# Guidance for Flood Risk Analysis and Mapping

## Dams/Reservoirs and Non-Dam Features

November 2019


FEMA

Requirements for the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program are specified separately by statute, regulation, or FEMA policy (primarily the Standards for Flood Risk Analysis and Mapping). This document provides guidance to support the requirements and recommends approaches for effective and efficient implementation. Alternate approaches that comply with all requirements are acceptable.

For more information, please visit the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage (https://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping). Copies of the Standards for Flood Risk Analysis and Mapping policy, related guidance, technical references, and other information about the guidelines and standards development process are all available here. You can also search directly by document title at https://www.fema.gov/resource-document-library.

# Table of Revisions

| Affected Section or Subsection | Date | Description |
|---|---|---|
| First Publication | November 2019 | Initial version of new transformed guidance. The content was derived from the Guidelines and Specifications for Flood Hazard Mapping Partners, Procedure Memoranda, and Operating Guidance documents. It has been reorganized and is being published separately from the standards. |

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# Acronyms and Abbreviations

| Acronym/Abbreviation | Spelled-Out Term |
|---|---|
| ASDSO | Association of State Dam Safety Officials |
| BFE | Base Food Elevation |
| BLM | U.S. Bureau of Land Management |
| BW12 | Biggert-Waters Flood Insurance Reform Act of 2012 |
| CCO | Consultation Coordination Officer |
| CEO | Chief Executive Officer |
| CFR | Code of Federal Regulations |
| CLOMR | Conditional Letter of Map Revision |
| CTP | Cooperating Technical Partners (Program) |
| DMA 2K | Disaster Mitigation Act of 2000 |
| DOT | Department of Transportation |
| EAP | Emergency Action Plan |
| EM | Engineer Manual |
| ER | Engineering Regulation |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| FHBM | Flood Hazard Boundary Map |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Map |
| FIS | Flood Insurance Study |
| FPA | Floodplain Administrator |
| GIS | Geographic information system |
| H&H | Hydrologic and hydraulic |
| HEC-ResSim | Hydrologic Engineering Center Reservoir Simulation System |
| HMP | Hazard Mitigation Plan |
| HOA | Homeowner's Association |
| IBWC | U.S. International Boundary and Water Commission |
| ICODS | Interagency Committee on Dam Safety |
| LOMR | Letter of Map Revision |

| Acronym/Abbreviation | Spelled-Out Term |
|---|---|
| MSHA | Mine Safety and Health Administration |
| NDSP | National Dam Safety Program |
| NDSRB | National Dam Safety Review Board |
| NEH | National Engineering Handbook |
| NFIP | National Flood Insurance Program |
| NID | National Inventory of Dams |
| NLD | National Levee Database |
| NOAA | National Oceanic and Atmospheric Administration |
| NPS | National Park Service |
| NRC | Nuclear Regulatory Commission |
| NRCS | Natural Resources Conservation Service |
| O&M | Operation and maintenance |
| PMR | Physical Map Revision |
| Risk MAP | Risk Mapping, Assessment, and Planning |
| SFHA | Special Flood Hazard Area |
| SOW | Scope of Work |
| TMAC | Technical Mapping Advisory Council |
| TVA | Tennessee Valley Authority |
| U.S. | United States |
| USACE | U.S. Army Corps of Engineers |
| USBR | U.S. Bureau of Reclamation |
| USC | United States Code |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| WIIN | Water Infrastructure Improvements for the Nation Act |
| WSEL | Water-surface elevation |

# 1.0 Overview

## 1.1 Introduction

This consolidated guidance document was prepared by FEMA, in support of the Risk MAP program, to promote sound and consistent implementation of National Flood Insurance Program (NFIP) regulations and mapping program standards that apply to dams/reservoirs and non-dam features.

From a FEMA flood mapping perspective, dams may be off-stream or function as obstructions located in the floodplain when they retain (or impound) floodwater by restricting outflow discharges to downstream areas. Dams may create a permanent water body or reservoir, or they may form a dry storage area used only for retarding floodwater.

For the purposes of this document, a non-dam feature is defined as a physical feature that is not designed, constructed, operated, maintained, or regulated as a flood-control structure, but may inadvertently confine flow during some flood events. Non-dam features (such as roadways and rail transit systems) cross the floodplain and restrict flow, creating incidental flood retention. They often are characterized by sizable embankments that function as dams. Some roadways are designed as dams and are subject to State dam safety regulations.

Canals that divert flow may include an embankment that is regulated as a dam or may serve as an obstruction in the floodplain that may function as a non-dam feature.

For purposes of this document, dams/reservoirs are human built as multi-purpose structures or for many primary uses, the most prominent being floodwater control, water supply, hydropower, irrigation supply, recreation, environmental protection, and firefighting. Dams may be subject to local, State, or Federal regulations. Federal agencies, such as the U.S. Army Corps of Engineers (USACE) and the U.S. Bureau of Reclamation (USBR), that own dams regulate their own dams. Several Federal agencies regulate non-Federal dams, such as the Federal Energy Regulatory Commission (FERC) and the U.S. Department of Labor, Mine Safety and Health Administration (MSHA) (mining dams). The Natural Resources Conservation Service (NRCS), which has designed thousands of dams in the United States (U.S.), does not own or operate dams. NRCS-designed dams are either privately owned and operated or are owned and operated by project sponsors, typically a quasi-governmental entity that is subject to State dam safety regulations.

Non-dam features, for the purposes of this document, may be subject to review and approval by local, State, and Federal government officials and agencies; however, they generally are not subject to permits to impound water. The non-dam features may be designed to pass a design flood frequency event based on varying flood hazards, risks, and economic criteria.

This document provides current information on the mapping of dams/reservoirs and non-dam features and associated flood hazards. This document captures current standards and practices and, therefore, does not address all topics related to the identification of flood hazards and risks associated with dams/reservoirs and non-dam features.

The primary audiences for this document are:

- Communities, regional entities, Tribal entities, and State agencies, including those participating in the Cooperating Technical Partners (CTP) Program, referred to as CTPs
- FEMA Project Teams that are formed to carry out Flood Risk Projects for FEMA Regional Offices in support of the Risk MAP program
- FEMA Regional Office and Headquarters staff
- Dam safety professionals, dam safety regulators, dam owners and operators, and various planners involved with dam safety-related efforts

The FEMA Project Teams often include representatives of the FEMA Risk MAP providers, referred to as Production and Technical Services, Community Engagement and Risk Communication, Customer and Data Services, and Program Management providers.

In this document, the use of "FEMA" refers collectively to FEMA Regional Office staff and FEMA Headquarters staff.

The guidance in this document emphasizes the Risk MAP program vision of collaborating with local, regional, State, and Tribal entities throughout a watershed or project area to deliver quality data that increase public awareness and lead to mitigation actions that reduce flood risk to life and property. To achieve this vision, FEMA transformed its historic documents for flood hazard identification and mapping efforts into a more integrated process of identifying, assessing, communicating, planning, and mitigating flood-related risks aligned with the Risk MAP vision.

To accomplish this process, the appropriate analyses, mapping, and communication of risk of dams/reservoirs and non-dam features is necessary throughout the Risk MAP Flood Risk Project lifecycle. FEMA has prepared this consolidated guidance document in keeping with the Risk MAP vision.

## 1.2 Objectives

This document provides guidance and recommendations on how to evaluate the impacts of flood-retarding structures (dams and non-dam features) and how to incorporate them in the Flood Insurance Study (FIS) Reports and on the Flood Insurance Rate Maps (FIRMs) produced under the Risk MAP program. The purpose of this document is to provide a consistent engineering approach to include dams and non-dam features on these FEMA regulatory products.

This document either updates or supersedes applicable guidance included in Appendix C, "Guidance for Riverine Flooding Analyses and Mapping," of Guidelines and Specifications for Flood Hazard Mapping Partners, dated November 2009. Refer to Subsection 1.5.1 for additional details regarding prior guidance.

## 1.3 Limitations and Constraints

The guidance document contains the following limitations and constraints:

- This document focuses on evaluating the impact of dams and non-dam features on the base (1-percent-annual-chance) flood for flood hazard mapping. Risk assessment concerning the possibility of a dam break is not considered.
- This document generally applies to steady-state hydraulic modeling related to developing Base Flood Elevations (BFEs) for Flood Risk Projects. FEMA is developing guidance for incorporating the flood-retarding effects of dams and non-dam features for use in unsteady-state and two-dimensional models; that guidance will be incorporated into this document when available.
- CTPs, Project Teams (FEMA, local and State providers that partner with FEMA to develop hydrologic and hydraulic [H&H] modeling and mapping, Risk MAP providers) can access the National Inventory of Dams (NID) database through USACE at https://nid.sec.usace.army.mil/ords/f?p=105:1 when conducting the Discovery Phase of a Flood Risk Project and performing the H&H analyses.
- FEMA should be consulted for guidance to address unique or unusual modeling of flood-retarding structures not clearly addressed in this document.
- This document is not intended to address the mandate of the Technical Mapping Advisory Council (TMAC), a Federal advisory committee established to review and make recommendations to FEMA, on matters related to the national flood mapping program authorized under the Biggert-Waters Flood Insurance Reform Act of 2012 (BW12) specifically related to levees and dams. TMAC recommendations will address the FEMA regulatory requirements for dams to comply with the following provisions of BW12:

  > "Section 100216 (A) (iii), (iv), and (v) authorized FEMA to identify, review, update, maintain, and publish National Flood Insurance Program Rate Maps with respect to areas of residual risk, including areas that are protected by levees, dams, and other flood control structures, including areas that could be inundated because of the failure of a levee, dam, or other flood control structure and the level of protection provided by flood control structures."

FEMA may amend this document in the future to include guidance on quantifying risk and the TMAC recommendations.

Subsection 1.4 provides guidance on when to evaluate the flood hazard reduction effects of dams and non-dam features and how to model and map the resultant flood elevations and floodplains.

## 1.4 Dams and Non-Dam Features (Flood-Retarding Structures to be Included)

The FEMA Project Officer, in consultation with Project Team partners and State agencies involved in the flood risk study process, will decide when and how to include the impacts of dams and non-dam features in the H&H modeling of flood hazards for Flood Risk Projects.

FEMA may consider the level of flood hazard reduction afforded by a dam or non-dam feature on the BFEs downstream of the dam or non-dam feature, as well as the aerial extent of the flood

hazard reduction when determining whether to include the flood hazard reduction in the modeling performed for the Flood Risk Project. FEMA also may consider the cost of modeling the hydrologic impacts of a dam or non-dam feature.

The Project Team should consider the technical guidance provided below in evaluating dams and non-dam features.

The flood-retarding effects (flow reduction to the downstream areas) of dams and non-dam features may be included in the Flood Risk Project if one of the following conditions is met:

- The dam is owned or operated by an agency or corporate entity (i.e., the Tennessee Valley Authority [TVA]) of the Federal Government and was designed or can provide a level of flood control for the base flood. This includes dams and dry flood-retarding structures with a primary function of providing flood reduction for the base flood, multipurpose dams with designed flood reduction for the base flood, and dams not designed for flood reduction that provide significant incidental floodflow reduction for the base flood. The determination of significant incidental floodflow reduction is based on impacts to the areal extent of downstream flood reduction and/or the BFE to downstream areas. Questions to be considered in the determination of significant incidental floodflow reduction include:
    - Does the floodflow reduction change the flood elevation of the base flood to the degree that it results in a BFE change shown on the FIRM?
    - Is the downstream stream reach with floodflow reduction limited in areal extent due to the influences of contributing sources of floodflows?
    - Is the base flood floodplain boundary shown on the FIRM that represents the floodflow reduction coincident with the base flood boundary without floodflow reduction at the scale of the FIRM?
- The dam is owned or operated by a government entity, such as a local or State government, or by a government-sanctioned publicly funded entity, such as a drainage and flood control district, watershed authority, or public water utility. The dam and/or dry flood-retarding features were designed with a primary function of providing flood hazard reduction for the base flood, are multipurpose dams with designed flood hazard reduction for the base flood, and/or are dams not designed for flood hazard reduction that provide significant incidental flood control for the base flood. The dam is compliant with all applicable regulations of the State or Federal agencies with review authority or regulatory authority to issue permits to operate and impound water and, if required, has a current permit with a State dam regulatory legislated dam safety program or a permit with FERC. Dams not subject to State or FERC regulations must have a documented structural stability analysis during the base flood (signed and stamped by a Professional Engineer) that states the dam will function during the base flood event and not fail. In addition, an operation and maintenance (O&M) plan is required.
- The dam is owned or operated by a non-government entity, such as a private dam owner or organization, or is a dam owned by a homeowner's association (HOA). The dam was designed with a function of providing flood hazard reduction for the base flood, is a multipurpose dam with designed flood hazard reduction for the base flood, and/or is a dam

not designed for flood hazard reduction that provides significant incidental flood control for the base flood. The dam owner provides a statement that the dam is compliant with all applicable regulations of the State or Federal agencies with regulatory authority to issue permits to operate and impound water and, if required, has a current permit with a State-legislated dam safety program or a permit with the FERC. Dams not subject to State or FERC regulations must have a documented structural stability analysis during the base flood signed and stamped by a professional engineer that states the dam will function during the base flood event and not fail. In addition, an O&M plan is required.

- The non-dam feature is a roadway, railroad, lock, gate, or other structure, such as an irrigation canal, that incorporates earthen embankments into the water conveyance system that restricts the base flood and provides incidental flood control effects. The following factors will be considered when determining whether to include the incidental flood control effects in the H&H modeling for a Flood Risk Project:
    - The feature does not overtop during the base flood unless designed with overtopping protection to guard against failures.
    - The feature was designed hydrologically and hydraulically in such a way that may have resulted in flood hazard reduction for structures, such as a roadway and conveyance structures designed per State Department of Transportation (DOT) guidelines or the guidance of the U.S. Department of Transportation Federal Highway Administration (FHWA) Publication No FHWA-HIF-12-026, Hydraulic Design Series Number 5. The feature also has a documented structural/ geotechnical stability analysis that shows it will not fail during the base flood event. Or, the FEMA Project Officer makes the case-by-case decision based on engineering judgement that certain features, such as multilane interstate highways, have sufficient mass, designed conveyance systems, or have historical information to impact the base flood for the anticipated duration of ponding.
    - A covenant or agreement has been exercised by the non-dam feature owner and the local government with jurisdictional authority under the NFIP that ensures that the conveyance system will not be enlarged, thus reducing the flood storage, unless mitigated, and thereby increasing the base flood discharge downstream.
    - The non-dam feature will be adequately maintained to ensure it will function as intended and as included in the H&H modeling. O&M plans for State-owned and operated roadways that are subject to system operation and maintenance are not required to be provided. For other private non-dam features, a covenant or agreement has been exercised by the non-dam feature owner and the local government with jurisdictional authority under the NFIP that ensures that the feature will be maintained by the local government if not maintained by the private owner.

For dam and non-dam features for which flood hazard reduction is included in the hydrologic analysis, the flood elevations downstream of the dam or non-dam feature will be established based on the attenuated floodflow. The flood elevations upstream of the dam or non-dam feature are to be established at the routed flood elevation. The regulatory floodway upstream of the dam or non-dam feature should be modeled consistent with Subsection 3.2, “Storage Considerations,” Floodway Analysis and Mapping, dated November 2016.

For all other structures that do not meet the previously mentioned conditions and for which flood hazard reduction is not included in the hydrologic analysis, the flood elevations are to be established as follows:

- The backwater effects upstream of the structure may be established based on the routed elevations from a hydrologic model unless no hydrologic model routing was performed or the structure overtops during the base flood. If no hydrologic model routing was performed or the structure overtops during the base flood, the backwater effects are to be established assuming the structure remains in place and the top of the structure functions as a weir.
- Flood discharge reduction downstream of the structure is not to be included in the hydraulic modeling.

## 1.5 Prior Guidance and Historical Practices

### 1.5.1 Prior Guidance

The consolidation of work that guided users through decades of dam-related procedures implemented during flood hazard mapping projects was incorporated into this document. This is intended to promote sound and consistent implementation of policies, regulations, and standards for dam-related flood hazard identification. This guidance enhances compliance with the NFIP regulations as cited in the Code of Federal Regulations (CFR) at Title 44, Chapter 1, Part 65 (44 CFR Part 65), incorporating portions of previous guidance documents and FEMA standards to facilitate implementation during Flood Risk Projects. FEMA has prepared this document to expand on and supersede guidance provided in the previously referenced Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C, dated November 2009 and the following Risk MAP Flood Risk Analysis and Mapping guidance documents:

- Floodway Analyses and Mapping, Subsection 3.2, dated November 2016
- Base Flood Elevation Mapping Guidance, dated November 2014
- General Hydrologic Considerations, dated May 2016
- General Hydraulics Considerations, dated November 2016

More details for each superseded guidance document are provided in each chapter of this document.

This document supersedes any other existing dam guidance document for NFIP flood hazard mapping.

### 1.5.2 Historical Practices

Based on general program knowledge and past historical practices, most H&H models have been one-dimensional steady-state models. Hydrologic analysis performed using stream gage data or based on the statistical analyses of regional stream gage data has been preferred over more labor-intensive rainfall-runoff models. Still, many dams and non-dam features have been hydrologically modeled using rainfall-runoff models to reflect flood storage. The decisions to do so were made on a case-by-case basis by FEMA in consultation with a FEMA mapping provider.

Typically, if the dam or non-dam feature was considered to have a significant hydrologic effect on downstream areas and existing rainfall-runoff model data could be leveraged, the mapping provider modeled the dam or non-dam feature in the hydrologic rainfall-runoff model to derive peak discharges that were transferred and applied to the hydraulic model. For other, older cases, the mapping provider adjusted the hydrologic effect using a gage analysis or modified regression equation. For some lakes and reservoirs, the mapping provider used the flood elevation from the hydrologic routing at the dam, and generally the mapping provider hydraulically modeled the dam or non-dam feature as an obstruction in the floodplain. If the base flood overtopped the embankment, the mapping provider assumed the embankment would function as a weir, stay in place, and not fail, mapping the higher hazard by showing the backwater effect to upstream areas.

Generally, the downstream peak flows from the dam usually were handled in one of two ways (options):

- Option One. If the dam or non-dam feature likely would be overtopped or fail during the base flood event, the mapping provider set the downstream peak flows to the same peak flows entering the reservoir (no reduction of peak flows due to retention upstream of the structure). This option was used most often for non-dam features and dams that were not significantly related to the base flood event (smaller dams).
- Option Two. If the mapping provider determined (based on engineering judgement, design information, field reconnaissance, etc.) that the embankment would remain in place during the base flood event, was being properly maintained, and had an operation plan (if applicable) that provided for dedicated flood storage in the reservoir, then the mapping provider based the downstream flows on the routed outflow from the hydrologic model. This option was used less often because getting the certified engineering data to support this option was difficult if not impossible.

This document advises when the storage behind the non-dam feature should be included in the Flood Risk Project and how it should be modeled.

Historically, the needs and specifications for dams have been more stringent than for levees due to the typical use of dams. However, no previous national guidance has been available on how best to model dams. To better explain why this guidance is needed, specific examples of the differences between dams and levees are shown in Table 1.

**Table 1: General Differences between Dams and Levees**

| Item Considered | Dams | Levees |
|---|---|---|
| Design Criteria | Dams are designed in general to a higher standard than levees. | Levee design is similar, but more simplified, because levees only hold back temporary flooding and generally are lower in height. |

| Item Considered | Dams | Levees |
|---|---|---|
| Freeboard | Freeboard is set by the design flood hydrographs that will affect the dam and reservoir and standard engineering practice as defined by State standards or, in the absence of State standards, by Federal publications such as the Design of Small Dams from the USBR; Chapter 4, "Hydrology," of the National Engineering Handbook from the NRCS; and other standards. | Freeboard requirements for NFIP accreditation are cited in the NFIP regulations at 44 CFR §65.10 and the standards provided in USACE Engineer Manual (EM) 1110-2-1913 and EM 1110-2-299. |
| Structural Requirements | Structural requirements generally are more stringent for dams due to higher embankment heights, often larger engineering loads to consider, and long-term saturation of the embankments. | Structural requirements are less stringent than dams because levee embankments are subject to shorter-term flood inundation and generally have lower embankment heights. |
| Original Design Intent | Dams are designed for multiple reasons, but can include providing storage for water supply, fire protection, power generation, and recreational uses. Dams may provide either designed or incidental flood control. | Levees are designed mainly to prevent temporary flooding of areas for agricultural purposes or flood hazard reduction, but usually are not designed to have any (planned or measurable) impact on downstream peak flows. |
| Regulatory Responsibility | For dams that meet the State criteria for regulation (usually set based on height and/or storage), States typically have authority for permitting; requiring or performing inspections; enforcing non-compliance; and regulating their construction, maintenance, operation, rehabilitation, alteration, repair and removal. Dams that are not subject to State regulatory requirements then may be the responsibility of the local government jurisdiction to comply with development or other permit requirements to protect the public. FEMA application forms for map revisions (MT-2 forms) will help identify dams falling under either the jurisdiction of the State or Federal agency, so that stakeholders can coordinate with the appropriate responsible agencies for design review, including H&H, structural, etc. For a dam not regulated by a Federal agency or State, FEMA would require the local government agency to perform a design review. | For levees to be accredited by FEMA, if they are designed and constructed by another Federal agency responsible for design and construction of levees, and they certify the levee meets 44 CFR §65.10 requirements, FEMA would accept their certification and map the areas landward of the levee as Zone X (shaded) and provide credit for the flood hazard reduction. For any other levees, a registered professional engineer is required to provide the 44 CFR §65.10 information, with FEMA, or their providers, reviewing the data for completeness. |

## 1.6 Regulatory Requirements

FEMA has congressional authorizations related to dams as part of the NFIP, the National Dam Safety Program (NDSP), and BW12.

The NFIP regulations are set forth in 44 CFR Parts 59 through 80. These intertwined parts are both mitigation-related and flood insurance-related. The main regulations for flood insurance and the Standard Flood Insurance Policies are 44 CFR Parts 61, 62, and 63.

Although dams are not directly referenced in the NFIP regulations, the requirement to map flood hazards for existing physical conditions requires consideration for mapping the impacts of dams. The regulations also address the mapping of similar flood hazard reduction measures, such as levees, and include requirements for map changes that FEMA applies to dams. 44 CFR §60.3(b)(7) of the NFIP regulations requires that communities assure the flood-carrying capacity within an altered or relocated portion of any watercourse is maintained. This requirement can apply to any dams and levees impacting these watercourses. In addition, 44 CFR §65.6(a)(12) further defines that if a community or other party seeks recognition from FEMA, on its Flood Hazard Boundary Map (FHBM) or FIRM, that an altered or relocated portion of a watercourse provides flood hazard reduction from, or mitigates potential hazards of, the base flood, the Administrator may request specific documentation from the community certifying that, and describing how, the provisions of §60.3(b)(7) of this subchapter will be met for the particular watercourse involved.

The FEMA authority under BW12 includes the authority to identify, review, update, maintain, and publish NFIP maps (i.e., FHBMs, FIRMs) with respect to areas of residual risk, including areas of hazard reduction by levees, dams, and other flood-control structures, or areas that could be inundated because of the failure of a levee, dam, or other flood-control structure and the level of protection provided by these flood-control structures.

### 1.6.1 NFIP

Through the Risk MAP Program, FEMA identifies flood hazards, assesses flood risks, and partners with States and communities to provide accurate flood hazard and risk data to guide them to mitigation actions. Flood hazard mapping is an important part of the NFIP, as it is the basis of the NFIP regulations and flood insurance requirements. FEMA maintains and updates data through FIRMs and risk assessments. FIS Reports include data on riverflow, storm tides, H&H analyses, rainfall, and topographic surveys.

FEMA uses the best available technical data to create the flood hazard maps that help communicate a community's flood risk areas.

#### 1.6.1.1 FEMA Risk MAP Regulatory Products

FEMA regulatory flood hazard products are the FIRM, FIRM database, and FIS Report. The regulatory products address the flood hazards associated with the base flood event and other recurrence interval flood events included on the FIS Flood Profiles (typically, the 10-, 4-, 2-, 1-, and 0.2-percent-annual-chance events). The base flood and select other recurrence interval event flood limits typically are mapped on the FIRMs.

#### 1.6.1.2 FEMA Map Revision Requirements

The NFIP regulations cited at 44 CFR Part 65, "Identification and Mapping of Special Flood Hazard Areas," contain the requirements related to revising NFIP maps. Specifically, 44 CFR §65.6, "Revisions of base flood elevation determinations," outlines the procedures for requesting

map changes through the map revision process. Additional guidance related to map revisions is found in MT-2 Application Forms and Instructions for Conditional Letters of Map Revision and Letters of Map Revision.

#### 1.6.1.3 FEMA Flood Risk Products for Dams

FEMA has developed dam-related Flood Risk Products to effectively communicate risk to a broad audience. These products comprise the following datasets: Dam Locations; Dam Cross Sections (and associated Dam Scenario Lookup Table and Dam Cross-Section Model Results Lookup Table); Dam Upstream Inundation Areas; Dam Downstream Inundation Areas; Dam Easements; Dam Arrival Time Grids; Dam Flood Inundation Duration Grids; and Dam Time to Peak Grids.

The dam Flood Risk Database products are non-regulatory and document potential dam failure mapping and flood risk. The dam Flood Risk Database products are enhanced non-regulatory products that typically are not funded by FEMA, but in partnership with local governments as part of new Flood Risk Projects performed under the Risk MAP program.

### 1.6.2 Biggert Waters Flood Insurance Reform Act of 2012

BW12 was signed into law in 2012, authorizing FEMA to map flood risk related to dams. BW12 required FEMA, along with TMAC, to address the following provisions:

> Section 100216 (A) (iii), (iv), and (v) authorized FEMA to identify, review, update, maintain, and publish National Flood Insurance Program Rate Maps with respect to areas of residual risk, including areas that are protected by levees, dams, and other flood control structures, including areas that could be inundated because of the failure of a levee, dam, or other flood control structure and the level of protection provided by flood control structures.

In 2017, TMAC, at the request of FEMA, evaluated Section 100216 of the Act and recommended that FEMA focus on the assessment of residual risk and how to communicate that risk. TMAC further recommended that FEMA develop a series of mapping prototype products aimed at more effectively communicating residual flood risk related to levees, dams, and event-driven coastal erosion. TMAC also recommended that products developed should incorporate end-user and stakeholder testing, and FEMA should develop standards for routine production and presentation, if applicable.

FEMA is addressing the TMAC recommendations separately from this document and may revise this document in the future.

### 1.6.3 National Dam Safety Program Background

The first Federal legislation for dam safety, the National Dam Inspection Act (P.L. 92-367), was enacted in 1972 and codified under Title 33 United State Code (USC), Chapter 9, Subchapter VII. The 1972 Act authorized the Secretary of the Army to inventory and inspect non-Federal dams across the U.S, to create the NID, and to provide recommendations for a national program for the inspection and regulation for the safety of dams.

In 1979, Executive Order 12148 established FEMA and provided it the authority to coordinate all national efforts in dam safety, and to:

> …reduce the risk of life and property from dam failure in the United States through the establishment and maintenance of an effective National Dam Safety Program to bring together the expertise and resources of the federal and non-federal communities in achieving national dam safety hazard reduction.

In 1996, the National Dam Safety Program Act, included within the Water Resources Development Act (P.L. 104-303), authorized the formation of the National Dam Safety Review Board (NDSRB), financial assistance (in the form of grants) to State dam safety programs, and funding for maintaining the NID, research, and training related to dam safety.

In December 2016, the NDSP was amended under the Water Infrastructure Improvements for the Nation (WIIN) Act, which authorized FEMA to establish a new grant program under the NDSP (33 USC 467(f)). Section 5006 of the WIIN Act, "Rehabilitation of High Hazard Potential Dams," provides technical, planning, design, and construction assistance in the form of grants for rehabilitation of eligible high hazard potential dams.

The purpose of the NDSP is to:

> ...reduce the risks to life and property from dam failure in the United States through the establishment and maintenance of an effective National Dam Safety Program to bring together the expertise and resources of the federal and non-federal communities in achieving national dam safety hazard reduction (33 USC §467).

One of the key roles of FEMA and its partners is to provide technical assistance to the individual State dam safety programs. State dam safety programs are autonomous and develop State-specific regulations and guidance. Numerous technical publications developed by Federal agencies are incorporated by the States in their guidance documents on dam design, O&M, breach assessments, and preparation of Emergency Action Plans (EAPs). Due to the autonomous nature of the State dam safety programs, not all States require EAPs and, among those States that do, the H&H guidance used to prepare breach inundation mapping for EAPs is not consistent.

FEMA, with input from the NDSRB, determined that a new guidance publication related to dam breach inundation mapping for areas downstream of dams could lead to more consistent inundation mapping efforts and improved EAPs. In 2013, FEMA published FEMA P-946, Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures as nationwide guidance for modeling and mapping flood hazards associated with dam failures. This guidance can be used for multiple purposes, including dam safety, hazard mitigation, consequence evaluation, emergency management, and developing EAPs.

As mentioned earlier, BW12 included an authorization for the FEMA flood hazard mapping program to be carried out in coordination with the NDSP and TMAC. The authorization includes new requirements related to mapping flood risks related to dams.

## 1.7 Dam-Related Communication and Community Engagement

To appropriately analyze and map the flood hazards in impacted areas, FEMA and FEMA-led Project Teams will engage with community officials and other stakeholders during the Discovery

Phase of a Flood Risk Project, and throughout the project lifecycle as necessary, to understand the location and impacts of dams and non-dam features. Additional information on stakeholder engagement activities during the Discovery Phase is provided in Stakeholder Engagement Guidance: Project Planning and Discovery Process, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

For dams in a watershed/project area, FEMA coordinates with community officials and other stakeholders to solicit data and information on the dams, discuss decisions on which dams to include in the H&H analyses, and document community requirements for covenants or agreements necessary to consider the impacts of these dams on flood hazard identification.

Where non-dam features exist near or within flood-prone areas, the impact of these features on the conveyance of floodwater may change over time. The current effective FIRMs may already represent these features as providing flood hazard reduction or other impacts on the conveyance of floodwater, and, as such, may indicate a lesser flood hazard and corresponding risk.

Communities and property owners may not be fully aware of the risks associated with these non-dam features. Therefore, coordination with local stakeholders is essential to identify, analyze, and map the flood hazards associated with these non-dam features and to provide relevant information and tools to help communities and property owners understand their flood risk and mitigation opportunities in these areas. This coordination is initiated during the Discovery Phase of a Flood Risk Project to identify non-dam features, make recommendations to produce dam-like datasets for these non-dam features, and/or use any information available to communicate flood risks associated with non-dam features.

# 2.0 Key Definitions

## 2.1 General Definitions

Table 2 presents the key definitions used in this document. For a complete list of terms, see Section 6.0, Definitions.

**Table 2: Definitions**

| Term | Definition |
|---|---|
| Dam | An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.[1] |
| Non-dam feature | A physical feature that is not designed, constructed, operated, maintained, or regulated as a flood-control structure, but may inadvertently confine flow during some flood events. Non-dam features (such as roadways and rail transit systems) cross the floodplain and restrict flow, creating incidental flood retention. |
| Levee | Per 44 CFR §59.1, 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 to reduce flood hazards posed by temporary flooding. |
| Reservoir | A body of water impounded by a dam and in which water can be stored. In the case of mine tailings facilities, it can include the solids as well as the water retained.[1] |

[1]Reference: Selecting and Accommodating Inflow Design Floods for Dams, FEMA P-94 (August 2013)

## 2.2 Dam versus Levee Definition

During a Flood Risk Project, the function and/or classification of a flood-control structure sometimes can be questioned. That is, does this structure qualify as a dam or levee under the NFIP flood hazard mapping program? When dams are built, auxiliary or appurtenant structures exist that could be considered a dam or a levee. If the structure is upstream in the reservoir area, within the pool, around the pool, etc., the FEMA Project Team should ask: Would this levee/embankment/dike/etc. exist if there was not a dam/reservoir? If the answer is yes, it is most likely a levee and should follow the guidance in Levees, which is accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage. If the answer is no, then it is associated with the dam that is enabling the reservoir pool to be used and/or it is needed for the reservoir regulation and should be managed as a dam.[1] Generally, that structure would follow the FEMA guidance for dams.

[1] Engineering Regulation (ER) 1110-2-1156. Engineering and Design, Safety of Dams—Policy and Procedures, U.S. Army Corps of Engineers, Washington, DC, 31 March 2014

When an assigned Project Team considers this guideline unclear or not applicable to a structure, that member should discuss the issue with the FEMA Project Officer. (See Table 1, General Differences between Dams and Levees, for more information on the design differences between dams and levees.)

# 3.0 Flood Hazard Study and Revision Process for Dams and Non-Dam Features

As part of the Risk MAP program, FEMA works with Federal, State, Tribal, and local partners across the nation to identify flood hazards and promote informed planning and development practices to help reduce flood risk. The Risk MAP program provides high-quality maps, information, and tools to better assess flooding risks, as well as planning and outreach support to help communities act to reduce (or mitigate) flood risk. Each Flood Risk Project or map revision process should be tailored to the needs and capabilities of each affected community and may involve different steps, products, and services.

The following subsections provide general descriptions of the flood hazard analysis and mapping study and map revision process that would apply to both dams and non-dam features. Details addressing the flood hazard analyses and mapping of dams and non-dam features are provided in Section 4.0 of this document.

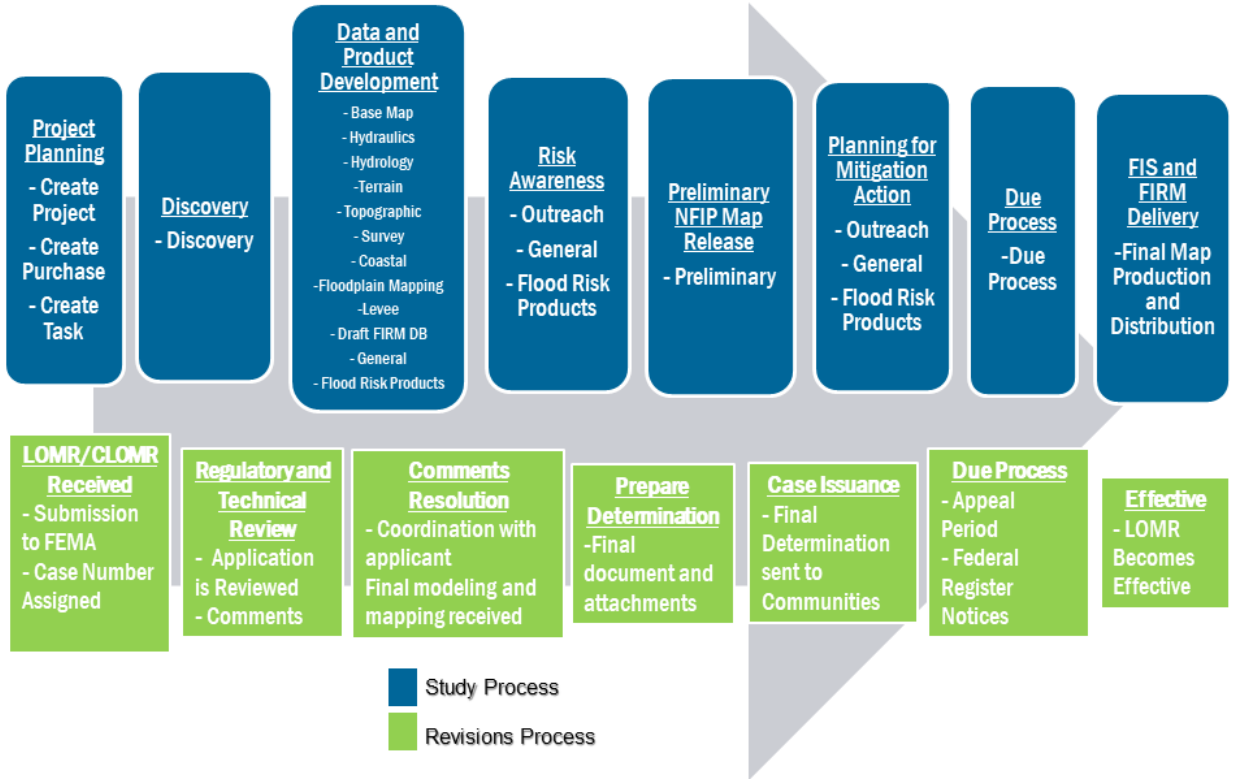
## 3.1 Flood Hazard Study Process

The flow diagram shown in Figure 1 provides an overview of the Risk MAP study process and the revisions process outlined in Subsection 3.2 of this document. During each phase, consideration and incorporation of data on dams or non-dam features will be evaluated. Dams or non-dam features within each phase of the study process are explained in more detail in the following subsections.

### 3.1.1 Project Planning

As part of the overall program planning effort, FEMA Regional Offices must develop and select individual projects that are aligned with and meet overarching program objectives. The presence of dams and non-dam features may impact the project scope of work. The FEMA Regional Office may select several project types to initiate. For example, to make progress toward deploying projects that deliver quality data, FEMA Regional Offices should consider how to annually initiate the appropriate quantities of flood hazard data updates to balance inventory decline with available resources and critical framework data (e.g., high-quality Light Detection and Ranging data).

**Figure 1: Studies and Revision Business Flow Diagram**




FEMA evaluates many other factors and data considerations to enable informed decisions to be made on project selection to achieve the program objectives. These factors help to organize the project planning and prioritization process into four major categories: Risk, Need, Equity, and Data. Dams and non-dam features contribute to these categories in the following ways:

- **Risk** - Consider the risk, defined generally as a probability of a threat/event times consequence. For example, consider the population below a dam. Larger population counts below the dam may increase project prioritization. Also, consider population growth, as this may require changes to the dam's hazard classification. If existing flood hazard analyses do not reflect current risks, then they need to be updated, which could increase project priority.
- **Need** - Consider Hazard Mitigation Plan (HMP) status, as areas with no HMPs, or with long-expired HMPs, may receive increased priority. These areas may not have key inputs needed to understand risk and act on it. Also consider the stream's New, Validated, and Updated Engineering status, as unverified streams increase project priority.
- **Equity** - Consider areas that do not have digital flood hazard data and place a higher priority on these areas. These areas may have dams to be considered.
- **Data** - Consider availability of quality data to contribute to the project. Higher priority project areas are those with unavailable quality data. Owners of dams may have H&H analyses available to enhance the flood hazard data.

Engagement with both internal and external stakeholders is strongly encouraged and is necessary to achieve success during the Project Planning Phase of a Flood Risk Project. While more thoroughly discussed in the Stakeholder Engagement Guidance: Project Planning and Discovery Process, specific partners to consider engaging for dam and non-dam features include:

- Dam owners and operators, which may include Federal agencies, State agencies, quasi-governmental organizations (i.e., watershed districts), HOAs, or private owner districts
- State dam safety officials
- FEMA NDSP personnel
- NFIP-participating communities
- Other watershed stakeholders

FEMA should initiate the contact with the owner of the dam. Then, upon mutual understanding, the FEMA Project Team can engage with the owner of the dam under the agreed-upon direction from the FEMA Project Officer. Successful stakeholder engagement during the Project Planning Phase should result in a clearer understanding of the project activities that a watershed/project area may benefit from most; a clearer understanding of State preferences and priorities for Risk MAP project scopes; and strengthened relationships, a sense of partnership, and shared objectives between FEMA and community officials.

### 3.1.2 Discovery

The Discovery Phase of a Flood Risk Project is essential to locating the dams or non-dam features (i.e., dams, roadway embankments, railroad embankments) that may potentially affect the flood risk in the study area. The features may be located within the watershed upstream or downstream of the study area. When a dam or non-dam feature is identified, the Project Team, led by FEMA, should engage stakeholders to collect applicable information, which may include, but is not limited to, the following:

- Dam Name and NID and/or State Dam Inventory ID number.
- Date of construction or major repair/rehabilitation, if known. If not known, document that it is unknown.
- Who owns the flood-retarding structure?
- What is the primary purpose of the dam? Is there documentation that it was designed for flood control?
- Is the structure regulated by the local, State, or Federal government?
- Does the structure have an O&M plan?
- Does the structure have a documented structural/geotechnical stability analysis associated with it?
- Do as-built plans exist?
- Do design H&H data/calculations/models exist? If a design H&H analysis does exist for the facility, then:

    - Does a computer model exist, such as the USACE Hydrologic Engineering Center Reservoir Simulation System (HEC-ResSim)?
    - Is the full operation plan of the dam with all the dependencies on the gate operations available to code into a model?
    - What is the typical pool history or an assumption of where to start the pool, based on a pool elevation below which the dam is required to keep?
- Does it overtop during the base flood event? If so, by how much does it overtop?
- What is the inflow design flood event for the dam?
- Does a base flood pool easement exist?
- Is it a regulated dam or a non-dam flood-retarding structure?
- Is the dam in sequence with other dams? If so, what are the names and NID ID or State ID of the other dams? Is there a watershed management plan for these sequenced dams?
- Is (are) the dam(s) mentioned in the current effective FIS Report or named on the current effective FIRM panel? Are they named as a dam or as some other name, such as a culvert?
- What is the hazard potential classification for the dam(s) within the NID and the State inventory database? Is there a difference in the classification between the NID database and the State inventoried database? If so, what is the difference and why?

Using the data collected above, the Project Team will assess the data for possible flood-retarding structures. Based on the specifics of each possible flood-retarding structure, the FEMA Project Officer will make an initial decision regarding the study approach for each dam and non-dam feature for inclusion in the Flood Risk Project. Possible study approaches include, but are not limited to, the following:

- A full enhanced study, including the hydrologic routing of flows through the structure and the hydraulic modeling of routed flows upstream and downstream of the facility.
- A study that does not include any hydrologic routing through the structure, but instead shows the structure as a hydraulic obstruction.
- A study that does not include any H&H calculations and ignores the presence of the structure. This study approach should only be applied to the following situations:
    - When preparing automated approximate studies where the work scope involves the exclusion of the hydraulic modeling of stream crossings.
    - When minor structures, such as footbridges, private roads, fords, and small embankment stream crossings, are deemed to not be hydraulically significant during a base flood event. In some cases, a dam or non-dam feature so significantly overtops during the peak of the base flood event that the existence of the feature does not have a noticeable effect on the water-surface elevation (WSEL).
- No study of the structure since the effective FIS Report and FIRM appropriately depicts the flood hazards and validity of the effective study.

A purpose of the Discovery Meeting is to obtain a common understanding among the Project Team, the local communities, and other stakeholders of the Flood Risk Project effort and finalize the scope of the project. During the meeting, the Project Team will present the initial findings of all the dam and non-dam features possible for the study approach, specifically those potential flood-retarding structures. Each dam or non-dam feature recommended for the study approach for the Flood Risk Project also will be discussed at the meeting.

At the conclusion of the Discovery process, the data collected and decisions made will be documented in the Discovery Data Capture.

For more information on the Discovery Phase, refer to two FEMA guidance documents: Discovery, and Stakeholder Engagement: Project Planning and Discovery Process. Both documents are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 3.1.3 Data and Product Development

During the Data and Product Development Phase, the Project Team should review the existing data for each dam and non-dam feature and determine if it is acceptable or if supplemental data are needed that also satisfy the H&H approach to data requirements determined in the Scope of Work (SOW). The Project Team should perform a field reconnaissance, including photographs taken of any pertinent dam/non-dam features observed during the field reconnaissance in accordance with FEMA standards, to help validate existing data and topographic data development. The most suitable and best available topographic data are required for updating flood hazard data. The horizontal and vertical datum should be set to North American Datum of 1983 and North American Vertical Datum of 1988 , respectively (in accordance with FEMA Standard 41), unless there is some consideration for cost or data sharing with another stakeholder for the area being acquired, or collection is outside the conterminous United States. For additional detail and guidance document references pertaining to field reconnaissance and incorporating dam and non-dam features into project terrain, see Subsection 4.2 of this document.

The Project Team should review the NID to help identify potential flow regulation by dams. It is important to consider that significant flow-retarding structures may make regression equations invalid (Automated Engineering). When the Project Team will perform new, revised, or validated H&H analyses for a specific potential flood-retarding structure, the Project Team should follow the procedures outlined in Section 4.0 of this document. Per FEMA Standard 90, the methods and models used to evaluate the flood hazard must be technically reliable, must be appropriate for flood conditions, and must produce reasonable results. The Project Team choice of H&H procedures must be approved by the FEMA Project Officer and coordinated with the stakeholders affected and agreed upon during the SOW development.

A hydrologic analysis to develop the base flood hydrograph pertaining to each dam or incidental flood-retarding structure is associated with the size and characteristics of the watershed, the study type and structure type, the methods used for the effective study, the availability of data, the requirements from the hydraulic study, and the allocated funds. The current or newly selected hydrologic analysis approach should accurately match the hydraulic analysis input required, whether it be a developed inflow hydrograph, cumulative runoff volume mass balance, or other

empirical method. Subsection 4.3 of this document elaborates on the H&H analysis requirements, approaches, and relevance to the overall dam or non-dam feature analysis in greater detail.

Special considerations when mapping the floodplain and regulatory floodway into and downstream of each dam and non-dam feature should be determined during the Discovery and SOW development process steps and may be validated or omitted during the H&H analyses, based on results. For additional details and guidance pertaining to floodplain and regulatory floodway mapping, see Subsection 4.4 of this document.

### 3.1.4 Risk Awareness

Dams/reservoirs provide vital benefits to communities, including flood risk reduction, water supply storage, hydropower, irrigation, transportation pathways, and recreation. But if they fail, dams can pose significant risks to people and property downstream. Understanding the risks associated with these hydraulic dam features within the community allows officials to plan for emergencies and generate mitigation activities, which, in turn, helps create a more resilient response to flood disasters.

Dam failures are low-probability but high-consequence events. Dam failures or partial failures are not usually caused by storm events. Most failures fall into one or more of the following categories:

- Structural failures: Foundation defects, including settlement and slope instability, or damage caused by earthquakes cause dam failures.
- Mechanical failures: Malfunctioning gates, conduits, or valves cause dam failure or flooding both upstream and downstream.
- Hydraulic failures: Overtopping of a dam is often a precursor to dam failure. Overtopping due to inadequate spillway design, debris blockage of spillways, or settlement of the dam crest accounts for dam failures.

Planned releases through the operation of spillways, either planned or in response to emergency situations can create flooding and public safety hazards, even in the absence of a dam failure. During periods of extreme flow, dams may fill to capacity, necessitating emergency releases that can flood downstream areas. People swimming and fishing downstream of dams have been caught in spillway releases, at times with tragic results.

The Flood Risk Products produced during a flood risk study help community officials and the public view and understand their local flood risk. The Flood Risk Products include a Flood Risk Map, Flood Risk Report, or Flood Risk Database . These products are non-regulatory resources that supplement the flood hazard information produced for the regulatory FIRM, FIS Report, and FIRM database products. Both the general public and government officials are encouraged to use these free resources to help make better-informed decisions about preparing for and mitigating flood loss. An example non-regulatory flood risk dataset in the Flood Risk Database is a dam downstream inundation area showing multiple flood and dam failure scenarios. More information on dam Flood Risk Projects can be found in the Dam-Specific Non-Regulatory Flood Risk Datasets guidance document.

Communication to the communities about risk to life, property, and infrastructure located upstream or downstream of dams takes place during the Flood Risk Review Meeting and the

Resilience Meeting. During those meetings, the Risk MAP study data and Flood Risk Products are shown.

The Flood Risk Review Meeting is intended to be a technical, engineering-focused meeting that gives community officials (i.e., floodplain administrators [FPAs], engineers, other "technical" stakeholders) a chance to review the draft flood risk information included in the project scope. The Flood Risk Review Meeting allows the Project Team to highlight the flood risk associated with the changes and gives communities and other technical stakeholders the opportunity to review the results and prepare to communicate that risk to impacted residents and businesses. The Project Team should encourage discussions about flood hazards and risks associated with dams and non-dam features, rather than talking primarily about the flood insurance implications or what locations are "in or out" of Special Flood Hazard Areas (SFHAs). Additional guidance on Flood Risk Review Meetings is provided in Stakeholder Engagement: Preliminary Production Process, which is accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

The Resilience Meeting purpose is to continue to build local capacity for communicating risk and implementing priority mitigation activities within the watershed or other geographic area. The objectives of the Resilience Meeting are to help community officials and other stakeholders better understand:

- The flood risks. An example is to provide an online interactive map bringing locational awareness using aerial imagery to view the dam's proximity to areas of interest. Also include layers for the SFHA, the permanent pool elevation, roads, and easements.
- Their role as leaders in flood risk identification, communication, and mitigation. An example is to coordinate with local emergency personnel on the EAP and dam annex to the Emergency Operations Plan. Coordinate with local emergency personnel on the dam breach inundation map and development of evacuation mapping.
- Strategies they can use to reduce the flood risk and improve the watershed's resilience to floods. An example is to create easily accessible permanent signage near dams with information on evacuation planning and routes, as well as instructions to recreation users warning of floodgate operation.
- Resources available to help them implement the appropriate risk reduction strategies. An example is to provide dam owners and the public with information on vegetation and wildlife control requirements on and adjacent to dams. Left unmaintained, woody growth and wildlife burrows or larger animal preferential paths located on or near earthen dams can have a detrimental effect over time on a dam's structural integrity and mapped floodplain.
- Resources available to help them communicate effectively with the public about flood risk and why that is important. An example is to distribute the booklet titled Living With Dams: Know Your Risk.

The Resilience Meeting is the appropriate time to introduce or provide contact information for the State's Dam Safety Officer. In addition, provide information on the NDSP, as well as a link to the Association of State Dam Safety Officials (ASDSO) website, damsafety.org.

Additional guidance on Resilience Meetings is provided in Stakeholder Engagement: Post-Preliminary Due Process, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 3.1.5 Preliminary NFIP Map Release

During the Preliminary NFIP Map Release Phase of a Flood Risk Project, the Project Team delivers preliminary versions of the FIRM and FIS Report to community officials and posts them publicly through the FEMA Flood Map Service Center for review and comment. These preliminary products show new or updated flood hazard data that will affect floodplain development requirements and/or flood insurance premium rates in communities after the FIRM becomes effective. This phase includes two touchpoints with communities within the study area. First, FEMA organizes a Consultation Coordination Officer (CCO) Meeting to present the preliminary products to community officials and alert them that their floodplain ordinance likely will need to be updated. Then, FEMA will work with community officials to hold a Flood Risk Open House to familiarize the public with any changes in flood hazard.

Additional information on the CCO Meeting and Flood Risk Open House and other stakeholder engagement activities during this phase is provided in Stakeholder Engagement: Post-Preliminary Due Process, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 3.1.6 Planning for Mitigation Action

The Disaster Mitigation Act of 2000, also referred to as DMA 2K (P.L. 106-390), provides the legal basis for FEMA mitigation planning requirements for State, local, and Tribal governments as a condition of mitigation grant assistance. DMA 2K amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by repealing the previous mitigation-planning provisions and replacing them with a new set of requirements that emphasize the need for State, local, and Tribal entities to closely coordinate mitigation planning and implementation efforts. The requirement for a State mitigation plan is continued as a condition of disaster assistance, adding incentives for increased coordination and integration of mitigation activities at the State level through the establishment of requirements for two different levels of State plans.

DMA 2K requires a community to describe the type, location, and extent of all natural hazards as well as information on previous occurrences of hazard elements and the probability of future hazard elements. Dams may be considered and incorporated into a local community-adopted DMA 2K plan if the flood hazard associated with the dam has been identified by the community. The DMA 2K plan may provide important technical information that should be considered in the modeling and mapping of flood hazards as defined by these guidelines.

The Risk MAP program seeks to integrate flood hazard mapping, risk assessment tools, and mitigation planning into one seamless program to increase public awareness and inspire action that reduces risk to life and property. Technical assistance to support mitigation planning plays a key role in the Risk MAP program vision and should be offered as part of every Flood Risk Project. By building stakeholder understanding of Risk MAP information and tools, such technical assistance can support the development of more robust mitigation and outreach strategies that are more precisely tailored to a community's risks. More detailed information and guidance can

be found in Incorporating Mitigation Planning Technical Assistance into Risk MAP Projects and Post-Preliminary Due Process, both of which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

Dam-related Flood Risk Products can be developed to effectively communicate risk to a broad audience to help the community better understand risk and take appropriate mitigation action. For example, knowing if the dam would overtop during the base flood event. More detailed information is provided in Dam-Specific Non-Regulatory Flood Risk Datasets, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 3.1.7 Due Process

Communities have the opportunity for due process when receiving an update to the FIRM. The Post Preliminary Due Process is described in more detail in Post-Preliminary Due Process, and more detailed information on appeals and comments is available in Appeal and Comment Processing, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

The data and information provided by communities during a Flood Risk Project, Physical Map Revision (PMR), or Letter of Map Revision (LOMR) are classified as either a Comment or an Appeal. Comments or Appeals may concern technical issues involving dam-related influences on flood discharge values, BFEs, floodplain and floodway boundary delineations, base map information (e.g., corporate limits, road locations, road names, dam feature locations), or other information presented in the FIS Report.

### 3.1.8 FIS Report and FIRM Delivery

After the Project Team has finalized all changes to the FIRM and FIS Report, FEMA issues a Letter of Final Determination (LFD) to each affected community's Chief Executive Officer (CEO). The LFD establishes the effective date of the new FIRM and FIS Report for the community and initiates a 6-month adoption/compliance period. During this period, the community must adopt and amend its floodplain management regulations to reflect the new regulatory information.

Two distinct touchpoints can be introduced into this step. Before the FIRM effective date, the Project Team can organize discussions with CEOs, FPAs, and other local officials on the adoption of local floodplain ordinances that meet or exceed minimum NFIP and State standards. An example of exceeded standards is including in the floodplain management ordinance about the adoption of easements based on the upstream and/or downstream inundation areas to limit or restrict development near dams. These discussions also should touch on opportunities for lower flood insurance premiums through the Community Rating System.

Before or after the effective date, the Project Teams also can organize a Resilience Meeting. The Resilience Meeting provides an opportunity for FEMA, State, Tribal, territory, and local leaders to (1) discuss ways that Risk MAP products can support ongoing risk assessment and planning efforts, and (2) work together to identify additional mitigation actions to reduce natural hazard risks. The Resilience Meeting and other stakeholder engagement activities are discussed in detail in Stakeholder Engagement: Due Process Phase, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

## 3.2 Map Revision Process

Generally, the H&H and mapping data required and FEMA's review are the same regardless of the map change vehicle, either a LOMR or a PMR/flood risk study. This subsection should help better prepare communities and requesters when submitting a Conditional Letter of Map Revision (CLOMR) or LOMR request.

The map revision process revises the effective FIRM when there is an existing, proposed, or modified dam or detention basin along a flooding source. This includes existing or new embankments that are designed or modified to serve as flood detention structures. Map revision applicants should use the guidance provided in Subsection 1.4 of this document to determine under what category the dam or detention basin will fall for flood hazard mapping purposes.

For all dams or detention basins that are within the map revision area, the map revision requester should follow the requirements and procedures listed in Subsection 3.1 and Section 4.0 of this document, which will include engineering analysis and engineering drawings of the dam/basin. The drawings should indicate the dam/basin dimensions (height, top width, side slopes), the crest elevation of the top of the dam/basin, the type of spillway, the spillway dimensions, the crest elevation of the spillway, the type of outlet, the outlet dimensions, and the invert elevation of the outlet. The information required to support a map revision request is summarized, but not limited to, the items below.

1. Submit completed applicable MT-2 Forms and detailed information about the dams/ basins, to include the MT-2 Form 3, Riverine Structures Form. As usual, indicate the reason for the revision request involving a dam/basin, including if the dam/basin is existing or part of the project associated with the MT-2 case. For each dam/basin, indicate what the primary purpose of the facility is.
2. Indicate the agency or organization that designed the dam/basin.
    a. Indicate the name of the agency or organization responsible for permitting the dam, along with the appropriate permit or identification number for the dam.
    b. Provide related "as-built" or "proposed" drawings, specifications, and supporting design information for a local dam or a private dam.
3. Indicate if the dam/basin is regulated by the State dam safety program.
4. If the dam/basin is not regulated by the State dam safety program, submit all Federal, State, and/or local regulatory and permitting information pertinent to the structure.
5. Indicate if the hydrologic analysis is revised as a result of the dam/basin and complete Form 2, Riverine Hydrology & Hydraulics Form. Any storage upstream of the dam/basin considered in the hydrologic analysis to reduce the peak base flood discharge should be dedicated to flood storage as part of the flow regulation plan or designated as floodway on the FIRM in accordance with the Floodway Analysis and Mapping, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage. If the outflow of the dam is regulated, submit an explanation of the flow regulation plan. Provide this documentation as part of the O&M information required per Item 9, below. Provide documentation showing that the dam/ basin was designed using the critical storm duration

that would yield the maximum reservoir stage or maximum volume of runoff during the design storm. Provide the regulatory BFE for the reservoir behind the dam/basin.

6. If the dam/basin has been included in previous H&H analyses completed by FEMA, indicate if any changes are being proposed.
7. In locations where sediment transport will affect the BFEs, the effects of sediment transport should be considered in the design of the dam/basin, and Section F of Form 3 should be submitted. Provide justification if sediment transport analysis is not considered for the dam/basin design.
8. Indicate if the BFEs change as a result of the dam/basin. If impacted, list the stillwater elevations behind the dam/basin in the table provided.
9. Include a copy of the formal O&M Plan and EAP if required by the regulator for the dam/basin. For CLOMR submittals, draft versions of the plans are acceptable and need to be submitted if the plans are required by the regulator.

# 4.0 Flood Hazard Analysis and Mapping for Dams and Non-Dam Features

## 4.1 Sources of Data for Dams and Non-Dam Features

During a Flood Risk Project, FEMA updates the hazards associated with dams and non-dam features that exist along new or restudied flooding sources that impact the attenuation of the base flood event. These structures are identified during the Discovery Phase (see Subsection 3.1.2 of this document) and through coordination with Federal, State, and local agencies to determine the inclusion of these structures. Before initiating the project, the Project Team should gather existing data pertaining to dams and non-dam features for consistency of approach with other agencies. Other considerations for modeling dams and non-dam features may be unique for individual cases, so the Project Team may need to consider the selection of modeling procedures on a case-by-case basis in coordination with FEMA.

The first step in the decision process is identifying existing dams and non-dam features on streams to be studied for the project. Additionally, data may be captured regarding dams and non-dam features not being studied within the FIS Report, and this information should be kept for use at the discretion of FEMA. Data on the details and condition of dams and non-dam features can come from other Federal agencies, State dam safety programs, and other sources discussed in Subsections 4.1.1 through 4.1.4.

### 4.1.1 Other Federal Agencies

Several Federal agencies have the responsibility of design, operations, ownership, maintenance, and/or regulation of dams within the United States and may have records of design information for the dams. Federal agencies that may have information to leverage include, but are not limited to, the following:

- USACE
- USBR
- FERC
- U.S. International Boundary and Water Commission (IBWC)
- NRCS

Each State NRCS office usually maintains as-built records and analyses for watershed dams constructed within their respective States. For more information, see: http://www.nrcs.usda.gov/about/organization/regions.html.

In addition, USACE maintains the NID database (http://nid.usace.army.mil), which includes information such as location, height, storage, and hazard potential for Federal and State dams. Information in the NID is updated periodically and the latest information may need to be obtained and verified from the regulating Federal or State agency.

### 4.1.2 State Dam Safety Programs

Except for Alabama, each State has a State-legislated dam safety program with permitting, inspection, and enforcement authorities for regulated dams within the State. The State agencies

may have information regarding permit status, data and analyses, EAPs, and dam failure inundation modeling and mapping. Permitting requirements and level of information vary by State agency; therefore, it is recommended that the Project Team contact the agency directly to discuss available data. A list of State agency contacts can be found on the ASDSO website at: https://damsafety.org/states.

Many State dam safety agencies require dam failure inundation modeling and mapping and EAPs for high-hazard dams. Although this information is not required by FEMA, the Project Team should consider capturing these data during a Flood Risk Project as Flood Risk Products (see FEMA Dam-Specific Non-Regulatory Flood Risk Datasets, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage).

### 4.1.3 Other Potential Dam Data Sources

Other data sources that may provide basic information or visualization of a dam can include:

- Aerial or road base maps or map applications
- Street view applications (if a road traverses the dam crest)
- U.S. Geological Survey (USGS) aerial images
- State fish and wildlife department websites (if a dam impounds a reservoir for recreational/fishing purposes)
- Effective (or historical) FIS Reports and models
- Local or State HMPs
- Stakeholder feedback obtained through project stakeholder engagement activities
- Engineering field reconnaissance

### 4.1.4 Non-Dam Feature Data Sources

Non-dam features typically are not regulated for flood control purposes by Federal, State, or local agencies, but may need to be identified on a FIRM based on the impact to the base flood hazard identified through conversations with the community during the Discovery Phase, as discussed in Subsection 3.1.2, and/or by engineering assessments. Data sources that may assist in evaluating the risk associated with these features can include, but are not limited to:

- Aerial or road base maps or map applications
- Street view applications (if the feature is a road embankment)
- USGS aerial images
- Local and State aerial and topographic maps and geographic information systems (GIS) data
- Local and county highway departments
- Railroad companies (if the feature is a railroad embankment)

- State DOTs
- Effective (or historical) FIS Reports and models
- Stakeholder feedback obtained through project stakeholder engagement activities
- Engineering field reconnaissance

While gathering information from Federal and State agencies, the Project Team should inquire about any concerns the agency may have pertaining to the performance of the non-dam feature and the risk associated with the non-dam feature attenuating the base flood event to determine the appropriate detailed or approximate mapping of the flood hazards. Recent inspection reports and known performance during flooding events (available from State or local agencies) may be helpful tools in determining the hazard to be shown on a FIRM.

## 4.2 Field Reconnaissance and Topographic Data Development

During the Project Planning and Discovery Process, the Project Team should identify available data and the need for new survey, field reconnaissance, and topographic development. Guidance for these data development tasks related to flood-retarding structures is provided in Subsections 4.2.1, 4.2.2, and 4.2.3. Existing FEMA standards and current guidance documents also should be followed, including (at the time of this publication) Elevation Guidance and Data Capture—Workflow Details, both of which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 4.2.1 Existing Data Sources

Structure-related data can be obtained from a variety of sources, such as photographs, orthophotography, existing topographic data, and design/as-built plans. Local sources of dam and non-dam feature data should be discussed as part of the Project Planning and Discovery Process, and may include the local emergency management agency, local city or community FPA, or the dam owner. For consistency with existing data and to avoid duplication of effort, the Project Team should gather existing data before determining the need for new survey and field reconnaissance.

This could include geometric features on the embankment, primary spillway, emergency/auxiliary spillway, channel, and/or reservoir normal pool elevation and storage. It may also include spillway and auxiliary inflow design flood / capacity.

### 4.2.2 Survey and Field Reconnaissance

Priority should be given to existing data sources for dam and non-dam features being studied within a project area. If data gaps emerge after leveraging information from Federal, State, local, or other reliable sources, then new survey and field reconnaissance may need to be included in a Flood Risk Project. In this case, FEMA may scope new survey and field reconnaissance data for dams and non-dam features of interest within the project area.

The specific types of facility-related data that should be collected are officially defined in Data Capture—Workflow Details and include, but are not limited to, the following:

- General dam geometry (for example, top/crest of dam and toe elevations, crest width and length, side slopes).

- Normal pool/reservoir elevation (or depth).
- Dam type (e.g., earthen, concrete).
- Principal spillway type and basic geometry (inlet/outlet elevations and dimensions).
- Emergency/auxiliary spillway type and basic geometry (control section width, channel side slopes, inlet/outlet elevations and dimensions, as applicable).
- Survey and reconnaissance for other structures and natural cross sections along the impacted reach, including downstream bridge/culvert information (general geometry, e.g., bridge opening, culvert size).

In addition to the standard survey requirements, data collection and field reconnaissance for dams and non-dam features should include:

- Visual observations of dam/non-dam embankment and collection of available monitoring data and/or inspection reports which would not constitute an assessment of performance during a flood event.
- Media review and stakeholder input on previous history of performance, if available.
- Photographs of any pertinent dam features observed during the field reconnaissance, in accordance with FEMA standards (a photo location log should be developed).

### 4.2.3 Topographic Data Development

The Project Team should base development of a project terrain on the best available data. Ideally, the team should base reservoir bathymetry on swath readings for a detailed development, but also may base the bathymetry on cross-sectional surveys, if needed. The team also may use stage-storage relationship data to develop flood elevations in place of bathymetry.

The Project Team should incorporate dams or non-dam features into the terrain using hard break lines and/or as model features if they are to be considered as floodflow-reducing structures.

## 4.3 H&H Analyses

H&H analysis requirements associated with dams and non-dam features generally are included in FEMA standards and guidance. The current relevant guidance documents, all of which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, are:

- General Hydrology Considerations (February 2019)
- Hydrology: Rainfall-Runoff Analysis (February 2019)
- General Hydraulics Considerations (November 2016)
- Hydraulics: One-Dimensional Analysis (November 2016)

Special concerns related to H&H analyses for dams and non-dam features are discussed in the subsections below.

### 4.3.1 Operational Flows/Existing Model Results

The Project Team may use existing operational flow-frequency plans and/or hydrologic modeling for flood-retarding structures performed as part of the design or for dam safety purposes that reflect existing hydrologic conditions to determine the flood-retarding effects for the base flood and to develop peak flows and/or flow hydrographs. The team must use current depth-duration-frequency data developed by Federal or State agencies, regional climate centers, local flood control agencies, or dam owners, or provide justification for another data source.

### 4.3.2 Gage Analysis

The Project Team may perform flood-frequency analysis for flood-retarding structures using stage and/or flow records available at gaged locations.

### 4.3.3 Hydrologic Modeling: Rainfall-Runoff

For structures where new hydrologic rainfall-runoff modeling is deemed necessary, the Project Team should determine the hydrologic flood-retarding effects of the structure by using a FEMA-approved model (https://www.fema.gov/hydrologic-models-meeting-minimum-requirement-national-flood-insurance-program).

The Project Team must coordinate with local and/or Federal agencies and find whether there are requirements about proceeding with hydrologic analyses prior to initiating a study because each State or local dam safety agency may have differing requirements.

The Project Team must fully document the elevation-storage-discharge relationship if used, including sources of data on reservoir operation; the outlet structure; and methods, sources, and measurements of data used to define the relationship.

#### 4.3.3.1 Hydrologic Routing

Routing for flood-retarding structures is the way that rainfall-runoff models account for the change in shape and timing of hydrographs through a hydrologic system. The Project Team should use the best available elevation-storage-discharge rating curve for the structure representing existing conditions. The team may use the elevation-storage-discharge rating curve developed for design of the structure if it approximates existing conditions, including siltation of the flood storage pool. Additional specific hydrologic routing guidance related to dams is provided below. In addition, the Project Team should be aware that each State dam safety agency and/or Federal agency may have differing requirements for H&H modeling with respect to dams and non-dam features. For example, some States require routings to start at the auxiliary spillway, while other States require it to be at some other level.

#### 4.3.3.2 Starting Water-Surface Elevation

The starting WSEL to be considered in modeling may vary depending on the function of the dam or non-dam feature. The Project Team must identify dam or non-dam feature functions prior to developing a hydrologic model. Functions can include hydropower generation, irrigation for agriculture, water supply, flood control, inland navigation, recreation, fisheries, sediment storage, non-dam highway or railroad embankment, or multiple purposes. Specific guidance concerning the function of the dam or non-dam feature follows.

For structures determined to be flood-retarding, the starting water surface for available storage may be based on a variety of data. For structures with a designed and documented flood control function, the starting WSEL for hydrologic routings may be set at the normal pool or based on the approved operation plan for the structure, whichever results in the higher hazard.

For dams with the primary function of water supply, energy generation, or other non-flood control purposes, the Project Team should set the WSEL for hydrologic routings based on the normal pool. If reservoir water level elevations are not available, the routings are to be started at the crest of the lowest overflow auxiliary or emergency spillway. In addition, the Project Team should review the O&M plans for these dams to determine what, if any, impact they may have on the flows.

Non-dam embankments with a standing water body may use the normal pool as the starting water surface elevation. For non-dam features that do not have a normal pool, the stage-volume rating curve is to be set based on the best topographic data available. If available, the Project Team must consider outlet structures in a hydrologic routing model.

#### 4.3.3.3 Storm Duration

The Project Team should use an appropriate storm duration for the routings in the modeling in line with the FEMA guidance Hydrology: Rainfall-Runoff Analysis, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage. Each State dam safety regulatory agency or authority may have its own specific requirements that the Project Team should consult when determining storm duration.

#### 4.3.3.4 Subbasin Computations

In hydrographs, the Project Team must include subbasin responses, which are outflows from subbasins as a function of time. The team will compute the subbasin responses in conjunction with infiltration as rainfall losses, rainfall data, time concentrations, input hydrographs if applicable, land use and soil types, or channel routings.

The Project Team must fully document the elevation-storage-outflow relationship if it is used, including sources of data on reservoir operation; the outlet structure; and methods, sources, and measurements of data used to define the relationship.

#### 4.3.3.5 Hydrologic Review

The Project Team member that reviews hydrologic routing models for dams and non-dam features must comply with the quality control process specified in the FEMA technical guidance in General Hydrologic Considerations and Hydrology: Rainfall-Runoff Analysis, which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 4.3.4 Hydraulic Modeling

The Project Team will determine hydraulic effects of a dam or non-dam feature using a FEMA-approved model (https://www.fema.gov/hydraulic-numerical-models-meeting-minimum-requirement-national-flood-insurance-program). In addition, the team will use the hydraulic modeling guidance specific to dams discussed in Subsections 4.3.4.1 and 4.3.4.2.

#### 4.3.4.1 Hydraulic Structures

The Project Team should compute flood elevations at the dam or non-dam feature through hydrologic routing.

For dams where the flood-retarding effects will be included in the hydraulic modeling, the regulatory floodway upstream of the dam will be coincident with the base flood pool elevation unless there is a more restrictive easement that the community and the FEMA Regional Office approve.

For dams where the pool is not protected by a permanent easement or a storage floodway, the Project Team must adjust the elevation-storage relationship for the flood-retarding pool in the hydrologic model to eliminate the storage volume in the floodway fringe. This modeling exercise will likely be an iterative process.

For dams where the flood-retarding effects (flow reduction to downstream areas) will be included in the hydraulic modeling, the Project Team should model the regulatory floodway downstream of the dam using the reduced flows.

#### 4.3.4.2 Hydraulic Review

The Project Team member that reviews hydraulic models associated with dams and non-dam features must comply with the quality control process specified in the General Hydraulics Considerations, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

### 4.4 Floodplain/Floodway Mapping

If the Project Team determines that the floodplain/floodway boundaries need to be developed or revised, the team must follow the procedures listed in existing FEMA standards and current guidance documents, including (at the time of this publication) the following guidance documents, all of which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage:

- Mapping Base Flood Elevations on Flood Insurance Rate Maps
- Riverine Mapping and Floodplain Boundaries Guidance
- Floodway Analysis and Mapping

Special concerns related to the floodplain/floodway mapping around dams are fully documented by existing FEMA guidance and standards.

The Project Team should base floodplain and floodway analysis on the regulatory modeling scenario. For dams credited for flood storage, the regulatory floodplain mapping floodway analysis should be based on the reduced flows downstream. The storage area must be designated as a regulatory floodway.

## 4.5 FIRM and FIS Report Guidance

### 4.5.1 FIRM Panels

The Project Team should show and label all dams that are being modeled on the FIRM panels under development. For dams shown in the FIS Report on a Flood Profile, the labeled dam name and NID ID or State ID number must match what is shown on the Flood Profile. The dam name should be taken from the dam regulatory agency first, then from the NID second, as the State inventories generally are more accurate than the NID. The team should store modeled dam and non-dam features in the FIRM database, with the STRUCT_NM field correctly matching the Flood Profile in the FIS Report and the label on the FIRM Panel. The guidelines presented in the FIRM Panel Technical Reference, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, should be followed for mapping of dam and non-dam features.

SFHAs upstream of a dam represent the base flood hazard and should be labeled with a BFE on the FIRM. These elevations may be represented as a static BFE value or stored within cross-section or BFE lines in the FIRM database.

### 4.5.2 FIS Report

The Project Team should list dams (with names, NID ID, and State ID) and non-dam features in the FIS Report regardless of their use in H&H modeling. Features not used for hydraulic modeling are to be listed in the Non-Levee Flood Protection Measures table, and the team should capture them in the FIRM database. Important dam-specific information to capture could include NID ID or a State-specific ID, the year built, length, height, storage volume, construction type, drainage area, Hazard Potential Class, etc.

Dams used in detailed hydrologic and/or hydraulic models should be represented on the Flood Profile or Summary of Non-Coastal Stillwater Elevations, as appropriate for the study reach. The dam name and ID on the Flood Profile should correspond to the FIRM and the FIRM database. The Project Team should include a description of how dams were modeled in the FIS Report. Refer to the guidelines presented in the FIS Report Technical Reference, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, for specific formatting and usage.

Published sources of data for dam information used in the Flood Risk Project should be listed in the Bibliography and References section of the FIS Report.

### 4.5.3 Flood Risk Products

Dam-Specific Flood Risk Products have been developed to effectively communicate risk to a broad audience. FEMA and Project Team members should use discretion when considering whether to produce these dam datasets and where to apply them as part of a Flood Risk Project. Dam-Specific Flood Risk Datasets can increase the community's risk awareness and/or lead them to mitigation actions. However, multiple factors must be considered before including these datasets in the project. Refer to Dam-Specific Non-Regulatory Flood Risk Datasets, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, for specific usage of these non-regulatory products.

After consulting the data sources presented in Subsection 4.1.1, the Project Team should capture the identified dam features in the Flood Risk Database for further Flood Risk Product availability. Pertinent Dam Flood Risk information, such as information from the NID and State dam inventory, is to be included in the Flood Risk Report, if available.

Dam-Specific Non-Regulatory Flood Risk Datasets identified for use in a project should be provided to communities during the life of a Flood Risk Project and should be updated after their initial delivery.

## 5.0 Other Federal Agency Collaboration

Other Federal agencies perform dam engineering and participate in dam safety in the United States through a series of congressional authorizations specific to their agency. These authorizations cover a wide range of activities, including operation and maintenance of dams under the jurisdiction of the specific agency, maintenance of the NID by USACE, the FERC regulatory oversight authority for dam safety of commercial hydropower dams, Federal agencies with review authority of dams under their jurisdiction, and the NRCS authority to provide technical support for non-Federal sponsors for watershed protection.

FEMA collaborates with these various Federal agencies as the lead Federal agency with the NDSP and in FEMA's regulatory role to provide flood hazard mapping under the NFIP.

As the lead for the NDSP, FEMA coordinates with the NDSRB and with the Interagency Committee on Dam Safety (ICODS) as discussed below.

- NDSRB advises the FEMA Administrator in setting national dam safety priorities and considers the effects of national policy issues affecting dam safety. NDSRB members include FEMA, the Chair of the Board, and representatives from four Federal agencies (U.S. Departments of Agriculture, Commerce, Homeland Security, and the Interior) that serve on ICODS, five State dam safety officials, and one member from the private sector.

- ICODS was founded in 1980 to encourage the establishment and maintenance of effective Federal programs, policies, and guidelines to enhance dam safety and security. The implementation of FEMA P-64, Federal Guidelines for Dam Safety, is an example of the coordination and information exchange among Federal agencies. ICODS serves as the permanent forum for the coordination of Federal activities pertaining to dam safety and security. FEMA also chairs ICODS.

Federal agencies that are part of the NDSRB and/or ICODS include:

- FEMA
- FERC
- IBWC
- Mine Safety & Health Administration (MSHA)
- National Oceanic and Atmospheric Administration (NOAA)
- National Park Service (NPS)
- NRCS
- Nuclear Regulatory Commission (NRC)
- TVA
- U.S. Bureau of Land Management (BLM)
- U.S. Department of Energy
- U.S. Environmental Protection Agency
- U.S. Forest Service (USFS)
- USACE
- USBR
- U.S. Fish and Wildlife Service (USFWS)

Several Federal agencies have missions that result in close collaboration with FEMA in support of the NDSP. Table 3, below, illustrates the collaborative roles that selected Federal agencies have with the NDSP and the FEMA Risk MAP program.

**Table 3: Federal Agency Collaboration with FEMA Related to Dams**

| Agency | Role/Authority | Collaboration with FEMA |
|---|---|---|
| USACE | • Operates and maintains approximately 700 Federal dams<br>• Is a member of the NDSRB and ICODS<br>• Maintains the NID<br>• Develops national dam design/ operations/maintenance standards and guidelines | • Developed H&H models of dams for design and dam safety that may be leveraged by FEMA<br>• Maintains the NID as a source of regulated dam data<br>• USACE H&H guidance for modeling dams |
| USBR | • Owns and operates approximately 340 Federal dams<br>• Is a member of the NDSRB and ICODS<br>• Developed national dam design/ operations/maintenance standards and guidelines | • Developed H&H models of dams for design and dam safety that may be leveraged by FEMA<br>• USBR H&H guidance for modeling dams |
| NRCS | • Designed more than 24,000 dams for non-Federal owners, with approximately 12,000 dams designed included in the NID<br>• Maintains NRCS Dam Watch to monitor and store dam data for approximately 12,000 dams<br>• Developed national dam design/ operations/maintenance standards and guidelines | • Developed H&H models of dams for design and dam safety that may be leveraged by FEMA<br>• Dam Watch data<br>• NRCS National Engineering Handbook methodology widely used for H&H modeling |
| FERC | • Has regulatory authority for dam safety of non-Federal hydropower dams<br>• Developed national dam design/dam safety/operations/maintenance standards and guidelines<br>• Maintains an elibrary of dam data from dam owner applicants | An elibrary contains H&H models of dams for design and dam safety that may be leveraged by FEMA (requires dam owner permission for release) |
| NPS | Owns, operates, and maintains approximately 100 Federal dams | H&H models of dams for design and dam safety that may be leveraged by FEMA |
| USFS | • Has review authority for design and dam safety of dams on USFS land<br>• Owns, operates, and maintains 1,745 dams (excluding mine tailing dams) on USFS lands in the NID; the USFS owns and operates 499 of these dams; the remainder are non-USFS-owned dams owned and operated under Special Use Permit or other authorities | H&H models of dams for design and dam safety that may be leveraged by FEMA |

| Agency | Role/Authority | Collaboration with FEMA |
|---|---|---|
| USFWS | • Owns, operates, and maintains Federal dams under its jurisdiction | H&H models of dams for design and dam safety that may be leveraged by FEMA |
| NRC | • Has review authority for dams that impact a commercial nuclear powerplant<br>• Developed national dam design/dam safety/operations/maintenance standards and guidelines | H&H models of dams for design and dam safety that may be leveraged by FEMA |
| TVA | • Owns/operates 49 dams under its jurisdiction<br>• Is a member of ICODS | H&H models of dams for design and dam safety that may be leveraged by FEMA |
| MSHA | • Has review authority for dams that are part of a mining permit application | H&H models of dams for design and dam safety that may be leveraged by FEMA |
| IBWC | • Has jurisdiction of 11 dams (two storage, four diversion, and five sediment and flood control) with review and dam safety oversight<br>• Is a member of ICODS | H&H models of dams for design and dam safety that may be leveraged by FEMA |
| USGS | • Provides data for mapping and GIS products<br>• Provides stream gage monitoring and records data | Data provider of stream gage records, high-water mark data, GIS mapping data |
| NOAA | • Provides precipitation gage records<br>• Provides real-time and flood forecasting | Data provider for rainfall data and river forecasting hydrographs and flood elevations |

## 6.0 Definitions

Table 4 presents definitions of terms that are commonly used in the field of dam mapping and their definitions.

**Table 4: Terms and Definitions**

| Term | Definition | Source |
|---|---|---|
| 1-percent-annual-chance floodplain | The floodplain inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. | Adapted from FEMA website https://www.fema.gov/flood-zones |
| 1-percent-annual-chance flood | The flood having a 1-percent chance of being equaled or exceeded each year. The 1-percent-annual-chance flood also is referred to as the base flood or 100-year flood. | Adapted from FEMA website https://www.fema.gov/flood-zones |
| Acre-foot | A unit of volumetric measure that would cover 1 acre to a depth of 1 foot. It is equal to 43,560 cubic feet. | FEMA 148 |
| Backwater | Backwater occurs when ineffective flow pools at the downstream end of incoming tributaries. Backwater from the receiving stream or other water body is represented as a static elevation at the downstream end of the profile. The backwater elevation is represented as a horizontal line using the applicable line type for each recurrence interval. The backwater is projected upstream until it intersects the corresponding modeled profile. If the receiving water body does not have a regulatory BFE, backwater is not displayed on the profile and a limit of study label is placed at the downstream location on the tributary where the approximate 1-percent-annual-chance profile would be greater than the tributary stream 1-percent-annual-chance profile and identified with a note reading "1-percent-annual-chance-backwater effects from [name of main stream]." | FEMA, Flood Profiles (November 2016) |
| Base Flood | The flood having a 1-percent chance of being equaled or exceeded in any given year. | 44 CFR §59.1 |

| Term | Definition | Source |
|---|---|---|
| Conveyance | The movement of a stream of water and/or other mobile substances from place to place. | Adapted from NRCS "Flow" https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmctn6333.pdf |
| Covenant | An agreement, a legally binding contract | |
| Dam | An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water. | FEMA 148 and FEMA P-94 |
| Dam failure | Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release. | Adapted from FEMA 148 |
| Dam safety | The art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. | Adapted from FEMA 148 |
| Embankment | A raised structure of earth, rocks, or gravel, usually intended to retain water or carry a roadway. | USACE ER-1110-2-1156 |
| Emergency Action Plan | A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood. | FEMA 148 |
| Erosion | The wearing away of a surface (bank, streambed, embankment, or other surface) by floods, waves, wind, or any other natural process. | FEMA 148 |
| Flood Hazard Boundary Map | An official map of a community, issued by the Federal Insurance Administrator, where the boundaries of the flood, mudslide (i.e., mudflow), or related erosion areas having special hazards have been designated as Zones A, M, and/or E. | 44 CFR § 59.1 |
| Flood Insurance Rate Map | An official map of a community, on which the Federal Insurance Administration has delineated both the Special Flood Hazard Areas and the risk premium zones applicable to the community. | IS-9, Managing Floodplain Development Through the NFIP |

| Term | Definition | Source |
|---|---|---|
| Flood Insurance Study Report | A report published by FEMA for a community in conjunction with the community's FIRM. The report contains background data that includes the base flood discharges and WSELs that were used to prepare the FIRM. | Adapted from IS-9, Managing Floodplain Development Through the NFIP |
| Flood Retention | The storage of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. | Adapted from FEMA 148 “Flood Storage” |
| Floodplain | An area adjoining a body of water or natural stream that may be covered by floodwater. Also, the downstream area that would be inundated or otherwise affected by the failure of a dam or by large floodflows. The area of the floodplain is generally delineated by a frequency (or size) of flood. | Adapted from FEMA 148 |
| Freeboard | A factor of safety usually expressed in feet above a flood level for purposes of floodplain management. “Freeboard” tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed. At times, overbuild to account for long-term settlement and incrementing the height to ensure maintenance access during flood events is referred to as freeboard as well. For dams and purposes of the NFIP, this is the vertical distance between a specified stillwater (or other) reservoir surface elevation and the top of the dam, without camber. | Adapted from Levees and FEMA 148 |

| Term | Definition | Source |
|---|---|---|
| Hazard Potential | The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from floodwaters released through spillways and outlet works of the dam, or from waters released by partial or complete failure of the dam. An area upstream of the dam also may be impacted by the effects of backwater flooding or landslides around the reservoir perimeter. | Adapted from FEMA 148 |
| Hydraulic Analysis | An engineering analysis of a flooding source carried out to determine how floodwaters will move within the system in response to differing discharge quantities. | Levees |
| Impoundment | Body of water created by a dam or non-dam feature. | USBR Glossary, https://www.usbr.gov/library/glossary |
| Lake | A water-filled basin with restricted or no outlet. Includes reservoirs, tidal ponds, and playas. | NRCS, https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmctn6333.pdf |
| 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 to reduce flood hazards posed by temporary flooding. | 44 CFR § 59.1 |
| Mapping Partner | A local, State, or regional entity (e.g., participating NFIP community, State agency/authority, local or regional conservation district, regional watershed entity, or CTP) that has established a relationship and agreement with FEMA to be a more active participant in the FEMA flood hazard mapping program and take on responsibility for development of Flood Hazard Risk Products in partnership with FEMA (. | |

| Term | Definition | Source |
|---|---|---|
| National Inventory of Dams (NID) | An inventory that contains information on more than 90,000 dams throughout the U.S. that are more than 25 feet high, hold more than 50 acre-feet of water, or are considered a significant hazard if they fail. The NID is maintained and published by USACE with information from all 50 States, Puerto Rico, and 16 Federal agencies. The NID is available at: https://nid.sec.usace.army.mil | Adapted from USACE ER1110-2-1156 |
| National Levee Database (NLD) | A dynamic, searchable inventory of information, developed by USACE in cooperation with FEMA, is for all levee systems in the U.S. The NLD contains information to facilitate and link activities, such as flood risk communication, levee system evaluation for the NFIP, levee system inspections, floodplain management, and risk assessments. The NLD continues to be a dynamic database with ongoing efforts to add levee data from Federal agencies, States, and Tribes. | Levee Guidance |
| Non-Dam Feature | A physical feature that is not designed, constructed, operated, maintained, or regulated as a flood-control structure, but may inadvertently confine flow during some flood events. Non-dam features (such as roadways and rail transit systems) cross the floodplain and restrict flow, creating incidental flood retention. | |
| Regulatory Floodway | The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water-surface elevation more than a designated height. | 44 CFR § 59.1 |
| Reservoir | A body of water impounded by a dam and in which water can be stored. In the case of mine tailings facilities, it can include the solids as well as the water retained. | FEMA P-94 |

| Term | Definition | Source |
|---|---|---|
| Residual Risk | The risk that remains after all mitigation actions and risk reduction actions have been completed. With respect to dams, FEMA defines residual risk as “risk remaining at any time” (FEMA, 2015, page A-2). It is the risk that remains after decisions related to a specific dam safety issue are made and prudent actions have been taken to address the risk. It is the remote risk associated with a condition that was judged to not be a credible dam safety issue. | USACE ER-1110-2-1156 |
| Risk | The product of the likelihood of a structure being loaded, adverse structural performance (e.g., dam failure), and the magnitude of the resulting consequences. | High Hazard Potential Dams Notice of Funding Opportunity for FY 2019 |
| Risk Assessment | A broad term that encompasses a variety of analytic techniques that are used in different situations, depending on the nature of the risk, the available data, and needs of decision makers. A risk assessment is a systematic, evidence-based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current condition and the same values resulting from a changed condition due to some action. Risk assessment includes explicit acknowledgment of the uncertainties in the risk. As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action. | USACE ER-1110-2-1156 |

| Term | Definition | Source |
|---|---|---|
| Special Flood Hazard Area | The land in the floodplain within a community subject to a 1-percent or greater chance of flooding in any given year. The area may be designated as Zone A on the FHBM. After detailed ratemaking has been completed in preparation for publication of the FIRM, Zone A usually is refined into Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, or V1-30, VE, or V. For purposes of these regulations, the term "special flood hazard area" is synonymous in meaning with the phrase "area of special flood hazard." | Adapted from 44 CFR § 59.1, "Area of special flood hazard" |
| State | Any State of the United States, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. | 44 CFR § 59.1 |
| State Dam Safety Agency | A State agency that has regulatory authority over the safety of non-Federal dams. | 33 USC § 467(14) |
| Storage | The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. | FEMA 148 |
| Watershed | The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam. | FEMA 148 |

## 7.0 References


Association of State Dam Safety Officials . (2019). Association Webpage. Available at: https://damsafety.org/

Code of Federal Regulations, Title 44—Emergency Management and Assistance, Chapter I—Federal Emergency Management Agency, Department of Homeland Security, Subchapter B—Insurance and Hazard Mitigation, Subjgrp—National Flood Insurance Program, Part 59—General Provisions, Subpart A—General, Section 59.1—Definitions. (2018). Available at: https://www.govinfo.gov/app/details/CFR-2018-title44-vol1/CFR-2018-title44-vol1-sec59-1

Federal Emergency Management Agency (FEMA). (April 2004). Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams. FEMA 333. Available at: https://www.fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf

FEMA. (April 2004). Federal Guidelines for Dam Safety: Glossary of Terms. Available at: https://www.fema.gov/media-library/assets/documents/3904

FEMA. (July 2013). Federal Guidelines for Dam Safety: Emergency Action Planning for Dams. FEMA 64. Available at: https://www.fema.gov/media-library-data/5b20db599c212f77fd5e85d256f471a3/EAP+Federal+Guidelines_FEMA+P-64.pdf

FEMA. (July 2013). Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures. FEMA P-946. Available at: https://www.fema.gov/media-library/assets/documents/34193

FEMA. (August 2013). Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams. FEMA P-94. Available at: https://www.fema.gov/media-library/assets/documents/3898

FEMA. (November 2015). Guidance for Flood Risk Analysis and Mapping: Riverine Mapping and Floodplain Boundaries Guidance. Guidance Document 60. Available at: https://www.fema.gov/media-library-data/1449866809789-9c0d4332ad18d207f33c72cfe9dc3b1a/Riverine_Mapping_and_Floodplain_Guidance_Nov_2015.pdf

FEMA. (May 2016). Guidance for Flood Risk Analysis and Mapping: Dam-Specific Non-Regulatory Flood Risk Datasets. Guidance Document 68. Available at: https://www.fema.gov/media-library-data/1468328608995-3ae941087722dad94f19b4de4a7dc7d9/Dam_FRP_Guidance_May_2016.pdf

FEMA. (November 2016). Guidance for Flood Risk Analysis and Mapping: Flood Profiles. Guidance Document 85. Available at: https://www.fema.gov/media-library-data/1485269649213-8f3f5dd54ab7c3ded7d5bcecaff61eab/Flood_Profiles_Guidance_Nov_2016.pdf

FEMA. (November 2016). Guidance for Flood Risk Analysis and Mapping: General Hydraulics Considerations. Guidance Document 52. Available at: https://www.fema.gov/media-library-data/1559218975056-a8d9146102a59f74c1442af50644e30a/General_Hydraulics_Guidance_Nov_2016.pdf

FEMA. (November 2016). Guidance for Flood Risk Analysis and Mapping Hydraulics: One-Dimensional Analysis. Guidance Document 80. Available at: https://www.fema.gov/media-library-data/1484864685338-42d21ccf2d87c2aac95ea1d7ab6798eb/Hydraulics_OneDimensionalAnalyses_Nov_2016.pdf

FEMA. (November 2016). Guidance for Flood Risk Analysis and Mapping Hydraulics: Two-Dimensional Analysis. Guidance Document 81. Available at: https://www.fema.gov/media-library-data/1484864685342-42d21ccf2d87c2aac95ea1d7ab6798eb/Hydraulics_TwoDimensionalAnalyses_Nov_2016.pdf

FEMA. (August 2018). MT-2 Application Forms and Instructions for Conditional Letters of Map Revision and Letters of Map Revision. Available at: https://www.fema.gov/media-library/assets/documents/1343

FEMA. (February 2019). Guidance for Flood Risk Analysis and Mapping: Levees. Guidance Document 95. Available at: https://www.fema.gov/media-library-data/1556726741363-2334a11b0de5b35a1e3210353c06148f/Levee_Guidance_Feb_2019.pdf

FEMA. (February 2019). Guidance for Flood Risk Analysis and Mapping: General Hydrologic Considerations. Guidance Document 71. Available at: https://www.fema.gov/media-library-data/1556727028010-090889650cfe5ad6845c3f2f39863053/General_Hydrologic_Considerations_Guidance_Feb_2019.pdf

FEMA. (February 2019). Guidance for Flood Risk Analysis and Mapping: Hydrology: Rainfall-Runoff Analysis. Guidance Document 91. Available at: https://www.fema.gov/media-library-data/1556726907712-531c28be5da64efc564530a5a167ade4/Hydrologic_Rainfall_Runoff_Analysis_Feb_2019.pdf

FEMA. (February 2019). Guidance for Flood Risk Analysis and Mapping: Mapping Base Flood Elevations on Flood Insurance Rate Maps. Guidance Document 31. Available at: https://www.fema.gov/media-library-data/1556723016883-db56f22acada9046862b968b44e86b8f/BFE_Mapping_Guidance_Feb_2019.pdf

FEMA. (June 2019). Guidelines and Standards for Flood Risk Analysis and Mapping webpage (www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping

FEMA. (July 2019). Hydrologic Models Meeting the Minimum Requirement of National Flood Insurance Program. Available at: https://www.fema.gov/hydrologic-models-meeting-minimum-requirement-national-flood-insurance-program

FEMA. (July 2019). Hydraulic Numerical Models Meeting the Minimum Requirement of National Flood Insurance Program. Available at: https://www.fema.gov/hydraulic-numerical-models-meeting-minimum-requirement-national-flood-insurance-program

FEMA. (September 2019). Interagency Committee on Dam Safety webpage. Available at: https://www.fema.gov/interagency-committee-dam-safety

FEMA. (September 2019). National Dam Safety Program webpage. Available at: https://www.fema.gov/national-dam-safety-program

FEMA. (September 2019). Rehabilitation of High Hazard Potential Dam Grant Program webpage. Available at: https://www.fema.gov/rehabilitation-high-hazard-potential-dam-grant-program

FEMA. (October 2019). The National Dam Safety Review Board webpage. Available at: https://www.fema.gov/national-dam-safety-review-board

Natural Resources Conservation Service (NRCS). (February 2005). Terminology and Definitions Associated with Revegetation. Available at: https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmctn6333.pdf

NRCS. (June 2012). Regions Map. Available at: http://www.nrcs.usda.gov/about/organization/regions.html

Stalker, T. (August 2013). Decade of Work to Reduce Flood Risk Nearly Complete in Napa. Retrieved from USACE Sacramento District Website: http://www.spk.usace.army.mil/Media/NewsStories/tabid/1033/Article/479184/deca de-of-work-to-reduce-flood-risk-nearly-complete-in-napa.aspx

U.S. Army Corps of Engineers (USACE). (March 31, 2014). ER 1110-2-1156, Engineering and Design: Safety of Dams—Policy and Procedures. Available at: https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf

USACE. (June 2019). National Inventory of Dams (NID) database. Available at: http://nid.usace.army.mil

U.S. Bureau of Reclamation. (2019). Reclamation Library, Glossary. Available at: https://www.usbr.gov/library/glossary/

## Related Templates Associated with this Guidance

The following templates will help practitioners comply with the guidance contained in this document and will help with overall Risk MAP program consistency. When they have been reviewed and comments have been addressed, the templates will be stored individually on the fema.gov Flood Risk Analysis and Mapping webpage under the "Templates and Other Resources" link (http://www.fema.gov/media-library/assets/documents/32786?id=7577). They are merely provided here to aid in the consolidation of review comments to one document.