

12.2. Flooding Source Floodway Determination

For non-accredited levee systems, the initial floodway analysis will be developed following established equal conveyance standards. **Floodway boundaries shall be placed on the riverside of a levee unless the community specifically requests otherwise, or where hydraulic calculations demonstrate a floodway is warranted elsewhere.**

If a levee is determined to be hydraulically insignificant and the Natural Valley Procedure is used, the regulatory floodway may still extend to the landward of the levee. In addition, if the analysis indicates the levee is overtopped during the 1-percent-annual-chance flood event and a defined flow path must be preserved, a floodway analysis of the flow path may be required.

The default method under the new levee analysis and mapping procedures will consist of two parts:

1. An initial analysis to determine the pre-levee equal conveyance reduction locations to set the regulatory floodway location on the non-leveed side of the flooding source; and
2. A "With Levee" analysis to verify that the allowable surcharges are not exceeded with the levee in place.

To perform the first part of the analysis, depicted in Figure 4, the floodway analysis will be modeled for the natural valley run.

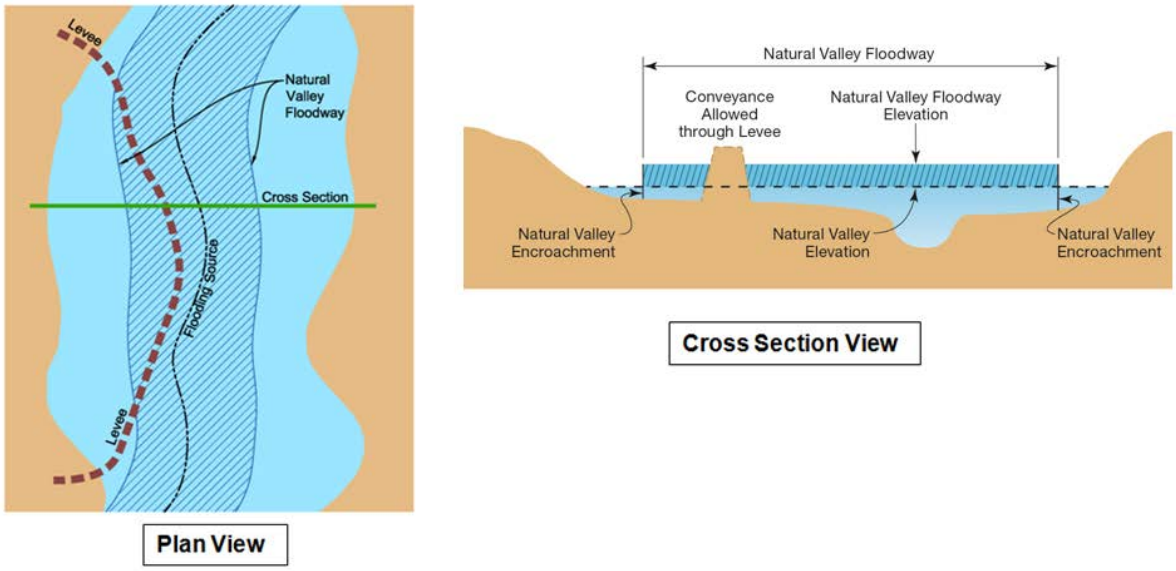

Figure 4 - Floodway Analysis Process Step 1

The resulting encroachment stations will then be put into the "With Levee" conditions model. (See Figure 5.) The non-leveed side encroachment stations will remain in place, and the leveed-side encroachment stations will be shifted to the levee line if the natural valley analysis resulted in a floodway encroachment landward of the levee. The resulting regulatory floodway surcharges are compared to the "With Levee" base model and modified only if the resulting surcharges exceed the allowable limits.

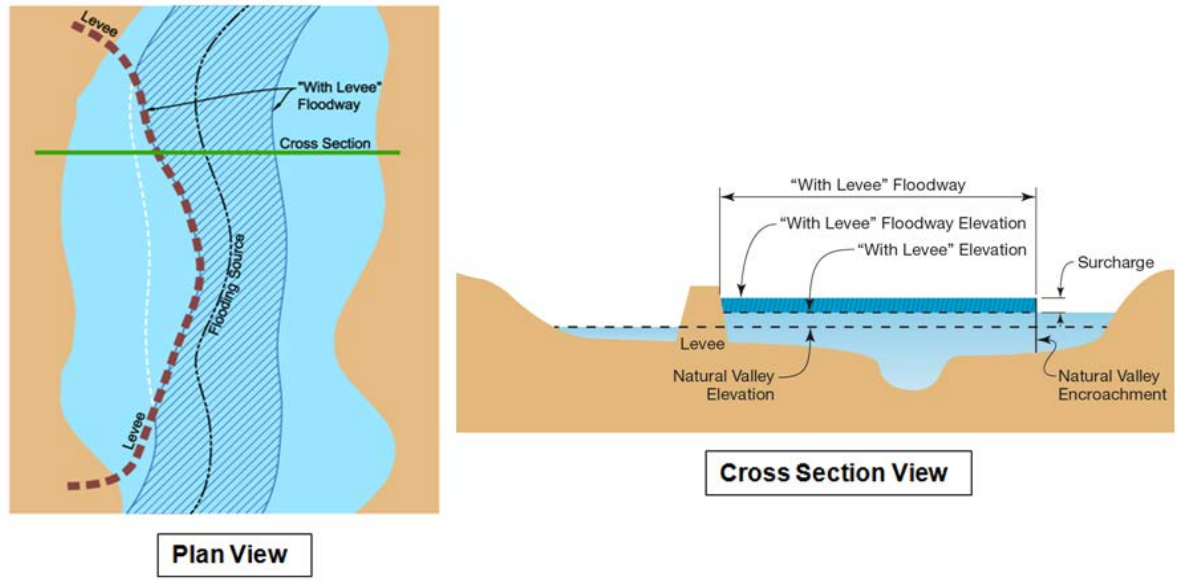

Figure 5 - Floodway Analysis Process Step 2

If the allowable surcharge is exceeded in Step 2, the regulatory floodway is shifted to bring the surcharge within the allowable limits, as shown in Figure 6. This condition would require coordination with community officials and impacted property owners.

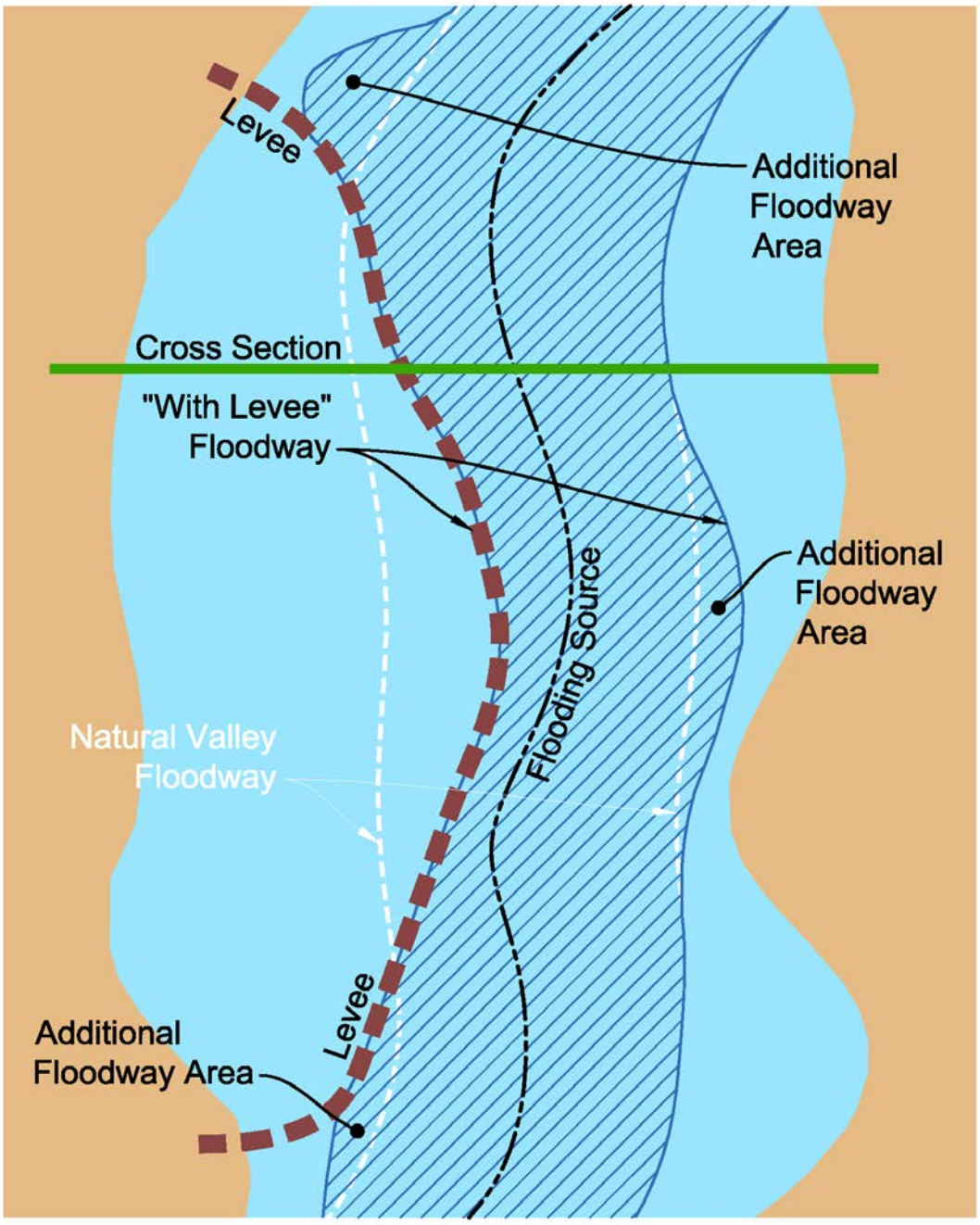

Figure 6 - Final Regulatory Floodway

While a default approach has been presented, the regulatory floodway is a community floodplain management tool and the final approach to determining the regulatory floodway will be made in coordination with officials of the affected communities, the levee owner(s), and impacted property owners. In addition, when the jurisdictions along either side of a flooding source are different, coordination between the Project Team and the State and local jurisdictions affected will need to take place before the modeling approach is finalized.

13. Hydrograph Development

13.1. Riverine Hydrograph Development

Traditionally, projects conducted for flood insurance purposes have only calculated peak-flow or peak-surge elevation. Both the Structural-Based Inundation and Overtopping Procedures will often require a 1-percent-annual-chance flood hydrograph[1] 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 SFHA delineations.

A cost-effective method is needed to estimate flood hydrographs for projects where only peak discharges/surge elevations are available, where a rainfall-runoff model or storm surge model is not available, or where funding is not sufficient to develop a rainfall-runoff or storm surge model. Procedures discussed below will use the 1-percent-annual-chance flood hydrograph for the levee analysis, but other flood return frequencies also could be used if appropriate.

The approach presented in this section is based on both the availability of existing data and the type of flooding. For flooding sources with gaging stations near the study location, two methods for developing desired-percent-chance flood hydrographs may be followed:

- 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 above methods for developing flood hydrographs are not the only acceptable approaches. The application of any method, including those above, should be evaluated for reasonableness.

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

[1] The term hydrograph is used in this 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).

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. The observed hydrograph with the largest peak discharge and volume is the most logical choice. Unit discharge data are available from the USGS Instantaneous Data Archive for many gaging stations from the late 1980s through September 2007. Since October 1, 2007, the unit discharge data are available on the National Water Information System (NWIS).

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 location, the desired-percent-chance hydrograph can be transferred upstream or downstream using the ratio of drainage areas and regional flood frequency relations. Scaling the peak discharge also scales the flood volume with the time base of the hydrograph held constant (basin lag time assumed constant for a given watershed).

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 NWIS. 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 and in USACE Engineer Manual EM 1110-2-1415, *Hydrologic Frequency Analysis*.

For ungaged watersheds, if the effective Flood Insurance Study (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 effective 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 effective 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.

Examples of dimensionless unit hydrographs are provided in Figure 7, 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 peak (T_P).

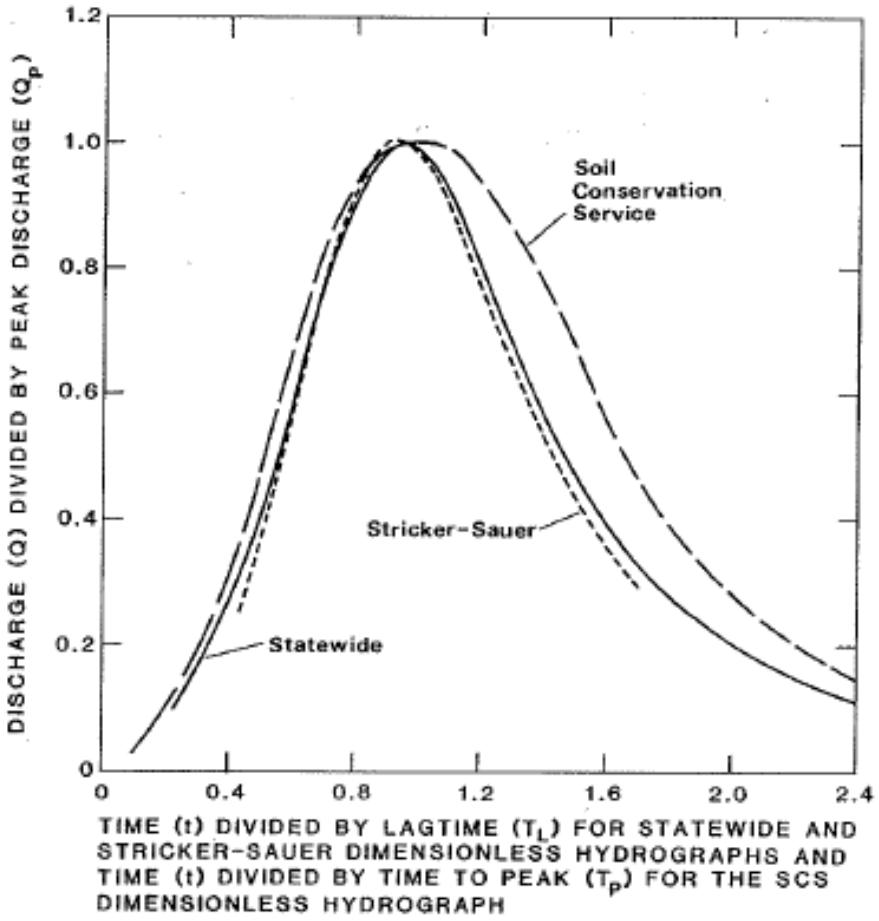

Figure 7 - Sample Dimensionless Unit Hydrographs

The "Statewide" hydrograph in Figure 7 was developed by E, J. Inman in USGS Water-Supply Paper 2317, *Simulation of Flood Hydrographs for Georgia Streams,* using data for 80 gaging stations in Georgia. This dimensionless hydrograph is implemented in the USGS National Streamflow Statistics (NSS) computer program. The "Stricker-Sauer" hydrograph (USGS Open-File Report 82-365, *Techniques for Estimating Flood Hydrographs for Ungaged Urban Watersheds*), was theoretically developed from Clark unit hydrograph procedures. The "SCS" hydrograph is described in Chapter 16, Part 630, Hydrology, of the Natural Resources Conservation Service (NRCS) *National Engineering Handbook*. The USGS dimensionless hydrographs shown in Figure 7 (Stricker-Sauer) 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. The desired-percent-chance peak discharge and the basin lag time are watershed specific characteristics that determine the shape of the hydrograph.

Other flood hydrograph estimation methods developed by State, regional, and local agencies can be used in a similar manner. In the more arid regions of the Western United States, methods developed by State, regional, and local agencies may be particularly relevant because the USGS national dimensionless hydrograph was developed for streams in Georgia and other USGS statewide analyses are generally restricted to the eastern United States.

In addition to the Georgia dimensionless hydrograph ("statewide") available in the USGS NSS program, the USGS has developed dimensionless hydrographs for several other States:

- Water-Resources Investigations Report 89-4076, *Techniques for Simulating Flood Hydrographs and Estimating Flood Volumes for Ungaged Basins in East and West Tennessee*;
- Water-Resources Investigations Report 89-4087, *Determination of Flood Hydrographs for Streams in South Carolina: Volume 1. Simulation of Flood Hydrographs for Rural Watersheds in South Carolina*; and
- Water-Resources Investigations Report 97-4279, *Techniques for Simulating Peak-Flow Hydrographs in Maryland*.

The dimensionless hydrographs developed for 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 USGS Techniques and Methods 4-A6, *The National Streamflow Statistics Program: A Computer Program for Estimating Streamflow Statistics for Ungaged Sites*, 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.

Using rainfall-runoff data for 81 watersheds in Maryland, in "Estimation of Time of Concentration for Maryland Streams", Thomas and others 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 travel time method documented in Technical Release 55, *Urban Hydrology for Small Watersheds*.

The balanced synthetic hydrograph method described above 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 streams;
- Developing regression equations for estimating the desired-percent-chance N-day volumes for ungaged streams; 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.

13.2. Coastal Hydrograph Development

For coastal analyses, one way to create a synthetic storm surge hydrograph is using procedures in the Federal Highway Administration (FHWA) Hydrologic Engineering Circular No. 25 , *Tidal Hydrology, Hydraulics, and Scour at Bridges*, if data from a detailed coastal model are not available. The required variables for the method are:

- Peak surge elevation (S_p),
- Forward speed of the storm (f), and
- 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 Flood Risk Projects 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 Flood Risk Projects where the Project Team did 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.

14. Flood Hazard Mapping

14.1. Mapping Process

The final SFHA delineation shown on the FIRM landward of the non-accredited levee system shall be based on a composite of flooding results from each independently analyzed reach, any interior drainage flooding of the system, and ponding against the landward side of the levee.

If BFEs are to be shown on the FIRM landward of non-accredited levee systems, they shall be based on the highest elevation of the composite analysis and mapping.

When the Structural-Based Inundation Procedure is used, the SFHA for that levee reach will be a composite of each independently analyzed breach location. **The resulting floodplain from the analysis of a Structural Based Inundation reach must reflect the fact 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 final mapping will not reflect the analyzed breach locations, however; the final mapping will reflect the composite flood hazards resulting from all breach analyses conducted.

The input data requirements to map BFEs on the FIRM for the Overtopping and Structural-Based Inundation Procedures follow existing FEMA guidance.

14.2. Graphic Specifications

For FIRMs developed using the standards detailed in FEMA's Guidelines and Specifications Appendices K and L dated April 2003, and Appendix J dated February 2002, the Project Team will annotate the Zone D areas developed under this guidance as "D PROTECTED BY LEVEE" in the FLD_ZONE field of the s_fld_haz_ar feature. The graphical portrayal on FIRMs for these Zone D areas protected by levee will be the same as 0.2-percent–annual-chance flood hazard area (shaded Zone X) with a boundary line matching the boundary used for Zone D areas.

For FIRMs developed using the standards detailed in FEMA's Guidelines and Specifications Appendices K and L dated April 2011 and PM 66, "Flood Insurance Study Report Alignment to Digital Vision", issued on December 8, 2011, the Project Team will use the following graphic portrayal:

1) Line weight 7 Pt. Black with RGB Values (0,0,0) at an angle of 45; Offset 5, separation 10; 70 percent Transparency
2) Line weight 3 Pt. Tan with RGB Values (242, 230, 115), at an angle of 45; Offset 0, separation 10; 70 percent Transparency

In addition, FIRMs prepared under these graphical specifications will include the following note for these levees:

> NON-ACCREDITED LEVEE SYSTEM NOTES TO USERS: These levee systems do not meet the minimum requirements of Section 65.10 of the NFIP Regulations, and therefore flood hazard boundaries were determined by methods which were coordinated and reviewed with impacted communities and other stakeholders.

These graphic specification changes will be incorporated into an updated Technical Reference Manual.

15. Flood Insurance Study

15.1. Text

For FIRMs developed using the specifications detailed in FEMA's Guidelines and Specifications Appendices K and L dated April 2003, and Appendix J dated February 2002, the Project Team should identify the levee reach extents and the methods and model types used to determine the flood hydrograph and SFHA landward of the non-accredited levee system.

For Flood Risk Projects performed using the standards detailed in PM 66, the Project Team should add information to Table 13: Summary of Hydrologic and Hydraulic Analyses. The flooding source should be identified as <Streamname> (Landside of Levee Reach #) and extents should correspond to the extents of the levee reach. The methodology used to determine the Zone D area should also be included in the table. An example of this table is provided in Table 3 below.

Table 3 - Sample Summary of Hydrologic and Hydraulic Analyses Table

Flooding Source	Study Limits		Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
	Downstream Limit	Upstream Limit					
Culvert Creek (Landside of Levee Reach 1)	Confluence with South Fork Inundation River	1.3 miles upstream of confluence of Ripple Creek	Scaled Stream Gage Hydrograph	FLO-2D v. 2009.06	3/31//2012	AE	Modeling using the Structural-Based Inundation Procedure
Culvert Creek (Landside of Levee Reach 2)	1.3 miles upstream of confluence of Ripple Creek	0.5 miles upstream of confluence of Ripple Creek	Scaled Stream Gage Hydrograph	HEC-RAS 4.0	3/31//2012	AE	Modeling using the Natural Valley Procedure
Culvert Creek (Landside of Levee)	Confluence with South Fork Inundation River	0.5 miles upstream of confluence of Ripple Creek	Log Pearson Type III Frequency Analysis	HEC-RAS 4.0	3/31//2012	D	Modeling using the Natural Valley Procedure

15.2. Floodway Data Table

The Floodway Data Table should show the elevations and surcharges based on the "With Levee" run. However, if applicable, the Floodway Data Table should include the following footnote to alert future users that may modify the regulatory floodway:

> *The floodway limits on the non-leveed side of the flooding source are determined from the Natural Valley analysis.*

16. Documentation

Data should be documented following the FEMA Data Capture Standards. For levee reaches analyzed and mapped using the Structural-Based Inundation Procedure, the Project Team must document levee breach location, parameters, and description of the methods used to determine this data. The Project Team should also document any historic breach data or other data used to support various procedures and decisions that were available.

The Project Team should include documentation, such as reports submitted to satisfy the requirements of 44CFR65.10, except for survey data for each reach, in the General Folder of the Hydraulics Data Capture Standards submission.

The Project Team should update the data available for a levee system in the NLD as appropriate based on data collected during the mapping process.

17. Review Procedures

FEMA Regional Offices may determine that the review for mapping non-accredited levees should be conducted through the Regional Support Centers operated by their Production and Technical Services contractors. Decisions made during the process should be coordinated with the entity performing the independent Quality Assurance/Quality Control (QA/QC) review.

Submittals must include backup data and supporting information for all calculations, in case a more detailed review is required. A more detailed review must be coordinated with FEMA Headquarters (HQ).

The independent QA/QC reviewer will verify that all components use the same flooding elevations and conditions, and that the entire levee system (if a system consists of different segments) is considered in the submittal.

17.1. Reviewing Data Required To Apply Different Procedures

FEMA will review the submittal in accordance with the appropriate sections of PM 63. Due to the complexity and uniqueness of each coastal levee, coordination and consultation must occur with FEMA HQ for all levees affected by coastal forces.

To verify that a submittal meets the overtopping analysis standard, the independent QA/QC reviewer will verify that the submission includes documentation supporting two main items. First, the documentation must show that no appreciable erosion of the levee crest, toe, embankment, or foundation occurs during the overtopping of the 1-percent-annual-chance flood event as a result of either currents or waves. Second, documentation must indicate 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).

The independent QA/QC reviewer will verify that the submission includes a discussion of the items to consider as discussed in this guidance document and why they may or may not apply.

17.2. Reviewing Modeling and Mapping for Non-accredited Levees

All hydraulic analyses, hydrologic analyses, and floodplain mapping submitted will be reviewed to verify that they satisfy FEMA standards.

For interior drainage analyses submitted, the independent QA/QC reviewer will verify that all interior ponding areas greater than 1 foot in depth have been mapped and that this analysis was conducted assuming that the levee remains in place during the 1-percent–annual-chance flood event.

For reaches modeled using the Structural-based Inundation Procedure, the independent QA/QC reviewer will focus on verifying the following:

- The resulting SFHA does not indicate where individual breaches were located.
- The analysis reflects that the levee reach could breach at any location within the reach. How the submitter determined that additional breach locations were not required must be documented.
- The breach parameters chosen fall within the historic ranges for the size, location, flooding source type, and soil type of the levee.
- The resulting SFHA reasonably reflects the composite results of all breach analyses.