



Emergency Operations Planning: Dam Incident Planning Guide

Dam Safety Collaborative Technical Assistance

November 2019



FEMA

This guide provides Dam Safety Technical Assistance (TA) participants with considerations for a Dam Incident Annex and the types of information often included in such plans. The content in this document is not prescriptive. TA participants may choose to use all, some, or none of the concepts as they develop annexes to their Emergency Operations Plans (EOPs), Comprehensive Emergency Management Plans, or other planning architectures.

Contents

1	Introduction.....	4
1.1	Purpose.....	4
1.2	Background.....	4
1.3	Scope.....	6
2	Planning Principles	8
2.1	Considerations to Inform the Six-Step Planning Process for Dam Incident Planning	8
2.2	Roles and Responsibilities	11
2.2.1	Dam Owners and Operators.....	13
2.2.2	Private Sector and Nongovernmental Organizations.....	13
3	Key Concepts.....	14
3.1	Preventing and Mitigating a Dam Incident.....	14
3.2	Understanding a Dam Incident	14
3.2.1	Overview of Types of Dams.....	15
3.2.2	Overview of Potential Dam Incidents.....	17
3.2.3	Notice Incidents vs. No-Notice Incidents	18
3.2.4	Gathering Information about the Dam.....	19
3.3	Planning Considerations	21
3.4	Instituting a Phased Approach to Dam Incidents.....	23
3.5	Triggers and Activation	26
3.6	Protective Actions by Dam Incident Type.....	28
4	Developing an Evacuation Strategy.....	31
4.1	Phases of an Evacuation.....	31
4.2	Evacuation Orders.....	32
4.2.1	Delay Times.....	33
4.2.2	Evacuation Zone Identification.....	34
4.3	Recovery Factors for a Dam Incident	35
	Appendix A: Dam Incident Annex Template	37
	Appendix B: Planning Checklist.....	39
	Appendix C: Glossary	50
	Appendix D: Acronym List.....	53
	Appendix E: References.....	54
	Appendix F: Resources	57

1 Introduction

1.1 Purpose

The Federal Emergency Management Agency's (FEMA) National Dam Safety Program (NDSP) offers a Dam Safety Technical Assistance (TA) program. Through this program, emergency managers work collaboratively with neighboring communities, agencies, and the private sector to gain a detailed understanding of the risks they face from local and regional dams and how those risks can be addressed. A key product of the TA program is a completed dam incident plan or annex, which this guide has been produced to inform.

This *Dam Incident Planning Guide* supports state, local, tribal, and territorial emergency managers in planning for dam incidents and failures by summarizing the concepts that a community should consider when creating dam incident-specific elements of local emergency operations plans. This guide builds on *Comprehensive Preparedness Guide (CPG) 101: Developing and Maintaining Emergency Operations Plans*.¹ It also provides guidance for dam owners and operators on how to engage with emergency managers prior to an incident to ensure a well-coordinated response. Appendix A provides a general template for a community dam incident plan that can be adapted to meet each community's needs.

Some communities will choose to address dam incidents in an annex to their emergency operations plan (EOP) or comprehensive emergency management plan or as an appendix to other base planning products, or they will create a stand-alone dam incident plan. Emergency managers should choose the option that aligns to their planning architecture. Plans or annexes produced using this guide are intended to supplement, not replace, existing plans. In addition, dam incident plans should integrate and be consistent with any existing evacuation and/or protective action plans. Preparedness is a shared responsibility; it calls for the involvement of the whole community – not just the government – in preparedness efforts. By working together, everyone can help in preventing dam failures and reducing the impacts on lives and property that may be at risk from a dam failure.

1.2 Background

From January 2005 through June 2013, state dam safety programs reported 173 dam failures and 587 "incidents" — episodes that, without intervention, would likely have resulted in dam failure.² This document will use "dam incident" to refer to dam failures and other incidents that have the potential to harm downstream populations and/or infrastructure. A dam incident is an impending or actual sudden uncontrolled release or excessive controlled release of water from a dam breach or a failure of a critical appurtenant structure that impounds water such as a saddle dam or spillway structure. The release may be caused by damage to or failure of the structure, flood conditions unrelated to failure, or any condition that could affect the safe operation of the dam. The release of water might endanger human life, downstream property, or the operation of the structure.³ All dam failures are "dam incidents"; however, not all dam incidents are the result of failures. Figure 1 illustrates the relationship between these two terms.

¹ FEMA (Federal Emergency Management Agency) (2010). *Comprehensive Preparedness Guide 101: Developing and Maintaining Emergency Operations Plans*. Available at <https://www.fema.gov/media-library/assets/documents/25975>, accessed February 27, 2019.

² Association of State Dam Safety Officials (2019). *Dam Failures and Incidents*. Available at <https://damsafety.org/dam-failures>, accessed February 27, 2019.

³ FEMA (2013a). *Federal Guidelines for Emergency Action Planning for Dams*. Available at <https://www.fema.gov/media-library/assets/documents/3357>, accessed February 27, 2019.

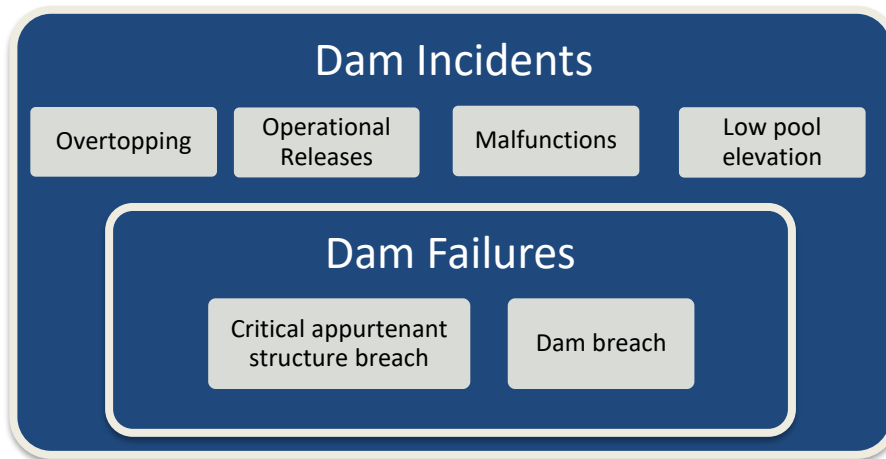


Figure 1: Example Dam Incidents and Dam Failures

Dam safety experts recognize that there are degrees of failure and that any malfunction or abnormality — outside of the design assumptions and parameters — which adversely affects a dam’s primary function of impounding water is properly considered a failure. Such lesser failures could ultimately lead to or heighten the risk of a catastrophic failure. They are, however, normally amendable to corrective action.⁴ The failure of a dam may be one of rapid onset, as in the case of equipment failure or a deliberate event; or of a long-developing situation preceded by prolonged heavy rain, snow melt and runoff, debris build up, or cascading failure of upstream dams.⁵

A *dam incident* other than a failure is an emergency that threatens the integrity of the dam or its components and could result in an increased risk to nearby populations. An incident includes operational releases from the dam (e.g., principal spillway, emergency/auxiliary spillway) that can result in flooded roads, homes, or businesses. Low pool elevations could also be considered a dam incident. This type of incident could result in loss of the benefit that the dam provides to the community, such as adverse impacts to shipping routes or reduced water or power availability.

Consequences of dam incidents require significant public-private collaboration with local, state, tribal, territorial, and federal emergency management agencies, as well as private sector organizations, dam owners, and operators. Prior to these incidents, emergency managers and dam owners and operators should understand what impacts these incidents may have on local and regional populations and infrastructure; what resources will be required to respond to and recover from these incidents; and how and where emergency managers, dam owners, and operators should collaborate prior to, during, and after a dam incident.

The coordination of protective actions for the public, such as evacuation and shelter-in-place orders, is one of the most significant responsibilities for emergency managers during a dam incident. If communities have an existing evacuation and/or protective action plan, their dam incident plan should

⁴ FEMA (2004a). *Federal Guidelines for Dam Safety: Glossary of Terms*. Available at <https://www.fema.gov/media-library-data/20130726-1516-20490-9730/fema-148.pdf>, accessed February 27, 2019.

⁵ The term *dam* is used throughout this document; however, levees and other water control devices would also be subject to many of the same hazards and protective actions.

PLAN COORDINATION

Community EOPs and dam emergency action plans (EAPs) should be written and updated in close coordination to ensure consistency and common understanding.

Coordination points include addressing the following:

- What incidents or potential problems necessitate heightened awareness?
- At what point in a potential incident should the dam operators notify emergency managers? Who in each organization will be responsible for sending and receiving these notifications?
- Coordinated decision making on issuing community alerts and warnings
- Coordination of protective actions such as evacuations as well as re entry
- Joint understanding of evolving dependencies and interdependencies (see page 23 for more on this topic)

be consistent with the concepts in that plan. Other plans should also be reviewed to ensure compatibility with the dam incident plan. For example, other plans should be reviewed to ensure that evacuation shelters are not located within an inundation area. If an evacuation and/or protective action plan does not exist, community planners should ensure that all evacuation recommendations in this plan are consistent with evacuation and/or protective action considerations in other plans. Community planners should review and update this plan regularly to help ensure that it remains consistent with other relevant plans.

Many dam owners and operators are required to create an Emergency Action Plan (EAP) to address how they will conduct operations during a dam incident. Communities creating a dam incident plan should ensure their planning efforts integrate the information in each dam's EAP into the planning process. Detailed information on dam emergency action planning can be found in the *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams*.⁶

1.3 Scope

This guide is intended to help community planners create a plan to respond to dam incidents that take place in, or affect, their communities. Some communities will choose to address dam incidents in an annex to their emergency operations plan (EOP) or comprehensive emergency management plan or as an appendix to other base planning products, or they will create a stand-alone dam incident plan. Emergency managers should choose the option that aligns to their planning architecture. During the planning process, community planners should identify government agencies, nongovernmental organizations (NGOs), private sector entities, and individuals who are directly responsible for emergency response and support services during a dam incident. These entities should then be considered for inclusion in the collaborative planning team and have clear roles and responsibilities in the plan. The planning process should also result in a clear management structure for coordinating and deploying essential resources.

The potential consequences from each dam incident vary by the dam type, downstream characteristics, affected populations, infrastructure, and economies. Dam incident plans must be scalable and include considerations for incident detection, evaluation, and emergency-level determination (i.e., severity of the incident), as well as notification and communication processes, emergency actions, and post-

⁶ FEMA (2013a). *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams*. Available at <https://www.fema.gov/media-library/assets/documents/3357>, accessed February 27, 2019.

FEMA Dam Incident Planning Guide

incident recovery efforts. The plan should guide protective action decision-making when there is actual, potential, or imminent threat to the health, safety, or welfare of persons or property.

Plans created using this guide will enhance a community's ability to work collaboratively with dam owners and operators, neighboring communities, private sector partners, and governmental agencies.

2 Planning Principles

The principles described in this section provide broad concepts to follow during the six-step planning process. Planning partners should agree to adopt these principles and ensure that they are included in all steps of the planning process.

The six-step planning process described in FEMA’s *CPG 101* is shown in Figure 2.⁷



Figure 2: Six-Step Planning Process in FEMA’s CPG 101 (Source: FEMA 2010⁷)

2.1 Considerations to Inform the Six-Step Planning Process for Dam Incident Planning

The following concepts should be included within the six steps of the dam incident planning process.

Involve Defined Authorities on the Planning Team

Dam incident planning must be consistent with existing authorities, roles, and responsibilities, as defined in current statutes, regulations, delegations of power, memoranda of understanding/agreement (MOUs/MOAs), policies, and other guidance documents. The driving authority for the community dam incident plan is usually the local agency that has authority to issue protective action or evacuation orders. However, sometimes the authority is the governor’s office, a local dam safety official, the mayor, a policy group, a county executive, the sheriff, a county judge, or others. If this is the case, the entity with this authority should be involved in the planning process. It is also important to consider the authorities and regulations under which each dam may operate. Some dams are privately owned, others owned by local or state organizations, and some are federally owned.⁸ Each of these dam owners and

⁷ FEMA (2010). *Comprehensive Preparedness Guide 101: Developing and Maintaining Emergency Operations Plans*. Available at <https://www.fema.gov/media-library/assets/documents/25975>, accessed February 27, 2019.

⁸ A comprehensive report of coordination between federal dam owners (e.g., U.S. Army Corps of Engineers [USACE]) and state/local emergency managers during the 2010 Cumberland River Basin floods can be found here: <https://www.hsd.org/?view&did=21310>, accessed February 27, 2019.

operators will have some of their own unique requirements for dam safety planning. The community dam incident plan must be informed by each local dam's EAP.

Communities and private sector dam owners should create a memorandum of understanding to identify specific roles, responsibilities, and equipment to be provided during an incident response.

Establish a Common Understanding

Establishing a common understanding of the plan's objectives, strategies, and tactics is important to overall coordination. Plans need to be viable for each community, as well as locally supportable, and they need to be acceptable to the dam owner/operator.

Using familiar terms and strategies helps align planning concepts into one cohesive approach. For example, if all-hazards or hazard-specific evacuation plans exist, those plans should be reviewed and adapted for use during a dam incident. Planners should ensure that terminology is clearly defined and consistent. Many dam-specific terms may not be familiar to emergency management personnel.

Employ Zone-Based Operational Strategies

Plans should articulate operational strategies and support decisions to promote phased, zone-based evacuation or other protective actions for notice and no-notice incidents. This process should be informed by detailed analysis of populations at risk.

Planners should identify specific evacuation zones for areas potentially affected by a dam incident or adapt evacuation zones created for response to other hazards (e.g., hurricanes). Planners may also identify zones as areas nearest the dam (i.e., those immediately downstream) or areas downstream of a dam that are lowest lying and most vulnerable to inundation. Protective action decisions that include evacuation orders or shelter-in-place direction should clearly state that the decision applies only to the specific zones that need evacuating or sheltering.

In the case of dam incidents, the option of "vertical evacuation" should be considered. This concept is most commonly seen when describing evacuations from tsunamis. In that context, a *vertical evacuation refuge* is defined as "a building or earthen mound that has sufficient height to elevate evacuees above the level of tsunami inundation, and is designed and constructed with the strength and resiliency needed to resist the effects of tsunami waves."⁹ In the context of dam incidents, vertical evacuation includes moving to higher, unaffected ground nearby (instead of driving far out of the affected area), or higher in a building that is built to building codes that ensure safety during the incident.

Communities should reference inundation maps and other dam incident modeling tools to understand what populations, infrastructure, and organizations could be affected during an incident.

Similar to the concept of evacuation to higher ground during hazards such as tsunamis, some populations evacuating during a dam incident may need only to move to nearby higher ground instead of driving entirely out of the impact area. Planners should consult inundation mapping products, population locations and types,¹⁰ and local topography to understand if this option is feasible.

⁹ FEMA (2012). *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*. Available at <https://www.fema.gov/media-library/assets/documents/14708>, accessed February 27, 2019.

¹⁰ Individuals with disabilities and others with access and functional needs, for example, may have a more difficult time evacuating quickly to higher ground.

Implement a Unified Coordination Process and Command

Most communities identify the need for specific coordination protocols across jurisdictional and organizational boundaries. When no one community, agency, or organization has primary authority and/or the resources on its own to manage an incident, unified command should be established. In unified command, there is no single incident commander. Instead, the unified command manages the incident using jointly approved objectives, which are often carried out through the unified coordination staff and incident management and support professionals. A unified command allows the participating organizations to retain their own authorities and control their own resources while addressing issues, such as overlapping and competing authorities, jurisdictional boundaries, and resource ownership, in order to navigate setting clear objectives and strategies for an incident. The resulting unity of effort allows resources to be applied regardless of ownership or location. Unified command does not affect individual agency authority, responsibility, or accountability.¹¹

During a dam incident, the dam owner and operator and any significantly affected private sector organizations (such as utility companies) should be included in the unified command structure. Such inclusion helps to ensure a common understanding of the evolving situation at the dam, resulting consequences, and the response actions being taken (see the example in Figure 3).

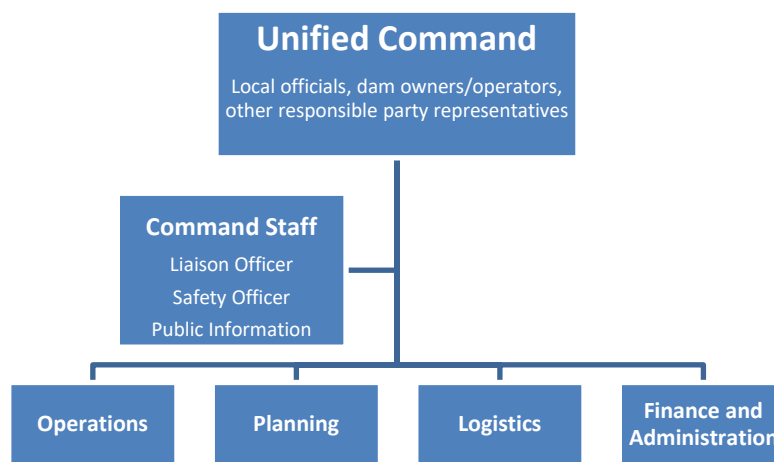


Figure 3: Notional Unified Command Structure

Communities downstream from the planning community's dam(s) should also be included in the planning process as they could experience consequences resulting from an upstream community's dam emergency.

Use a Public/Private Planning Approach

Local community planners should include a whole community approach in developing dam incident plans, including dam owners and operators, other private sector stakeholders, and NGOs. To provide perspective and solicit buy-in, community planners should engage these partners early and throughout the planning process.

¹¹ FEMA (2017). *National Incident Management System: Third Edition*. Available at https://www.fema.gov/media-library-data/1508151197225-ced8c60378c3936adb92c1a3ee6f6564/FINAL_NIMS_2017.pdf, accessed February 27, 2019.

Private and public sector stakeholders such as utility companies, water and wastewater plants, and local businesses should be involved in dam incident planning efforts. This joint planning effort will help to ensure that these private sector organizations understand the potential impacts to their properties and employees, as well as provide them with opportunities to mitigate potential damage and provide resources during a response. This collaboration also helps to ensure that planners understand potential damage to, and restoration timelines for, the private sector and how those may affect the local community during and after a dam incident.

These public and private stakeholders will have diverse needs during a dam incident. Accounting for the characteristics and needs of the community, as well as the resources owned and operated by nongovernmental entities, is vital to responding effectively to a dam incident. This response includes providing for individuals with disabilities and/or access and functional needs, those without access to a vehicle, and those with limited English proficiency (among others).

Articulate Planning Assumptions

Planners estimate potential parameters for an incident and use these assumptions as a context, basis, or requirement for plan development. If one or more of these planning assumptions is not valid for a

Models should not be used as specific maps of how an incident will unfold, as assumptions used during modeling will likely not match actual conditions during the incident.

specific incident's circumstances, the plan might not lead to a successful response.¹² Assumptions are used to enable planning in the absence of actual situational awareness. The assumptions must be clearly documented in the plan. Communities should ensure that they have a clear understanding of assumptions made in dam incident modeling products, such as in inundation maps, and how

changes in those assumptions would affect response requirements. Actions in the plan should be adjusted to the incident as it unfolds.

2.2 Roles and Responsibilities

When mitigating, planning for, and responding to dam incidents, the many of the roles and responsibilities lie with the dam owner/operator and the emergency manager. Figure 4 lays out the major areas of responsibility for these two groups.¹³ The following sections describe the actions of governments, dam owners and operators, and the private sector prior to, during, and following a dam incident.

¹² FEMA (2010). *Developing and Maintaining Emergency Operations Plans: Comprehensive Preparedness Guide 101*. https://www.fema.gov/media-library-data/20130726-1828-25045-0014/cpg_101_comprehensive_preparedness_guide_developing_and_maintaining_emergency_operations_plans_2010.pdf, accessed February 28, 2019.

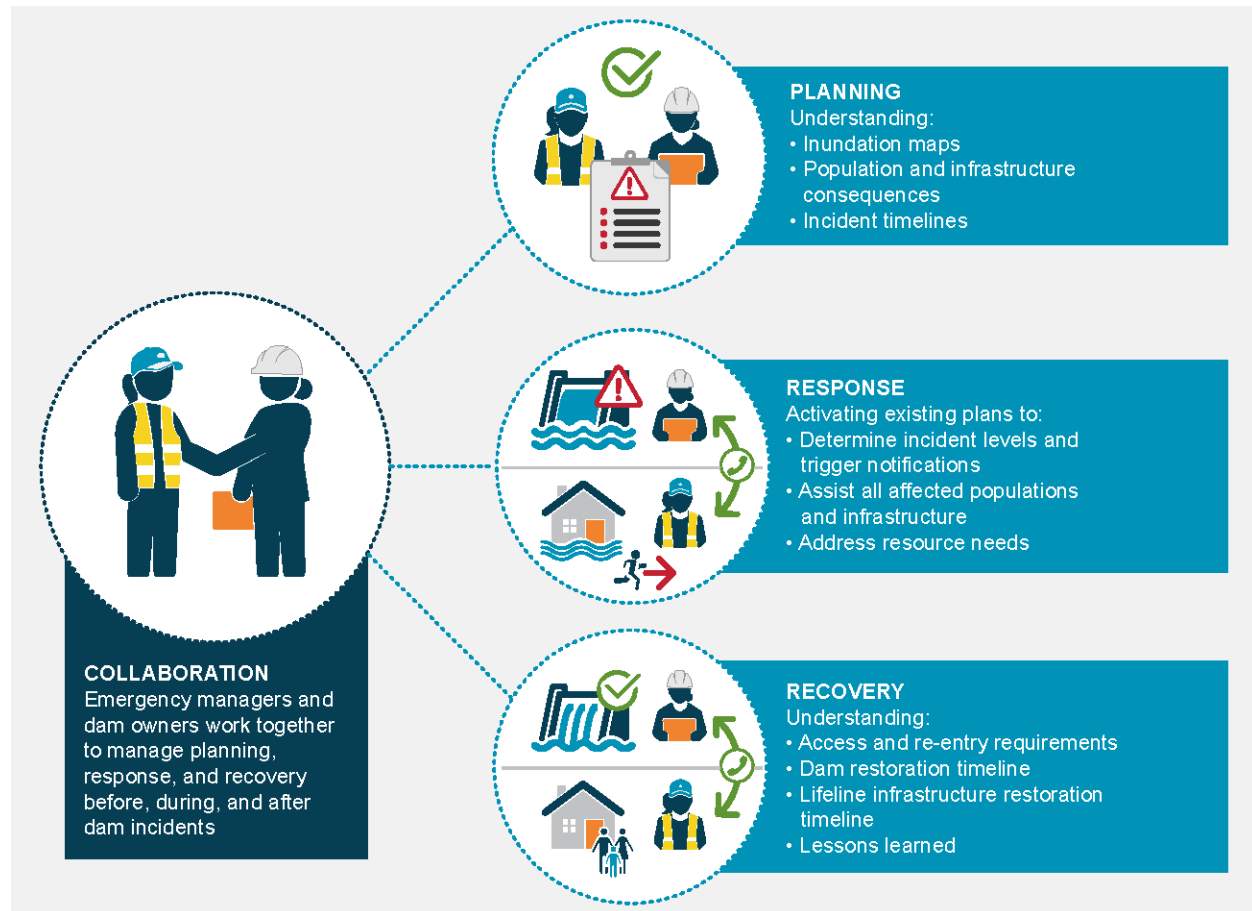


Figure 4: Collaboration between Dam Owners and Emergency Managers, Federal, State, Local, and Tribal Governments

Coordination between all levels of government is important to help ensure consistency in guidance and response actions. A plan should comply with state emergency planning, evacuation, and general emergency management guidance. For dam incidents, government agencies must coordinate with dam owners and operators to ensure ongoing mutual understanding. During an incident, stakeholders should have a shared understanding of the situation at the dam, current and potential future impacts, and the incident timeline.

Considerations for evacuation plans include:

- Issuance of evacuation orders
- Identification and communication of identified evacuation routes
- Management of traffic flow
- Identification of disability-related and access and functional needs
- Identification and communication of the location of shelters for those displaced

In addition, a community should plan for disruptions to government operations and ensure they have continuity of operations and continuity of government plans in place. These plans activate in the event of government disruption and/or government relocation from an impacted area.

Dam owners and operators and emergency management officials should ensure that individuals and families who live within a dam’s inundation zone understand both their risk and their potential evacuation and sheltering arrangement. Officials must also take steps to educate individuals and families

so that they will quickly respond to protective-action messaging. Officials may do this through community engagement offices or dam-specific programs that communicate individual and family roles and responsibilities. As part of their general emergency or disaster preparedness activities, individuals and families should discuss plans for evacuating their homes in the event of a dam incident. For more information, please consult *FEMA's Planning Considerations for Evacuation and Shelter-in-Place*.¹⁴

Significant incidents could require assistance from FEMA or other federal agencies. If unified command decides that federal resources such as FEMA urban search and rescue teams (including swiftwater rescue teams) are necessary, they should work through their established state coordination mechanism (such as a state emergency operations center) to request those resources.

2.2.1 Dam Owners and Operators

Dams can be owned by various entities, including federal and local governments and private sector agencies such as corporations and homeowners' associations. Dam owners and operators should work with emergency managers as a part of the collaborative planning team. Sharing information and plans (such as EAPs) can, in turn, inform community emergency plans and create distinct lines of communication. These plans should be exercised regularly to ensure clear coordination during emergencies.

If dams are used for purposes beyond water retention, such as power generation, water supply, or recreation, dam owners and operators should discuss how loss of those services during a dam incident would affect the community.

Communities should work with dam owners and operators to understand all purposes of local dams in order to plan for impacts to their communities beyond flooding damage. This effort may include, for example, reduced power or water generation or loss of recreational areas.

2.2.2 Private Sector and Nongovernmental Organizations

Private sector entities, not including those who are dam owners (whose responsibilities are discussed above), with locations in the inundation zone also play an important role in dam incident response. Involving these entities in the planning process will provide them with an opportunity to plan for the evacuation or sheltering in place of employees, implement mitigation measures to prevent or lessen damage from a dam incident, and share resources with local communities to assist in dam incident response operations.

NGOs could have locations in the inundation zone and should be included in planning, as well. They are also a rich resource for community support during an incident, including by providing food and shelter for those affected.

Communities should collaborate with private sector partners and NGOs to develop a shared understanding of protective-action concepts, plans, terminology, and roles. Communities should also work with these partners in the planning process to identify resources available to them that could facilitate a large-scale evacuation. From the private sector, this support could include resources such as buses or vans for transportation or retail store parking lots as evacuation points, and mass care supplies such as food and water for evacuees. For NGOs, this support could include services such as sheltering and animal care.

¹⁴ FEMA (2018a). *Planning Considerations: Evacuation and Shelter in Place*. Available at <https://www.fema.gov/media-library/assets/documents/168342>, accessed February 28, 2019.

3 Key Concepts

The following key concepts serve as a foundation for successful dam incident planning. These concepts include developing a thorough understanding of the dam(s) in question, identifying potential mitigation and preventative measures, and identifying opportunities for emergency managers to collaborate with dam owners and operators prior to a dam incident. These activities are supported by a detailed analysis of potential dam incident consequences for downstream populations and infrastructure.

3.1 Preventing and Mitigating a Dam Incident

Preventative measures, such as the maintaining of effective operation, maintenance, and inspection programs by dam owners and operators, are crucial to avoiding a dam incident. These programs allow dam owners and operators to detect unusual or changing conditions that may lead to or signal a dam incident. Dam owners and operators should be encouraged to share their findings regularly with emergency management officials, so that their community is always aware of any potential issues that could lead to an incident.¹⁵ Emergency management officials should also communicate regularly with the dam owners and operators. Suggestions for fostering these relationships include by:

- Hosting regular meetings of the collaborative planning team, including private and public-sector partners, to understand current and future dam operations; and
- Engaging in exercises that examine how staff in emergency operations centers (EOCs) would support or coordinate response to a dam incident and how they would obtain information that triggers protective-action decisions from the dam owners and operators.

Mitigation measures are also important to consider when developing a dam incident plan. Community planners should consider both structural changes (e.g., vegetative buffers) and nonstructural changes (e.g., insurance, zoning, building codes) that can reduce or eliminate potential effects from a dam incident.

3.2 Understanding a Dam Incident

Prior to a dam incident, jurisdictions should work closely with dam owners and operators to ensure that personnel have a thorough understanding of the dams in or impacting their community, what types of incidents may occur, the potential consequences of such incidents, what measures can be taken for different types of emergencies, and when they should be taken. EAPs, which are often created by dam owners and operators, are an important source for developing dam incident plans. If a dam owner or operator does not have an EAP or has an outdated one, involving the owner/operator in the dam incident planning process could provide an impetus for addressing that gap.

EAPs typically include the following information:

- Actions that the dam owner will take to moderate or alleviate a problem at the dam.
- Actions the dam owner will take in coordination with emergency management authorities to respond to incidents or emergencies related to the dam.
- Procedures that dam owners will follow to issue warning and notification messages to downstream emergency management authorities.

¹⁵ Montana Department of Natural Resources and Conservation (2016). *Dam Owner Emergency Intervention Toolbox*. Available at https://damsafety.org/sites/default/files/files/MDNRC%20Dam%20Owner%20Emergency%20Intervention%20Toolbox_Final.pdf, accessed February 28, 2019.

- Inundation maps to help dam owners and emergency management authorities identify critical infrastructure and population-at-risk sites that require protective measures, warning, and evacuation planning.
- Responsibilities of all those involved in managing an incident or emergency and how the responsibilities should be coordinated.
- Authority and procedure for issuing evacuations.
- Communication strategy and toolkit for both governments and the public.

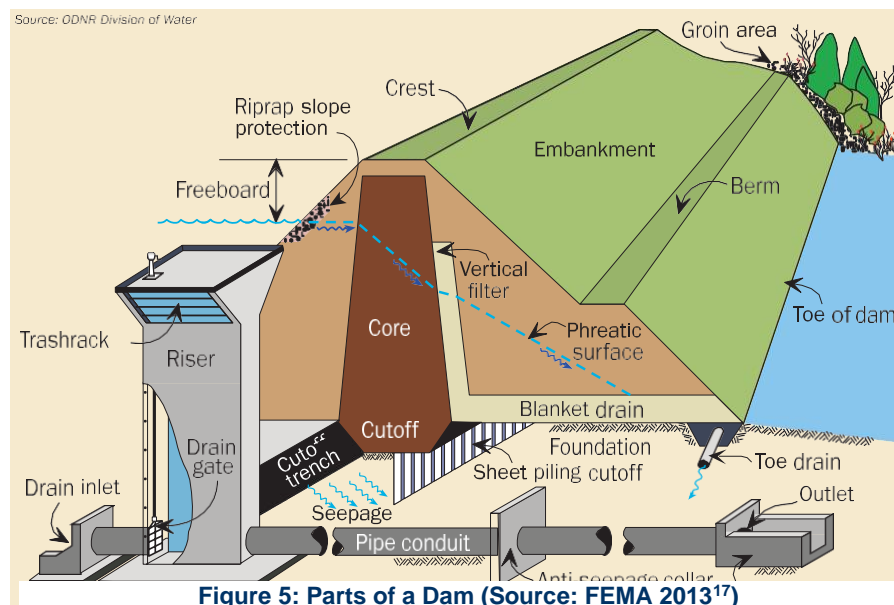
KEY TAKEAWAY

Emergency management officials must understand the impact that a dam incident could have on life and property. Being able both to recognize the dam hazard potential classification and understand potential failure modes provides officials with a better understanding of the potential severity of an incident.

3.2.1 Overview of Types of Dams

Dam incidents vary depending on several factors, including the kind of dam. Understanding common kinds of dams will help scope initial estimates as to the scoping necessary for a community’s dam incident plan. A simple overview of the most common kinds of dams can be found on FEMA’s website in *Types of Dams and Failure Modes*.¹⁶ Descriptions can also be found in FEMA P-956, *Living with Dams: Know Your Risks*.¹⁷

Generally, a dam has a principal (or “service”) spillway and a drawdown facility. Some dams also have auxiliary spillways to handle extremely high water levels. A spillway is a structure that water flows over or through to be discharged into a reservoir. Figure 5 shows some general elements of dams.



¹⁶ FEMA (2019a). *Types of Dams and Failure Modes*. Available at <https://www.fema.gov/types-dams-and-failure-modes>, accessed February 28, 2019.

¹⁷ FEMA (2013c). *Living with Dams: Know Your Risks*. Available at https://www.fema.gov/media-library-data/20130726-1845-25045-7939/fema_p_956_living_with_dams.pdf, accessed February 28, 2019.

Figure 6¹⁸ shows another perspective on dam elements, including principal and auxiliary spillways.

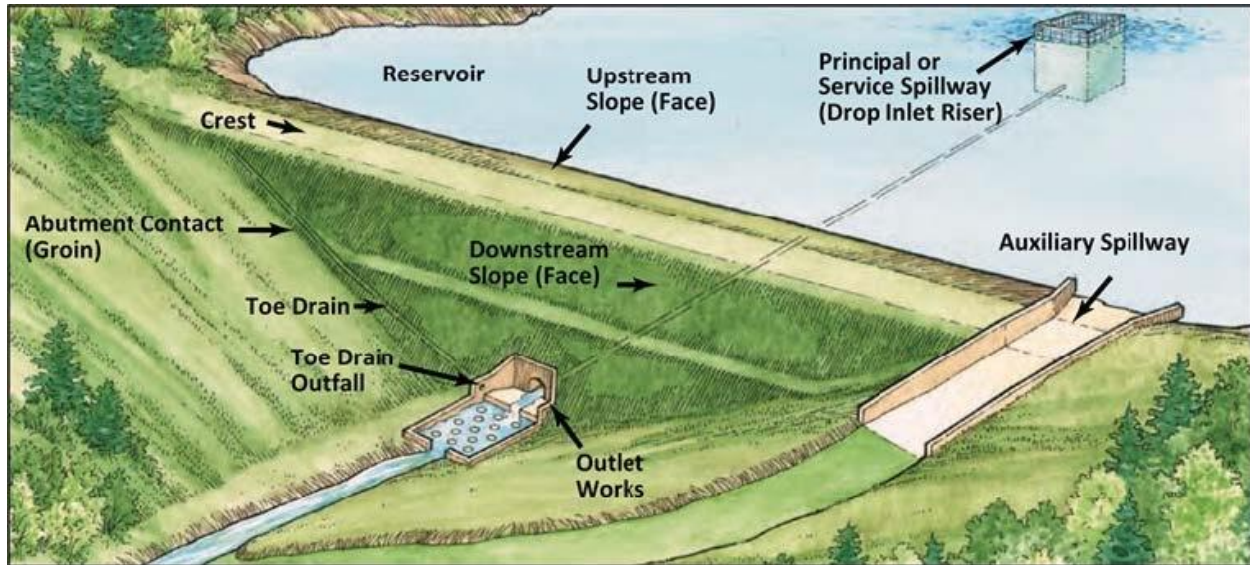


Figure 6: Typical Embankment Dam Elements (Source: FEMA 2016¹⁸)

FEMA's *Hazard Potential Classification System*¹⁹ describes a system for determining and communicating a dam's hazard potential. The classification levels build upon one another.

1. **Low Hazard Potential:** Dams where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to an owner's property.
2. **Significant Hazard Potential:** Dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, and/or disruption of lifeline facilities or can affect other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
3. **High Hazard Potential:** Dams where failure or mis-operation will likely cause loss of human life.

¹⁸ FEMA (2016). *Pocket Safety Guide for Dams and Impoundments*, P-911. Available at <https://www.fema.gov/media-library-data/1478633654726-9b1587e1cbe6898d38ba92c95dbf6f16/FEMAP-911.pdf>, accessed February 28, 2019.

¹⁹ FEMA (2004b). *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams*. <https://fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf>, accessed February 28, 2019.

According to the FEMA definition, more than 27,000 dams in the United States are considered to have high or significant hazard potential. Thus, their failure by any means, including a terrorist attack, could result in loss of life, significant property damage, lifeline²⁰ disruption, and environmental damage.²¹

3.2.2 Overview of Potential Dam Incidents

KEY TAKEAWAY

Understanding the various types of incidents and their potential impacts is important to creating a relevant and useful plan.

A dam incident can occur for many reasons, including as a result of natural hazards (e.g., floods, earthquakes, excessive rainfall) or man-made hazards (i.e., deliberate or negligent human actions). Emergency managers should understand the various types of dam incidents and the impact each type has on the downstream community.

The operators of many dams have conducted a “potential failure mode analysis” (PFMA) to understand the potential causes and effects of incidents or failures of the dam. A “potential failure mode” is defined as a specific chain of events leading to a dam failure.²² The results of the PFMA should be summarized and presented in a way to effectively communicate with stakeholders including non-technical audiences. Reviewing the PFMA provides emergency managers with an understanding of the ways in which a particular dam might fail and what downstream impacts may be seen. PFMA’s, however, are not comprehensive analyses of all potential failures and impacts. They should be used to inform dam incident plans and should be included as one of many data sources.

Dams can fail for one, or a combination of, the following reasons:²³

- Overtopping caused by floods that exceed the capacity of the dam;
- Structural failure of a dam or of materials used in dam construction;
- Spillway deficiency;
- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams;

²⁰ A lifeline provides indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety or to economic security. See: <https://www.fema.gov/media-library/assets/documents/175420>, accessed February 28, 2019.

²¹ The State of California has adopted a fourth category: “Extremely High,” which is defined as affecting highly populated areas or critical infrastructure, or having short evacuation warning times. See: State of California Division of Safety of Dams (2017). *Dams Within Jurisdiction of the State of California*. Available at http://www.water.ca.gov/damsafety/docs/Dams%20by%20Dam%20Name_Sept%202017.pdf, accessed February 28, 2019.

²² FERC (Federal Energy Regulatory Commission) (2017). *Identifying, Describing, and Classifying Potential Failure Modes*. Available at <https://www.ferc.gov/industries/hydropower/safety/initiatives/pfms/pfms.pdf?csrt=17541142006781503552>, accessed February 28, 2019.

²³ FEMA (2019b). *Why Dams Fail*. Available at <https://fema.gov/why-dams-fail>, accessed February 28, 2019.

- Mis-operation of the dam;
- Inadequate maintenance and upkeep; and/or
- Deliberate acts of sabotage.

3.2.3 Notice Incidents vs. No-Notice Incidents

A dam incident can be a notice or no-notice incident. A notice incident is one in which things like advanced weather forecasts, regular inspection of the dam, or intelligence on threats to a particular dam can give emergency management officials some advanced warning that an incident is about to occur. Alternatively, a no-notice incident is one in which there is no lead time to alert emergency management officials (or affected populations) to an incident.

Communities, along with dam owners and operators, should prepare for a no-notice incident as a worst-case scenario. However, regular inspection and maintenance of the dam can help prevent many no-notice incidents from occurring. Man-made incidents, such as hostile actors attacking a dam, are an example of a no-notice incident that regular inspections would not prevent.

When determining the types of protective actions to order, emergency managers should consider the time before impact. While a no-notice incident will always be a surprise, a notice incident that involves forecasted heavy rainfall may provide days or more of advanced notice. The time available before impact is a key factor in decision-making. It might not be reasonable to order a full evacuation of a population if that population has only 20 minutes to flee. Depending on the situation, a phased-evacuation order—in which certain zones adopt a shelter-in-place position until it is safe for them to evacuate—may be preferable.

Table 1 identifies common types of dam incidents based on Sections 3.2.2 and 3.2.3.²⁴

Table 1 – Common Types and Descriptions of Dam Incidents

Incident Type	Incident Description	Notice or No Notice Incident
Damage, Signs of Distress, Instability	Observations of damage, signs of distress, or instability of the dam appurtenant structures.	Notice incident
Dam Breach	Any incident resulting in the breach of a dam (partial or complete).	Either
Controlled Breach	Planned (non-emergency, non-incident-initiated) breach of the dam. Possibly carried out to remove the dam from service, to make major repairs, or as an interim risk reduction measure.	Notice Incident
Downstream Release Controlled or Uncontrolled	Uncontrolled releases from the reservoir (e.g., appurtenant structure mis-operation), or controlled releases that result in downstream damage.	Notice Incident
Mis operation, Operator Error	Mis-operation of appurtenant structures (e.g., failing to comply with the project rule curve).	Either

²⁴ Stanford University National Performance of Dams Program (undated). *What is a Dam Incident?* Available at <http://npdp.stanford.edu/node/41/>, accessed February 28, 2019.

Incident Type	Incident Description	Notice or No Notice Incident
Equipment Failure	Failure of mechanical or electrical equipment to perform the dam safety functions for which they were intended.	Either
Deterioration	Deterioration of concrete, steel, or timber structures that jeopardize the structural/functional integrity of the dam or appurtenant structures.	Either
Inflow Flood	Inflow incidents that: <ul style="list-style-type: none"> • Fill the emergency spillway half-full or more. • Damage or fail any part of the dam system. 	Notice Incident
Landslide or Rockfall	Landslides or rockfalls that: <ul style="list-style-type: none"> • Affect the reservoir operation of a dam or cause damage to elements of the dam system. • Produce wave action that affects the operation of a dam or causes damage to the elements of the dam system. 	No-Notice Incident
Wind Waves	Wave action that affects the operation of the dam system and causes damage to elements of the dam system.	Notice Incident
High Winds	Winds that affect the operation of the dam system and cause damage to elements of the dam system.	Notice Incident
Terrorist Attack	Any man-made event or attack on the dam that could cause damage or failure.	No-Notice Incident
Water Pollution (e.g., toxic contaminants released upstream, harmful algal blooms)	Harmful or toxic substances (e.g., chemicals or biological organisms) that contaminate a body of water, degrade water quality, and render water toxic to humans and/or the environment.	Either
Ice Loading or Icing	Icing that affects the operation of the dam system and causes damage to elements of the dam system.	Notice Incident

3.2.4 Gathering Information about the Dam

KEY TAKEAWAY
Understanding a dam owner and operator’s analysis products will help to ensure that emergency managers know the potential impacts on their communities. Regular communication with dam owners and operators will help emergency management officials keep their plans and dam fact sheets up to date.

Emergency management officials should work with dam owners and operators and the state dam safety office and/or other appropriate state dam regulatory agencies to compile and maintain (i.e., update at least annually) dam fact sheets highlighting site-specific information about the dams, including what resources are needed when responding to a dam incident.

Understanding a dam and its infrastructure is important for responding effectively to an incident. Emergency managers should collect information from dam owners and operators' EAPs to incorporate into the community EOP.

Details about the EAP can be found in FEMA's P-64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams*.²⁵

Important information to include in a dam fact sheet includes these points:

1. The type of dam (high hazard vs. low hazard).²⁶
2. The location of all dam infrastructure (main spillway, auxiliary spillway, etc.).
3. Contact information for the dam owner and operator.
4. Historical information about the dam.
5. Information about any current work or improvements to the dam.
6. Inventories of any supplies or materials kept on-site for use in a dam incident.
7. Inventories of any locally available supplies or materials that could be used in a dam incident.
8. Inventories of potentially toxic chemicals or other substances (e.g., if a water treatment plant is located at the dam site, there could be chlorine or other chemicals housed at the facility).
9. Inundation mapping and dam breach scenarios based on PFMA.

MODELING CAUTIONS

- Make certain that scenarios used for modeling are credible for the individual dam.
- Do not assume flow from a dam incident will be water only; consider debris flow as well.
- Models are based on assumptions that may not hold true for an actual incident. This uncertainty could mean that impacts will differ slightly or significantly from those predicted by the models.

FLOOD HAZARD MAPPING

Through FEMA's flood hazard mapping program, Risk Mapping, Assessment, and Planning (RiskMAP), 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 National Flood Insurance Program (NFIP), as it is the basis of the NFIP regulations and flood insurance requirements. FEMA maintains and updates data through Flood Insurance Rate Maps (FIRMs) and risk assessments. FIRMs include statistical information such as data for river flow, storm tides, hydrologic/hydraulic analyses, and rainfall and topographic surveys.

²⁵ FEMA (2013a). *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams (FEMA 64)*. Available at <https://www.fema.gov/media-library/assets/documents/3357>, accessed February 28, 2019.

²⁶ For more information on the Hazard Potential Classification System for Dams, see: FEMA (2004b): *Federal Guidelines for Dam Safety: Hazard Classification System for Dams (FEMA 333)*. <https://fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf>, accessed February 28, 2019.

3.3 Planning Considerations

Planning considerations provide context for planning efforts and operations. The following are examples of planning considerations that should be used during the dam incident planning process.

Lead time: Lead time for dam incident response operations vary based on the type of incident and factors such as the population of zones affected, time of day, and roadway capacity. For notice incidents, depending on the lead time available, decisions and requests for resources may be made several days in advance, so resources can be mobilized and in position before the arrival of the threat and prior to the start of an evacuation. This lead time helps to ensure that resources are in place to minimize the damage caused by a dam failure and to support the evacuation once the order is given.

No-notice incident considerations: Incidents that occur with no notice present significant complications and resource challenges. During a no-notice incident, actions to stabilize the dam and evacuation and shelter-in-place operations occur concurrently. Local officials must also assume that state and federal support may be unable to mobilize significant resources quickly enough to provide immediate assistance.

Protective-action decision prioritization: In determining the types of protective actions to take, dam owners and operators and emergency management and response personnel should prioritize the actions that will provide for the safety and security of the majority of the population downstream of the dam, protect property and the environment, and stabilize the situation. Emergency managers should work with relevant support agencies to make appropriate protective-action decisions. Priority should then shift to those actions that will prevent further damage or recurrence of the incident, and then to bringing the dam back to operational status as quickly as possible.

Weather forecasting limitations: For notice incidents, communities should include meteorological information from trusted sources such as the National Weather Service (NWS), and pre-existing weather conditions in evacuation and stabilization decisions. The variables in forecasting, such as duration, storm track, wind intensity, and onset timing, make it difficult to determine exactly when a weather-related dam incident will occur. The NWS provides ongoing hydrologic forecasts during flooding events. Emergency managers should work with their local NWS office to understand how to access and use these forecasts during incident response operations.

Zones for evacuation/shelter-in-place orders: Community officials must be able to clearly identify and easily communicate zones to people within those zones. Defining zones based on recognizable landmarks or boundaries, such as known neighborhoods or major roads, helps with this process. Community recognition of zones is essential to reducing confusion during an evacuation and, ultimately, promoting life safety. The method of zone delineation could vary across the region but should remain consistent within a particular community. If zones already exist for other hazards (e.g., hurricanes, wildfires), those zones should be used for dam incident evacuation zones whenever possible.

Public messaging: Issuing clear and consistent public messages is essential. Emergency messages should include five essential elements:²⁷

1. Source – Say who the message is from.
2. Threat – Describe the dam incident and its impact.
3. Location – State the impact area boundaries in a way that can be easily understood (use street names, landmarks, and natural features).
4. Guidance/Time – Tell people what protective action to take, when to do it, how to accomplish it, and how doing it reduces impacts.
5. Expiration Time – Tell people when the alert/warning expires and/or when new information will be provided. (This is most likely to be used in the case of severe weather warnings or watches that might only last a specific length of time.)

Social media is also an effective tool for communicating with the public through coordinated messages. It can be useful throughout evacuation operations to provide and collect information. For more information on public messaging, please refer to the U.S. Army Corps of Engineers' (USACE's) *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*.²⁸

Security concerns: A dam incident plan could contain proprietary or other sensitive or protected information. While it is important that emergency management officials have access to the plans and review them on a regular basis, community planners must ensure that only those with a need to know view the sensitive or protected portions of these plans.

Recovery time: Recovery from a dam incident could take months or years, depending on the severity of the incident, its impact on survivors, the infrastructure impacted, and the magnitude of damage to the dam's structure and/or equipment.

Re-entry timeline: The length of time before affected populations can safely re-enter the affected zone/region is unpredictable. Emergency managers should coordinate with dam owners and operators to understand when the dam and resulting incident have been stabilized and jointly determine when it is safe for re-entry. In extreme cases, survivors may never be able to return to their homes. Allowing re-entry could have limitations: a population could be allowed to return to their homes to pick up clothes or other items, but this population may not be allowed to reoccupy their homes permanently. For more information on access and re-entry considerations, see the U.S. Department of Homeland Security (DHS) publication, *Crisis Event Response and Recovery Access Framework*.²⁹

Economic impacts: A dam incident can have long-term economic impacts on a community. To minimize these impacts, strategies to mitigate economic impacts should be developed during the planning process. For example, one year after Hurricane Katrina, employment was still more than 30 percent

²⁷ USACE (2015). *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*. https://silverjackets.nfrmp.us/Portals/0/doc/WarningGuidebook_USACE.pdf?ver=2015-08-10-213008-520, accessed February 28, 2019.

²⁸ Ibid.

²⁹ DHS (2018). *Crisis Event Response and Recovery Access Framework*. <https://www.dhs.gov/sites/default/files/publications/Crisis%20Event%20Response%20and%20Recovery%20Access%20%28CERRA%29%20Framework.pdf>, accessed February 28, 2019.

lower than before the storm. The oil companies located in the Gulf took more than a year to reach pre-Katrina production levels.

Dependencies and interdependencies: A dam incident may affect other critical infrastructure in ways that have a compounding effect on the incident. For example, an incident at a dam that provides water for a community could cause the entire community to lose water service, affecting a population far larger than just those downstream of the dam. This loss of water service may also affect power plants that rely on that water service. Alternatively, a loss of power which affects a dam can cause or exacerbate a dam incident. Planners should consider these critical infrastructure dependencies and interdependencies when planning for dam incidents.

Four “classes” of interdependencies should be considered when analyzing a dam³⁰:

- **Physical:** Operations depend on material output(s) of other infrastructure through a functional and structural linkage of the two assets. For examples, a dam uses power from a local power plant to operate. The dam provides water service to a local community.
- **Cyber:** Operations depend on information and data transmitted through the information infrastructure. Outputs from the information infrastructure serve as inputs to other infrastructure. For examples, the dam uses a supervisory control and data acquisition (SCADA) system for many operations. The power generation element of a dam uses information from the dam’s information technology (IT) systems to run the power generation facility.
- **Geographic:** Operations depend on the local environment, where an event can trigger changes in the state of operations in multiple infrastructure assets or systems. For example, an earthquake may cause a catastrophic failure at an upstream dam, which causes water to rise rapidly and debris to affect a downstream dam, which may cause damage.
- **Logical:** Operations depend on the state of other infrastructure via connections other than physical, cyber, or geographical. These interdependencies are attributable to human decisions and actions and are not the result of physical or cyber processes. For example, state-level water conservation policies may affect the water level of a recreational reservoir.

3.4 Instituting a Phased Approach to Dam Incidents

A dam incident plan should incorporate the concepts and requirements found in federal, state, and local laws, regulations, and guidelines including the *National Response Framework (NRF)*³¹ and *National Incident Management System (NIMS)*.³² The plan should also build on the principles and goals stated above to describe dam incident-specific protective actions in the community. The plan identifies the

³⁰ Petit, F., et al. (2015). *Analysis of Critical Infrastructure Dependencies and Interdependencies*. <https://publications.anl.gov/anlpubs/2015/06/111906.pdf>, accessed February 28, 2019.

³¹ FEMA (2013d). *National Response Framework: Second Edition*. Available at https://www.fema.gov/media-library-data/20130726-1914-25045-1246/final_national_response_framework_20130501.pdf, accessed February 28, 2019.

³² FEMA (2019c). *National Incident Management System (Main Page)*. <https://www.fema.gov/national-incident-management-system>, accessed February 28, 2019.

responsibilities and actions required to protect lives and property, protect the environment, and stabilize lifeline services through dam incident response.

Incidents in a community typically begin and end locally. They are managed daily at the lowest possible geographical, organizational, and jurisdictional level consistent with law, policy, and agreements. When additional or different resources are required, emergency managers often depend on neighboring communities, the private sector, not-for-profit organizations, and the state for support. State Dam safety offices can be tremendous resources in dam incidents and may have already been in contact with dam owners providing resources.

Assuming a notice incident, Table 2 outlines activities involved in a phased approach to operations.

Table 2 – Phased Operational Approach

Phase	Status	Key Activities	Relevant Goals
Normal Operations	Normal Condition	Monitor the dam	Maintain operational status of the dam
Mobilization Phase	Elevated Threat	Continue monitoring, activate EOC, draft potential public messages	Prevent loss of life, maintain operational status of the dam, prevent dam from failing (where possible)
Impact Phase	Imminent Threat	Issue protective action guidance, monitor from the EOC	Prevent loss of life, prevent dam from failing (where possible)
Zero Hour (dam breach/uncontrolled release)	Imminent Threat	Continue to issue protective action decisions, monitor the dam	Prevent loss of life, protect property and the environment, stabilize the situation, and bring dam back to operational status as fast as possible
Re-Entry	Normal Condition	Implement recovery operations such as clean-up of the site or movement of people	Implement recovery plans, allow population to re-enter the area

The four emergency level categories listed in Table 3 are recommended in FEMA’s *Federal Guidelines for Dam Safety* (FEMA 64).³³ However, dam owners, in coordination with emergency management authorities, should determine the appropriate number of emergency levels required for each dam on a case-by-case basis.

Table 3 – Emergency Level Categories

Emergency Level Category	Description
High Flow	The High Flow emergency level indicates that flooding is occurring on the river system, but there is no apparent threat to the integrity of the dam. The High Flow emergency level is used by the dam owner to convey to outside agencies that downstream areas may be affected by the dam’s release. Although the amount of flooding may be beyond the control of the dam owner, information on the timing

³³ FEMA (2013a). *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams (FEMA 64)*. Available at <https://www.fema.gov/media-library/assets/documents/3357>, accessed February 28, 2019.

	and amount of release from the dam may be helpful to authorities in making decisions regarding warnings and evacuations.
Non-Failure	The Non-Failure emergency level applies to an event at a dam that will not, by itself, lead to a failure but requires investigation and notification of internal and/or external personnel. Examples are (1) new seepage or leakage on the downstream side of the dam, and (2) malfunction of a gate. Some incidents, such as new seepage, may only require an internal response from the dam owner. Others, such as a gate malfunction, may lead to unexpected high releases that could pose a hazard to the downstream public and would require the notification of outside agencies.
Potential Failure	The Potential Failure emergency level indicates that conditions are developing at the dam that could lead to a dam failure.
Imminent Failure	The Imminent Failure emergency level indicates that time has run out, and the dam has failed, is failing, or is about to fail. Imminent Failure typically involves a continuing and progressive loss of material from the dam. It is not usually possible to determine how long a complete breach of a dam will take. Therefore, once a decision is made that there is no time to prevent failure, the Imminent Failure warning must be issued. For purposes of evacuation, emergency management authorities may assume the worst-case condition that failure has already occurred.

After an emergency is detected and confirmed, the dam owner should categorize the condition of the incident by a warning level based on the severity of the initiating condition or triggering events. Both the dam owner and emergency management authorities should understand and agree on the use of the warning level categories. The warning level categories should trigger the appropriate response activities delineated in the owner’s EAP and the emergency management authorities’ EOP. Maintaining the consistency of the warning level categories is essential to eliminate confusion for emergency responders whose community contains multiple dams and dam owners.

A community might have its own dam incident warning levels which differ from other local EOCs or those used by the USACE, FERC or FEMA P-64. Table 4 provides a template to assist in reconciling leveling system terminology. The USACE leveling system appears in the first column, the corresponding FERC level appears in the second column (note that FERC does not include a level III equivalent level; therefore it is blank), the third column the corresponding FEMA P-65 levels, and a blank fourth column is included for communities to include their own equivalent leveling terminology. Planners should review the definitions and associated actions for each USACE and FERC level in the footnoted documents and ensure community warning levels are comparable.

Table 4 – Warning Level Integration Matrix

USACE ³⁴	FERC ³⁵	FEMA P 64 ³⁶	Community
Level IV (highest)	Imminent Threat Alert (highest)	Imminent Failure	
Level III	–	Potential Failure	
Level II	Elevated Threat Alert	Non-failure	
Level I	Normal Condition	High Flow	

*Aligns with DHS guidelines on National Terrorism Advisory System (NTAS).

KEY TAKEAWAY

Develop thresholds that will trigger specific response actions. When time is of the essence, knowing exactly which protective action to order can save lives.

3.5 Triggers and Activation

Dam owners and operators should be involved in helping emergency managers determine the conditions that will trigger a specific protective action.

Communities should develop triggers to activate the dam incident plan when an incident meets, or is expected to meet, **at least one** of the following conditions:

- Requires protective action orders and/or a local emergency declaration from the authority having jurisdiction to access needed funding and resources to support the mission;
- Requires activation of the Multi-Agency Coordination (MAC) group³⁷ to address the needs of the incident, including accessing significant or unusual resources and coordinating continued operations of the dam;
- Anticipates or experiences impacts that exceed the capability or capacity of the community and requires assistance from other communities, the state, and/or the federal government;
- Requires citizens to evacuate from their homes;
- Covers large geographic areas that will require extensive internal and external jurisdictional coordination; and
- Affects large numbers of people and requires mass care and human services missions and life sustainment missions for those sheltering in place.

³⁴ USACE (2018). *Guidance for Emergency Action Plans, Incident Management and Reporting, and Inundation Maps for Dams and Levee Systems*. Available at https://www.publications.usace.army.mil/Portals/76/Publications/EngineerCirculars/EC_1110-2-6074.pdf, accessed February 28, 2019.

³⁵ FERC (2016). *FERC Security Program for Hydropower Projects: Revision 3A*. Division of Dam Safety and Inspections. Available at <https://ferc.gov/industries/hydropower/safety/guidelines/security/security.pdf>, accessed February 28, 2019.

³⁶ FEMA P-64 (2013). *Federal Guidelines for Emergency Action Planning for Dams*. Available at <https://www.fema.gov/media-library/assets/documents/3357> accessed September 26, 2019.

³⁷ FEMA (2017). *National Incident Management System: Third Edition*, p. 40. Available at https://www.fema.gov/media-library-data/1508151197225-ced8c60378c3936adb92c1a3ee6f6564/FINAL_NIMS_2017.pdf, accessed February 28, 2019.

The USACE’s *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*³⁸ recommends developing assumptions based on a cooperative process between the dam owner and operator and local emergency managers. Table 5 highlights example physical observations that can serve as triggers for protective issues and actions during a dam breach incident. Table 6 highlights flood threats, their designated threat levels, and sample protective actions. Table 7 highlights example physical observations that can trigger specific protective actions during a levee incident.

Table 5 – Example Triggers, Threat Level Designation, and Protective Action Decisions for a Dam Breach Incident³⁹

Physical Observations	USACE Threat Level Designation	Flood Threat	Protective Action Options
Water flowing through breach in embankment	Level IV Dam breaching or breached	Imminent or in progress	Evacuate by vehicle Evacuate on foot Evacuate to higher ground Evacuate to safer structure Expedite protection of people Avoid area
Rapidly enlarging sinkhole	Level III Dam breach very likely	Very likely	Evacuate by vehicle Expedite protection of possessions Avoid area
New seepage areas with cloudy discharge or increasing flow rate	Level II Conditions at dam may or may not lead to breach	Possible but not certain	Expedient protection of possessions Seek or monitor information Prepare to evacuate
New seepage areas in or near the dam	Level I Safety issues being investigated	Potential being determined	Seek or monitor information

Table 6 – Example Threat vs. Public Actions for Controlled Dam Releases⁴⁰

USACE Threat Level Designation	Flood Threat	Protective Action Options
Level III: Releases exceed or are forecasted to exceed [xx] cfs	Significant for some occupied structures and evacuation routes	Evacuate by vehicle Evacuate on foot Expedite protection of structures Expedite protection of possessions

³⁸ USACE (2015). *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*. Available at https://silverjackets.nfrmp.us/Portals/0/doc/WarningGuidebook_USACE.pdf?ver=2015-08-10-213008-520, accessed February 28, 2019.

³⁹ Ibid.

⁴⁰ USACE (2015). *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*. Available at https://silverjackets.nfrmp.us/Portals/0/doc/WarningGuidebook_USACE.pdf?ver=2015-08-10-213008-520, accessed February 28, 2019.

		Avoid area
Level II: Releases exceed or are forecasted to exceed [yy] cfs	Some near river in unoccupied areas	Evacuate on foot Seek or monitor information Avoid area Prepare to evacuate
Level I: Releases less than [zz] cfs	None outside of channel	Evacuate on foot if in or on water Avoid area (water) Continue normal activities

Table 7 – Example Threat vs. Public Actions for Levee Breaches and Overtopping⁴¹

Physical Observations	Threat Level Designation	Flood Threat	Protective Action Options
Water flowing through breach in levee embankment	Level IV: Levee breached or overtopped	Imminent or in progress	Evacuate by vehicle Evacuate on foot Evacuate to higher ground Evacuate to a safer structure Expedite protection of people Expedite protection of structures Expedite protection of possessions Avoid area
River level is forecasted to exceed top of levee	Level III: Levee starting to breach or overtop	Very likely	Evacuate by vehicle Expedite protection of possessions Expedite protection of structures Avoid area
Visual movement/slippage of the embankment slope	Level II: Conditions at levee may or may not lead to flooding	Possible but not certain	Expedite protection of structures Expedite protection of possessions Seek or monitor information Prepare to evacuate
New seepage areas spotted in leveed area	Level I: Safety issues being investigated	Potential being determined	Seek or monitor information

3.6 Protective Actions by Dam Incident Type

The first steps in the response process include incident detection, evaluation, and emergency level determination. This phase of response is intended to lead to the proper protective action decisions and subsequent issuing of protective action orders or messages. Emergency management officials need to work closely with the dam owners and operators to make the most appropriate and effective protective action decisions.

⁴¹ Ibid.

Notification and communication (both official communications to the public and unofficial communication among emergency management officials and dam owners and operators) must be based on the dam incident type and severity. Making protective action decisions and announcements quickly maximizes available response time. Dam owners and operators are responsible for notifying and providing status updates to the emergency management officials when dam incidents occur or threaten.

The protective action decisions for dam incidents are normally based on the rate of water being released from a dam. In a severe rainfall event in which the dam is expected to overtop due to excess water, the time available to order a protective action decision, such as an evacuation, can be predictable. However, if a dam incident involves failing or damaged infrastructure, decisions should be based on the likelihood of dam breach, an assumption dam owners and operators can help emergency management officials make.⁴²

Table 8 categorizes some of the most common dam hazards and the protective action decisions recommended for that type of incident. Again, the community should work with the dam owner and operator to populate this list with actions specific to the community.

Table 8 – Common Hazards That Lead to Dam Failure, Sample Threat Level Designations, and Common Protective Actions

Incident Type	Cause	Potential Protective Actions
Overtopping	Excessive flooding/rainfall	<ul style="list-style-type: none"> Controlled release of the spillway where applicable Debris removal from clogged channels or culverts downstream Evacuation where flooding may occur Sandbag placement where flooding may occur
Structural/Infrastructure Failure	Bad design/poor maintenance/natural or man-made hazard	<ul style="list-style-type: none"> Evacuation Seeking or monitoring of information Sandbag placement where flooding may occur
Soil Erosion/Piping/Sand Boil	Bad design/poor maintenance/natural or man-made hazard	<ul style="list-style-type: none"> Seeking or monitoring of information Access provided to construction material Evacuation
Water Leakage	Bad design/poor maintenance/natural or man-made hazard	<ul style="list-style-type: none"> Seeking or monitoring of information
Turbine Failure due to Lack of Back-up Power	Electric power outage	<ul style="list-style-type: none"> Evacuation where lack of power could cause the dam to fail
Water Pollution	Release of contaminant(s) into the water or excessive growth of toxin-releasing biological organisms (e.g., harmful algal blooms)	<ul style="list-style-type: none"> Treatment to remove toxins Drinking water health advisory Recreational water use restrictions (swimming, fishing, boating)

⁴² USACE (2015). *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*. Available at https://silverjackets.nfrmp.us/Portals/0/doc/WarningGuidebook_USACE.pdf?ver=2015-08-10-213008-520, accessed February 28, 2019.

4 Developing an Evacuation Strategy

The following section provides basic considerations for developing an evacuation strategy for a dam incident. This section of the dam incident plan should build on existing community evacuation guidance. For more information, officials should consult FEMA's *Planning Considerations: Evacuation and Shelter-In-Place*.⁴³

Evacuations and the incidents that trigger them can affect multiple geographic regions and have both short- and long-term social, political, and economic impacts. A cooperative, whole community approach supports and helps to enable the safe and efficient movement of individuals and animals from an impacted or potentially impacted area, as well as the return of evacuees to the area once it is safe. Evacuations can begin with the spontaneous movement of people or an official evacuation order. They can occur before, during, and/or after an incident. In the case of dam incidents, evacuating to nearby higher ground or higher level, known as “vertical evacuation,” could be the best option. Emergency managers should look at updated inundation mapping and topography to determine whether this might be an appropriate option. During an event, there is often very little time for planning; consequently, it is critical that a community’s evacuation strategy be determined in advance.

The duration of an evacuation is incident-dependent and varies depending on community size, location, and resources. The best evacuation strategy is to move as few people as possible the shortest distance to safety. Planning evacuation operations to meet this goal also helps reduce resource burdens, facilitate a more efficient re-entry, and more quickly move a community toward recovery.

Planners will need to consider concepts such as roadway capacity, characteristics of the evacuating population, and effective evacuation communications.

It is important for emergency managers and dam owners to identify areas where warning time is critical and develop a strategy to address time sensitive areas. Strategies should include early warning systems, as well as proactive outreach and risk communication to the population at risk.

4.1 Phases of an Evacuation

Evacuation response operations occur in five phases—mobilization, evacuation, impact, mass care, and re-entry. Phases, used in conjunction with evacuation zones, provide a construct to move people to safety. These phases help community’s plan, organize, respond to, and delegate evacuation strategies, messages, tasks, and decisions. Phases differ across zones that face unique hazards and considerations, may not occur at all, or occur in any order based on the incident.

⁴³ FEMA (2018b). *Planning Considerations: Evacuation and Shelter in Place*. Available at <https://www.fema.gov/media-library/assets/documents/168342>, accessed February 28, 2019.

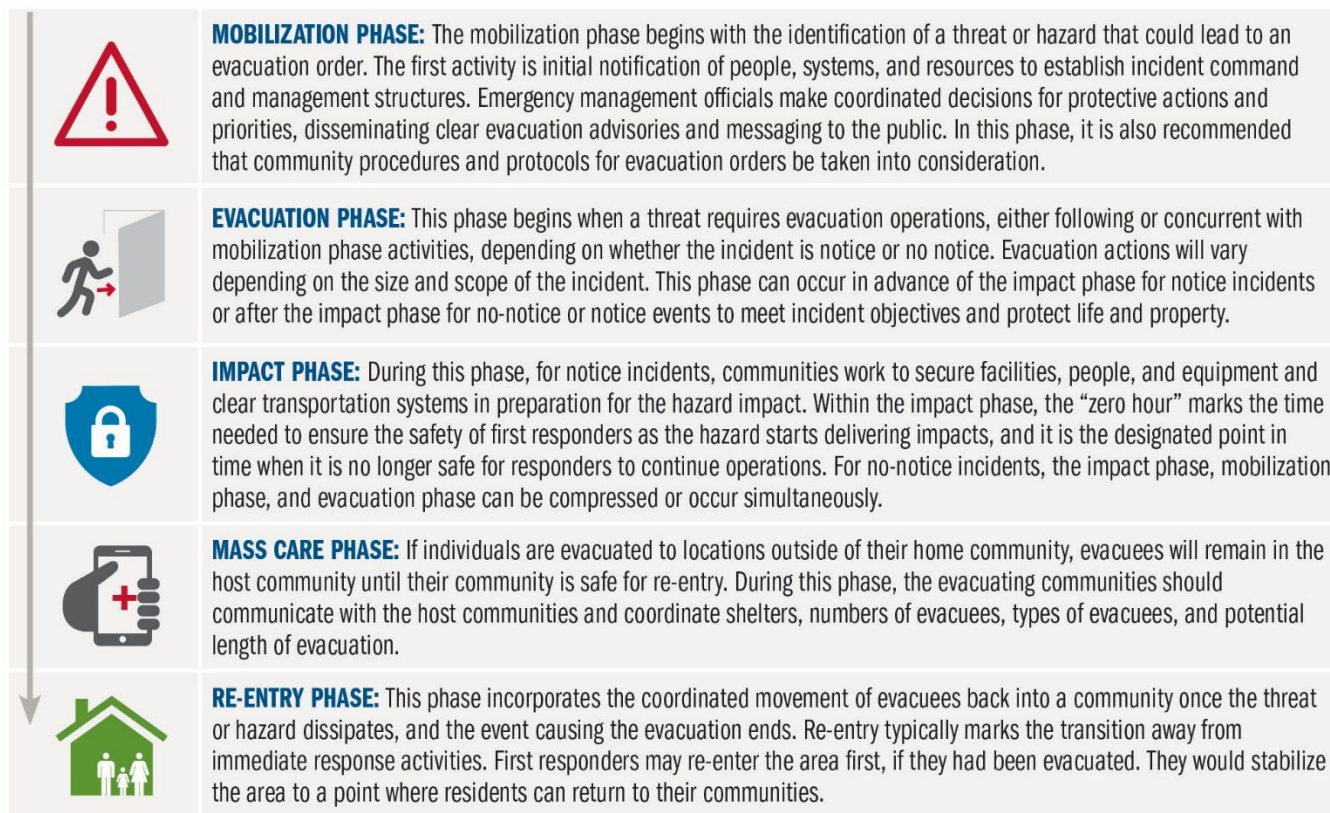


Figure 7: Phases of Evacuation

4.2 Protective Action Orders

KEY TAKEAWAY

When writing public messaging, use clear messages, know the audience, and consider the context.

The protective action order must be concise, accurate, accessible, and understandable. The public does not use the same jargon that emergency management professionals are familiar with and may interpret terms and instructions quite differently than intended (e.g., mandatory, voluntary, recommended, forced, phased, zoned).

For each protective action described in the dam incident plan, community planners should create clear and accessible messaging, and have it approved by leadership prior to any dam incident. Doing so ahead of time allows messages to be pushed to the public quickly when an incident occurs. Pre-approved messages can be modified to include information specific to the current dam incident (e.g., anticipated flooding, drinking water health advisories, recreational usage bans).

Community planners should ensure that the messages provide a clear explanation of the need for an immediate response. Messages should be tailored to the audience. For example, to stress the importance of evacuating right away, a communication could compare a significant rainfall event that would overtop levees in Houston or New Orleans to Hurricanes Harvey or Katrina, respectively.

4.2.1 Delay Times

Officials must consider delay time when determining how and when to issue public messages. According to USACE’s *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*,⁴⁴ the warning and protective action process is divided into three time periods (illustrated in Figure 7):

1. **Warning delay time:** The period between when a threat is first detected, or an emergency manager is first notified of the threat, and when an emergency manager with the proper authority issues a first alert/warning.
2. **Warning diffusion time:** The period after the first alert/warning is issued and the time that people receive that alert/warning.
3. **Protective action initiation time:** The period after people receive the first alert/warning and when they initiate protective action. During this time, most people do several things to prepare to implement a protective action. People may also receive subsequent warning messages during this time.

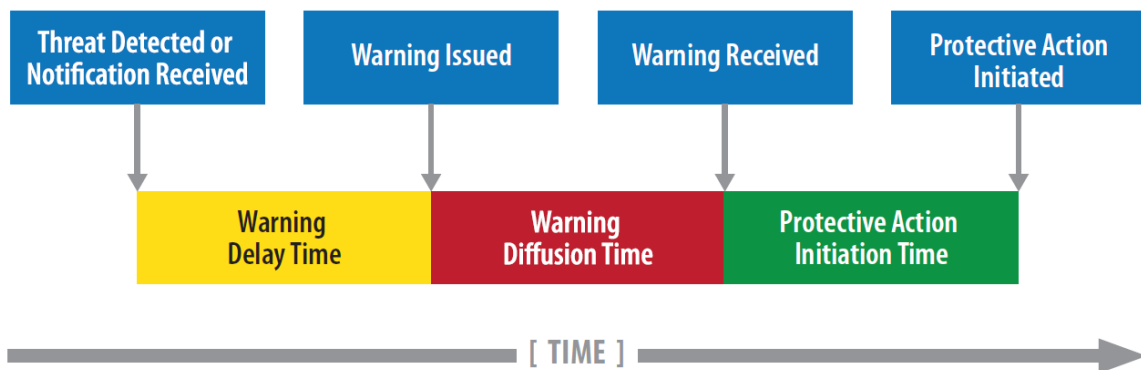


Figure 8: USACE Warning and Protective Action Timeline (Source: USACE 2015⁴³)

To reduce the delay between when the incident is first noticed and when emergency management officials issue alerts or warnings, having messaging that is ready to be sent out when an incident occurs is extremely important.

The “Triggers and Activation” section of the community’s dam incident plan should define what events or conditions trigger a warning message (see Section 3.5).

⁴⁴ USACE (2015). *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*. Available at https://silverjackets.nfrmp.us/Portals/0/doc/WarningGuidebook_USACE.pdf?ver=2015-08-10-213008-520, accessed February 28, 2019.

4.2.2 Evacuation Zone Identification

KEY TAKEAWAY

Do not expect the population to know their evacuation zone. Zone identification is important and can be utilized by both emergency management officials and the public, alike, but only if everyone understands how to determine their zone.

To communicate evacuation and other protective actions quickly and effectively, communities should identify zones based on when dam incident impacts are likely to arrive and then identify the zones specified in the plan by using a graphic, if possible.

When determining evacuation zones, communities should use geographic information systems (GIS) data layers that provide a visualization and analysis capability. Refer to a dam owner's inundation mapping products, if they are available, to determine zones and the most likely affected populations.

Inundation mapping products and modeling tools provide important insight into the potential impacts of a dam incident. These tools are scenario-based and provide information for specific situations such as sunny or rainy-day conditions, full or partial dam failure, and day or night downstream populations. An actual incident will likely not evolve exactly as the models have predicted as the basic assumptions will differ; therefore, maps and models should be used to inform planning but should not be consulted as predictions of how an actual incident will unfold. With these scenario-specific considerations in mind, these tools can help answer questions such as:

- Where will the water go?
- When will the water get there?
- How long will the water stay there?
- How deep will the water be?
- What facilities, homes, businesses, and critical infrastructure (power plants, fire stations, hazardous materials plants, etc.) will be underwater?

Inundation maps should not be used as the single input for evacuation planning. They should be used in conjunction with other analysis of the potential impacts of a dam incident, including population-at-risk analysis, infrastructure-at-risk analysis, transportation network analysis, traffic flow analysis, and PFMA to develop an evacuation plan.

The creation of evacuation zones is especially key if a dam failure will require the ordering of evacuations. Zone definition allows for zone-based evacuation, which targets the most vulnerable areas, while also limiting the need for evacuating large areas that are not under threat. Having defined zones helps communities understand shelter demand, evacuation clearance times, participation rates, and lead and lag times and thus develop facts and assumptions for planning.

Other data elements for establishing zone boundaries include:

- U.S. Census Blocks,⁴⁵
- U.S. Census Tracts,⁴⁶
- Neighborhood boundaries,
- Topographic data,
- School districts,
- Fire/police districts,
- Zip codes, and
- Existing preparedness plans and documentation (e.g., existing evacuation plans).

Communities may need additional information to establish zone boundaries. Additional evacuation and shelter-in-place zone research sources include:

- Real Time Evacuation Planning Model;⁴⁷
- State departments of transportation;
- State and community evacuation plans and other related plans;
- Hurricane Evacuation Studies;
- HAZUS-MH;⁴⁸
- Hurricane Evacuation (HURREVAC);⁴⁹ and
- Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Model.

Zone identification is only useful if those who are in an impacted zone understand the threats they face. Many emergency management agencies have rolled out “Know Your Zone” campaigns,^{50,51} through which they provide public outreach and educational materials to their communities.

4.3 Recovery Factors for a Dam Incident

As noted in the planning considerations section, recovery efforts may take anywhere from weeks to years depending on the severity of the incident (i.e., in the case of a total dam failure). Like a riverine flood, hurricane, or earthquake, a dam incident may result in impacts to people, infrastructure, housing, the economy, and the natural environment. Recovery from a dam incident may therefore require addressing any or all of these impacts. The recovery process is locally executed, typically with leadership

⁴⁵ U.S. Census (2013a). *2010 Census – Census Block Maps*. Available at <https://www.census.gov/geo/maps-data/maps/block/2010/>, accessed February 28, 2019.

⁴⁶ U.S. Census (2013b). *2010 Census – Census Tract Reference Maps*. Available at <https://www.census.gov/geo/maps-data/maps/2010tract.html>, accessed February 28, 2019.

⁴⁷ Old Dominion University (2013). *Real Time Evacuation Planning Model*. Available at <http://rtepm.vmasc.odu.edu/>, accessed February 28, 2019.

⁴⁸ FEMA (2019d). *HAZUS (Main Page)*. Available at <https://www.fema.gov/hazus>, accessed February 28, 2019.

⁴⁹ Sea Island Software, Inc. (undated). *HURREVAC*. Available at <http://www.hurrevac.com/>, accessed February 28, 2019.

⁵⁰ Virginia Department of Emergency Management (undated). *Tiered Evacuation and Know Your Zone FAQs*. Available at <https://www.vaemergency.gov/wp-content/uploads/drupal/assetdownload/KnowYourZoneFAQs.pdf>, accessed February 28, 2019.

⁵¹ Maryland Emergency Management Agency (undated). *Know Your Zone*. Available at <https://memm.maryland.gov/Pages/know-your-zone-md.aspx>, accessed February 28, 2019.

and support from states, and when the capacity of local and state government is exceeded, with support from the federal government. It also requires partnerships with the whole community, including individuals and families, the private sector, not-for-profits, and other stakeholders. While a dam incident annex may not incorporate all principles of recovery, where feasible it should integrate key concepts from the jurisdiction's recovery plan.

The prompt and accurate assessment of damage to public and private property following a disaster will be of vital concern to local officials. The assessment will guide recovery planning in the community. Local officials must work with dam owners to assess lifeline⁵² restoration and determine the time it will take to restore services lost, environmental impacts, economic impacts, and the timeline and cost to restore or remove the dam. Local official should work with an interagency, interjurisdictional team that includes dam owner/operators to set recovery priorities and find resources for and complete recovery projects.

The community should work together with local officials to develop a shared message so stakeholders have accurate and consistent information about what is happening; when residents, businesses owners, and other stakeholders can return to their homes/structures;⁵³ when infrastructure will be replaced; and when and how homes will be replaced.

The National Disaster Recovery Framework (NDRF) provides key planning considerations for a comprehensive, whole community approach to recovery from natural or man-made incidents. States and local jurisdictions may also have developed pre-disaster recovery plans that guide jurisdictional efforts following an incident, including through:

- Identification of a recovery leadership team, as well as roles and responsibilities;
- The assessment of disaster impacts and needs;
- The development of a cohesive recovery vision and goals;
- The identification of recovery strategies, as well as the resources needed to execute those strategies;
- Engagement of the whole community throughout the recovery process; and
- The implementation of the recovery vision, goals, and strategies.

⁵² FEMA (2018b). *Revised Community Lifelines Information Sheet*. Available at <https://www.fema.gov/media-library/assets/documents/175116>, accessed February 28, 2019.

⁵³ DHS (2018). *Crisis Event Response and Recovery Access (CERRA) Framework*. Available at <https://www.dhs.gov/publication/crisis-event-response-and-recovery-access>, accessed February 28, 2019.

Appendix A: Dam Incident Annex Template

The following template is designed for an Emergency Operations Plan (EOP) Dam Incident and Failure Annex. If a community chooses to create a stand-alone dam incident plan, the content suggested here is still pertinent; however, planners should refer to the Federal Emergency Management Agency's (FEMA's) Comprehensive Preparedness Guide (CPG) 101 for plan format options.

A.1 Purpose

Define the purpose of this annex.

A.2 Background

Detail any background information about the dam and its relationship to this plan. Have any dam incidents occurred already?

A.3 Scope

Define the types of dam incidents this plan addresses. Is this dam incident plan only for overtopping? Can it be used in case of a breach?

A.4 Relationship to Other Plans

Explain how this plan fits into the community's current emergency operations plans. Are there parts of existing EOPs that would also be relevant to this plan? Ensure that this plan aligns with local dam emergency action plans (EAPs).

A.5 Roles and Responsibilities

Define the roles and responsibilities in a dam incident. Do not forget to outline the roles and responsibilities of nongovernmental parties, such as the dam owner and operator, private sector entities that the community may need to rely on for supplies or other support, and the population.

A.6 Evacuation Guidance

Authority - Describe the thresholds that need to be met before the community will give an order to evacuate and who in the community has that authority to order the evacuation.

Evacuation zones – If the community has already defined evacuation zones, include maps or images that illustrate those zones here. If the community has not defined evacuation zones, detail the steps the community needs to take to create those zones. If the community does not want to use evacuation zones, detail instead how the community will issue evacuation orders (i.e., by subdivision; using street names; by other district boundaries [e.g., school district])?

Evacuation education – If the community currently has defined evacuation zones, define how the population will learn what zone they are in. Explain how emergency officials will communicate zone information to the public

Incident-specific public messaging – Define as much of the public messaging ahead of time as possible. Explain how those messages be communicated to the population including those with access and functional needs and those with limited English proficiency.

A.7 Triggers and Activation

Define, as clearly as possible, the triggers that will cause (1) an activation of the EOP; and (2) specific protective action decisions to be ordered.

Notice Incident

Detail the contact information for the dam owners and operators as well as contact information for the EOC.

Notification roles and responsibilities

Define who will notify the community of an impending dam incident and what the thresholds for notification are. Define clear roles and responsibilities for their communication.

Potential Protective Actions

Include a list or table of the protective action decisions specific to the dam and the thresholds that must be met to trigger those actions.

Consider:

- *Avoiding the area*
- *Evacuations*
- *Shelter in place*

No-Notice Incident

Define default public messaging and the protective action decisions that will be used in a no-notice incident

A.8 Dam Fact Sheet(s)

Maintain regularly updated documentation of information for each dam.

1. *The type of dam (high hazard vs. low hazard).⁵⁴*
2. *The location of all dam infrastructure (main spillway, auxiliary spillway, etc.).*
3. *Contact information for the dam owner and operator.*
4. *Historical information about the dam.*
5. *Current information about any current work or improvements to the dam.*
6. *Inventories of any supplies or materials kept onsite for use in a dam incident.*
7. *Inventories of any locally available supplies or materials that could be used in a dam incident.*
8. *Inventories of potentially toxic chemicals or other substances (e.g., if there is a water treatment plant located at the dam site, there may be chlorine or other chemicals housed at the facility)*
9. *Inundation mapping and potential failure mode analysis for a dam breach scenario (for more information on inundation mapping, see the section titled “Zone Identification”).*
 - a. *How is the dam expected to perform under certain loads?*
 - b. *What are the differences between an overtopping event and a breach event?*

⁵⁴ For more information on the Hazard Potential Classification System for Dams, see: <https://fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf>, accessed February 28, 2019.

Appendix B: Planning Checklist

The following pages can stimulate actions to take and information to obtain when a jurisdiction is developing its dam incident planning guide.

Planning

- Contact the dam owner(s)/operator(s), obtain a copy of their emergency action plan (EAP), and establish a communication plan with the owner/operator.
- Coordinate with the applicable state and federal dam regulatory agencies.
- Ensure that the occupants of the area downstream are kept informed regarding the dam hazard.
- Coordinate with the dam owner(s)/operator(s) for timely information affecting local communities.
- Coordinate with schools, daycare centers, hospitals, etc., in the downstream area concerning proper precautions and emergency actions prior to a potential dam failure.
- Coordinate with local planning boards and inspections departments regarding building codes and code enforcement to minimize damages downstream.
- Coordinate the establishment of local laws to prohibit or minimize construction in known floodplains or near spillways.
- Form a collaborative planning team to create and maintain dam incident plans or annexes for dams within your community.
- Consider representatives from the following function areas as core planning team members (Note: If multiple communities comprise the planning area, consider 5–6 key members from the following listing to represent your community in a multijurisdictional planning effort):
 - Jurisdiction chief executive (or representative)
 - Emergency management
 - Dam owners/operators from within your community
 - Law enforcement
 - Fire services
 - Emergency medical services (EMS)
 - Public health
 - Hospitals and healthcare facilities
 - Public works
 - Transportation
 - Social services
 - Key private-sector representatives
 - Volunteer organizations (Red Cross, Salvation Army, amateur radio, etc.)
 - School systems representatives
 - Key utilities representatives
 - Hazard mitigation representatives
 - National Weather Service (NWS)
 - Appropriate regional, state, and/or federal representatives where required
- Conduct research to understand the threat (Note: much of this information may be available from the state agency that has regulatory/oversight responsibility for dams):
 - Total number of dams within your community
 - Owners/operators of all dams
 - Total number of high-hazard dams (terminology may vary from state to state)
 - Total number of significant-hazard dams (terminology may vary from state to state)

FEMA Dam Incident Planning Guide

- Total number of low-hazard dams (terminology may vary from state to state)
 - Types of dams (public water supply, energy producing, recreational, etc.)
 - Condition of dams (inspection reports and schedule of inspections for each)
 - Total volume of water impounded by each dam
 - Potential inundation area with geographical boundaries should total failure of the dam occur
 - Determine the projected total impact on the inundation area, the communities therein, and the jurisdiction in general, including damage to private and public property, possible loss of life/injury, economic loss, and damage to the environment based on current response capabilities.
 - Historical climatological data that could affect the dam or its integrity
 - Past earthquake activity or susceptibility
- Analyze the information.
- Based on the projected inundation area mapping:
 - Identify houses, apartments, multiple dwelling, parks/campgrounds, businesses, and industry that would be affected.
 - Identify critical facilities, such as hospital, schools, nursing homes, prisons/detention centers, shopping malls, government-owned facilities, etc., that would be affected.
 - Identify critical infrastructure, such as water treatment, wastewater treatment, electric and gas generation/transmission facilities, communications facilities, airports, railroad, major highway, major bridges, etc., that would be affected.
 - Determine total estimated population that could be affected.
 - Identify concentrated population areas.
 - Identify special needs populations.
 - Using a total failure of the dam as the scenario, identify downstream water arrival times (when the water from the failure will arrive in areas downstream of the dam) and maximum water depths (how deep will the water get in areas downstream of the dam), especially for homes, businesses, and essential facilities closest to the dam. These water arrival/depth estimates should be analyzed for downstream locations, especially locations with concentrated populations of people.
 - Based on water arrival times/depths, determine the lead warning times for the selected downstream locations to successfully perform evacuation.
 - Identify warning/notification systems already in place that could be used for alerting the population in the inundation area (sirens, reverse 9-1-1 capabilities, tone alert radios, etc.).
 - Identify primary road/highways that could be used for evacuation.
 - Identify all facilities outside of the inundation area that could be used for shelters.
 - Identify transportation resources available to supplement evacuation, especially for those without personal transportation.
 - Identify medical resources within the community that can be implemented/used if required.
 - Identify the perimeter area that would need to be secured to prevent unnecessary entry into the possible inundation area.
 - Determine the projected total impact on the inundation area, the communities therein, and the jurisdiction in general, including damage to private and public property, possible loss of life/injury, economic loss, and damage to the environment based on current response capabilities.

FEMA Dam Incident Planning Guide

- Determine dam incident response goals and objectives (possibly use a dam failure scenario and related consequences). These may include the following:
 - The development of a positive working/coordination relationship with the dam owners/operators
 - Timely warning/notification of the affected populace of a dam failure
 - Expedient, orderly, and complete evacuation of the inundation area
 - The provision of expedient medical care services where required
 - The provision of shelter/mass care services for those who could be affected
 - The development of a recovery process

- Develop a draft plan.
 - Develop and analyze courses of action and operation tasks.
 - Develop procedures for possible event detection, including the following:
 - Establishment of responsibilities for the dam owner/operator to inspect, monitor, and evaluate the condition of the dam.
 - Enhanced monitoring/evaluation during periods of extremely wet weather, heavy rainfall/snowfall, etc.
 - Observations by law enforcement patrol for any changes in dam status or possible suspicious activity.
 - Inspection/monitoring following seismic activity.
 - Identify primary and secondary communications/notifications channels between the dam owner/operator and the designated 24/7 community warning point or other designated locations.
 - Develop emergency levels for classifying various stages of possible dam emergency/failure.
 - Based on these levels, develop communication/notification procedures for each level, as well as appropriate immediate response actions.
 - Divide the inundation area into zones for planning purposes.
 - Develop a notification flowchart that identifies all local, state, tribal, and federal agencies and specific personnel who require notification of a dam emergency.
 - Based on current warning capabilities, identify the percentage of the total population within the inundation area that can receive immediate warning to evacuate or take protective action.
 - Identify gaps in warning capabilities.
 - Begin development of a plan to bridge warning gaps and ensure that all residents can receive emergency warnings pertaining to dam emergencies. This notification effort would include using the following warning systems:
 - NWS Weather Radio
 - Emergency Alert System (EAS)
 - Sirens
 - Direct dial systems
 - Reverse 9-1-1
 - State police information networks
 - Door-to-door notifications
 - Identify potential command post locations.
 - If the inundation area or the planning area in general involves multiple jurisdictions, jointly identify possible locations for the establishment of a Unified Command.
 - If possible, include the incorporation of the dam management team (or their representative) with the Unified Command.

- If area commands are envisioned, identify areas by geographical boundaries.
- Establish pre-designated communication channels/groups to provide effective command and control, as well as tactical operations.
 - If multiple communities are involved, identify communications interoperability linkages, if required.
- Identify community emergency operations center (EOC)/multiagency coordination (MAC) group and possible backups.
- Identify the operational periods that will be used (most likely 12-hour periods).
- Identify primary response staging areas and staging area managers.
- Pre-identify who has the authority to order evacuation and the basis for ordering such evacuation. This designated authority could include the following:
 - Chief executive of the jurisdiction
 - Law enforcement official
 - Fire official
 - Emergency manager
 - Possibly dam owner/operator in some circumstances (these need to be detailed)
- Based on identified evacuation zones, identify primary and secondary evacuation routes to safety.
- Identify assembly points for evacuation where required.
- Based on identified planning zones and designated evacuation routes, identify the location of shelters to be used to accommodate the population from the evacuated inundation area.
- Working with the Red Cross and other shelter/mass care organizations, identify shelter support requirements and ensure that they are in place. This effort includes the following:
 - Shelter agreements (if Red Cross has not already developed them)
 - Shelter managers and staffs
 - Adequate parking
 - Toilet facilities
 - Feeding capabilities
 - Water
 - Pet accommodations
 - Sleeping accommodations
 - Provisions for special needs individuals
- Identify points of distribution (PODs) and develop plans for their operation and staffing.
- Develop procedures for disaster victim registration, family reunification, and addressing inquiries by families of disaster victims.
- Based on identified planning zones, identify hospitals to which the injured are to be transported.
- Identify lead/support law enforcement agencies for this plan.
- Identify lead/support fire services for this plan.
- Identify lead/support EMS for this plan.
- Identify lead/support agencies for public health issues.
 - Identify the lead/support agencies for mental health issues, including the provision of crisis counseling services.
- Identify lead/support transportation services agencies/organizations for this plan.
- Identify the lead/support agencies for public works issues, including debris removal, as well as water/wastewater issues.
- Identify the lead/support agencies for resource management and ensure that emergency procurement procedures are in place.

FEMA Dam Incident Planning Guide

- Identify all search and rescue capabilities with an emphasis on structural and swift water capabilities.
 - Identify a jurisdictional agency to serve as the primary liaison to energy utilities that service the area.
 - Identify the lead/support agencies for fatality issues, including disaster mortuary operations, victim identification, and the processing of human remains.
 - Develop procedures for establishing the perimeter and traffic control points to prevent unauthorized entry into possible dangerous areas.
 - Identify lead agencies and develop procedures for conducting an expedient damage assessment following the recession of flood waters. This effort will include the following:
 - Damage to private and publicly owned buildings, facilities, and equipment
 - Damage to critical facilities (hospitals, schools, nursing homes, etc.)
 - Damage to critical infrastructure (roadways, bridges, railways, water/wastewater systems, energy generation and transmission systems, etc.)
 - Economic loss
 - Environmental impact
 - Public health issues
 - Develop a public information program to raise the public's awareness of the potential for emergencies involving dams and the actions that they can take to protect their lives and the lives of their loved ones.
 - Develop pre-scripted warning messages for use during and after a dam emergency.
 - Identify volunteer organizations and their capabilities.
 - Identify key private-sector organizations that can provide supplemental assistance if required.
 - Coordinate with the local military representatives to incorporate their response capabilities into this plan.
- Identify resources available, as well as shortfalls/gaps, to address issues.
- Transportation:
 - School buses
 - Municipal transportation assets
 - Privately owned assets (charter companies, etc.)
 - Four-wheel drive vehicles
 - High-wheeled clearance-type vehicles
 - Boats and specialized water rescue equipment
 - Vehicles that could be used for medical transport
 - Helicopters and fixed-wing aircraft for transport and reconnaissance
 - Portable traffic information signs
 - Drivers/operators for all equipment
 - Communications:
 - Interoperable communications systems and equipment
 - Satellite communications
 - Cellular phones
 - High-frequency radios
 - Hard-line telephone
 - Internet capabilities
 - Amateur Radio
 - Portable communications integration equipment (with operators)

FEMA Dam Incident Planning Guide

- Public Works:
 - Dump trucks
 - Road closure barriers
 - Front-end loaders, bulldozers, and other types of heavy equipment
 - Portable generators
 - Portable lighting equipment
 - Power saws and hand tools
 - Enough drivers/operators for all equipment above
- Firefighting:
 - Hazardous materials response equipment
 - First response medical capabilities
 - Water rescue equipment (ropes, boats, life preservers, etc.)
- Emergency Management:
 - Mobile command vehicles
 - Supplemental communications
 - Volunteers
 - Trained damage assessment personnel (for individual and public damages)
 - Coordination channels for access to supplemental resources from other jurisdictions, as well as regional and state resources, mutual aid, memorandums of agreement (MOAs), and memorandums of understanding (MOUs)
- Mass Care/Shelter:
 - Enough shelters (including special needs shelters)
 - Shelter managers
 - Food
 - Water
 - Clothing
 - Translators
 - Sleeping accommodations
- Public Health and Medical:
 - EMS personnel
 - Ambulances and medical transport
 - Hospitals (or other medical care facilities, clinics, etc.)
 - Nursing home services
 - Disaster mental health services
 - Public health and disease outbreak services
- Search and Rescue:
 - Boats
 - Swift water rescue personnel and equipment
 - Structural rescue personnel and equipment
 - Hovercraft capabilities
- Hazardous Materials:
 - Booms
 - Containment equipment and supplies
 - Hazardous materials response equipment
 - Environmental monitoring equipment
- Agriculture/Natural Resources:
 - Local farm equipment and personnel to assist where required
 - Veterinary medical response teams
 - Personnel for pet assistance at shelters

FEMA Dam Incident Planning Guide

- Wildlife rescue capabilities
- Energy:
 - Heavy equipment
 - Generators
 - Portable light sets
- Law Enforcement:
 - Personnel and equipment for maintaining law and order, traffic control, evacuation, perimeter establishment, and identification check points
 - Possible search-and-rescue resources
 - Communications resources
- Public Information:
 - Established coordination channels with printed and electronic media
 - Pre-established warning, evacuation, and public information/public protection messages, etc.
- Establish a resource management section.
 - Begin the acquisition of needed resources based on the local community's internal and/or purchasing capabilities.
 - Identify resources available from the private sector.
- Work with emergency management in establishing mutual aid agreements and MOUs/MOAs with other communities and levels of government for the provision of resources.
 - Determine the information and intelligence needs necessary to provide efficient direction and control of the event.
 - If your community uses virtual EOC-type software, it should be detailed in the plan as a method of information and intelligence collection and dissemination.
 - Develop procedures for the following:
 - Determining the most significantly affected/potentially affected areas in the community and initiating warning and evacuations, if required
 - Rapidly establishing a community and county-wide direction and control organization
 - Identifying immediate needs pertaining to life-saving, life-safety, and life sustainment
 - Determining response priorities
 - Determining critical infrastructure remaining to support the response effort
 - Identifying all other critical needs
 - Developing and maintaining a common operating procedure (COP); at a minimum the COP should contain information pertaining to the following:
 - Casualties (injuries and fatalities)
 - Search-and-rescue requirements, actions, and capabilities
 - Communications status (public safety radio, cellular, landline, satellite, Internet, amateur radio)
 - Hospital/healthcare status
 - EMS status, response capabilities, and actions
 - Fire status, response capabilities, and actions
 - Law enforcement status, response capabilities, and actions
 - Direction and control capabilities and status
 - Damage to private property (homes, apartments, and businesses)

FEMA Dam Incident Planning Guide

- School system status
 - Water system/facilities status
 - Wastewater system/facilities status
 - Energy system status (natural gas, propane, oil, electric)
 - Transportation system status (roads, air, rail, water)
 - Hazardous materials issues
 - Mass care status, requirements, and capabilities
 - Public information dissemination status and capabilities (commercial, cable, satellite radio and television, and Internet)
- Allow the planning team to review the draft plan when it is complete and to make suggestions for revisions and improvements.
 - Finalize the plan, gain approvals, and disseminate it.
 - Incorporate all suggested changes/revisions made by the planning team and produce a final copy of the plan.
 - Provide a copy of the plan to all required signatories or conduct a seminar to introduce and explain the plan to them.
 - Obtain approvals of the plan by all signatories.
 - Signatories should include chief elected official; heads of all local, regional, state, and/or federal departments with a role in the plan; key voluntary agencies/organizations; and key private sector representatives
 - Make a controlled distribution of the plan with each copy being numbered.
 - Conduct training necessary to implement plan.
 - Identify and disseminate all National Incident Management System (NIMS) training requirements to all departments and agencies that have a role in the plan.
 - Conduct all specialized training courses as required, such as the following:
 - Search and rescue
 - Communication protocols
 - Shelter operations
 - Mass casualties
 - Mass fatalities
 - Exercise the plan, evaluate its effectiveness, and make changes as appropriate.
 - Follow the Homeland Security Exercise and Evaluation Program (HSEEP) methodology to conduct a capabilities-based exercise program that includes the following:
 - Seminars
 - Workshops
 - Tabletop exercises
 - Games
 - Drills
 - Functional exercises
 - Full-scale exercises
 - Following the HSEEP methodology, conduct exercise evaluation, develop after-action reports and improvement plans, and incorporate changes to the plan as required.
 - Maintain the plan in a constant state of readiness.

- Review the entire plan at least annually and make changes, additions, and deletions as appropriate.
 - Distribute changes, additions, and deletions to all holders of the plan (refer to the distribution list showing holders of all numbered copies of the plan).
 - Make corrections to key documents, such as the notification flow chart, and distribute to key notification stakeholders at least quarterly, if not more often. This action can be accomplished electronically, making distribution very easy.
 - Reprint and redistribute the entire plan every five years.

Response

- Based on threat verification, initiate actions to protect life and safety, including warning and the issuance of an evacuation order.
- Establish incident command.
- Establish command posts as needed.
- Establish communication with the dam owner/operator.
- Identify immediate action or response requirements.
- Activate or augment the EOC as appropriate.
- Establish communication with responding agencies.
- Through communication with responding agencies, determine the following as quickly as possible:
 - Number of casualties (injured and killed)
 - General boundary of the affected area
 - The general extent of damages
 - The general extent of power or other utility disruption
 - Immediate needs of response forces
 - Evacuation status

- Evaluate the overall community situation.
- Establish communication with the state.
- Establish communication with and request a liaison from electric and gas utilities.
- Establish ongoing reporting from the response forces services, private agencies, and utilities.
- Initiate the incident action planning process.
- Coordinate with Red Cross (or the designated lead agency) the opening of an appropriate number of shelters in the appropriate areas, based on the shelter procedure.
- Conduct the first staff briefing as soon as practical after EOC activation.
- Activate or establish rumor control through the public information officer (PIO).
- Establish a schedule for briefings.
- Brief city/county agency and utility executives.
- Activate the joint information center (JIC).
- Provide the PIO with updated information.
- Provide response forces with updated information.
- Release public information via the PIO as soon as practical.
- Issue public action guidance as appropriate.
- Establish a 24/7 duty roster for the EOC and/or command post.
- Develop and post any required maps or diagrams.
- Activate an events log.
- Review and follow the resource procurement procedure.
- Inventory additional resources that may be used or called on for use.

FEMA Dam Incident Planning Guide

- ❑ Activate a formal resource request procedure and resource tracking, including required mutual aid assistance, activation of MOUs/MOAs, etc.
- ❑ Coordinate all resource requests being forwarded to the state.
- ❑ Activate the financial tracking plan coordinated by the finance officer.
- ❑ Activate damage assessment teams and follow the damage assessment procedure.
- ❑ Develop a 12-hour incident action plan (IAP) outlining actions that must be accomplished in the next 12 hours.
- ❑ Conduct a second shift/relieving shift briefing.
- ❑ Discuss with and present to your relief the IAP for the next 12 hours.
- ❑ Develop re-entry procedures.
- ❑ Develop a transition plan to the recovery phase.
- ❑ Initiate demobilization procedures, including a debriefing process.

Recovery

- ❑ Gather damage assessment information (public, housing, business) from damage assessment teams.
- ❑ Obtain information from the Red Cross or other organizations responsible for managing shelters regarding number of shelterees and support necessary for continued operation.
- ❑ Obtain information from the dam owner/operator and/or U.S. Army Corps of Engineers (USACE) regarding safety, etc.
- ❑ Assess citizen/community needs for individual assistance and/or public assistance if applicable.
- ❑ Activate a local unmet needs committee if appropriate.
- ❑ Gather financial information for the finance officer.
- ❑ As appropriate, gather the following additional information:
 - Personnel who responded and the time involved in the response
 - Timesheets or time logs
 - Supplies used
 - Contracts issued
 - Purchase orders issued
 - Any other expenditures
 - Damages to public buildings, equipment, utilities, etc.
 - Loss of life of any public servant
 - Documents regarding economic impact
- ❑ Develop or generate reports for the following, as appropriate:
 - Federal Emergency Management Agency (FEMA)
 - State
 - Local elected officials
 - County/city/town managers
 - Others requiring or requesting reports
- ❑ Coordinate recovery organizations, including federal and state agencies and private or volunteer relief organizations.
- ❑ Establish donated goods management based on policy and procedure.
- ❑ If a Presidential disaster declaration is made, file a "Request for Public Assistance" form to apply for assistance as soon as possible with the proper state or federal agency.
- ❑ Ensure that public officials are made aware of the assistance application process, if applicable.

FEMA Dam Incident Planning Guide

- Ensure that the public is made aware, through the PIO, of the assistance application process, if applicable.
- Perform a formal incident critique as soon as possible with all possible response organizations.
- Review agency and self-performance.
- Review the strengths and needs of the plan.
- Develop a process for updating the plan.
- Correct weaknesses.
- Implement or modify a hazard mitigation plan accordingly.
- Brief elected officials with updated information and disaster recovery progress.

Appendix C: Glossary

Information in this appendix was obtained from FEMA P-148, *Federal Guidelines for Dam Safety: Glossary of Terms*.⁵⁵

Appurtenant Structures

Ancillary features of a dam such as outlets, spillways, powerplants, tunnels, etc.

Auxiliary/Emergency Spillway

Any secondary spillway that is designed to be operated infrequently, possibly in anticipation of some degree of structural damage or erosion to the spillway that would occur during operation.

Breach

An opening through a dam that allows the uncontrolled draining of a reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening caused by discharge from the reservoir. A breach is generally associated with the partial or total failure of the dam.

Consequences

Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of the dam. Also, effects of landslides upstream of the dam on property located around the reservoir.

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.

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. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Dam Incident

An emergency situation that threatens the integrity of the dam, or its components, that could result in an increased risk to the population but does not result in the catastrophic failure of the dam. An incident may also include operational releases from the dam (e.g., principal spillway, emergency spillway) that may result in flooding major roads, homes, or businesses.

Dam Safety

Dam safety is 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. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and

⁵⁵ Interagency Committee on Dam Safety (2003). *Federal Guidelines for Dam Safety: Glossary of Terms (FEMA 148)*. <https://www.fema.gov/media-library/assets/documents/3904>, accessed February 28, 2019.

consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible any unacceptable risks.

Emergency Action Plan (EAP)

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.

Flood

A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average probability of exceedance per year such as one-percent-chance flood or expressed as a fraction of the probable maximum flood or other reference flood.

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 flood flows. The area of the flood plain is generally delineated by a frequency (or size) of flood.

Hazard

A situation that creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts.

Inundation Map

A map showing areas that would be affected by flooding from releases from a dam's reservoir. The flooding may be from either controlled or uncontrolled releases or as a result of a dam failure. A series of maps for a dam could show the incremental areas flooded by larger flood releases.

Notification

To inform appropriate individuals about an emergency condition so they can take appropriate action.

Peak Flow

The maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph.

Piping

The progressive development of internal erosion by seepage.

Principal Spillway

A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir, without significant damage to either the dam or its appurtenant structures. This structure is also referred to as service spillway.

Reservoir

A body of water impounded by a dam and in which water can be stored.

Seepage

The internal movement of water that may take place through the dam, the foundation, or the abutments.

Shelter-In-Place

The use of a structure to temporarily separate individuals from a hazard or threat. Sheltering in place is the primary protective action in many cases. Often it is safer for individuals to shelter-in-place than to try to evacuate. Sheltering in place is appropriate when conditions necessitate that individuals seek protection in their home, place of employment or other location when disaster strikes.

Spillway

A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Toe of the Dam

The junction of the downstream slope or face of a dam with the ground surface; also referred to as the downstream toe. The junction of the upstream slope with ground surface is called the heel or the upstream toe.

Whole Community

Preparedness is a shared responsibility; it calls for the involvement of everyone – not just the government – in preparedness efforts. By working together, everyone can help keep the nation safe from harm and help keep it resilient when struck by hazards, such as natural disasters, acts of terrorism, and pandemics.

Whole Community includes:

- Individuals and families, including those with access and functional needs
- Businesses
- Faith-based and community organizations
- Nonprofit groups
- Schools and academia
- Media outlets
- All levels of government, including state, local, tribal, territorial, and federal partners

Appendix D: Acronym List

CPG	Comprehensive Preparedness Guide
DHS	U.S. Department of Homeland Security
EAP	Emergency Action Plan
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System
HSEEP	Homeland Security Exercise and Evaluation Program
IAP	Incident Action Plan
MAC	Multi-agency Group
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NGO	Nongovernmental Organization
NIMS	National Incident Management System
NWS	National Weather Service
PFMA	Potential Failure Mode Analysis
PIO	Public Information Officer
TA	Technical Assistance
USACE	U.S. Army Corps of Engineers

Appendix E: References

Association of State Dam Safety Officials (2019). *Dam Failures and Incidents*. Available at <https://damsafety.org/dam-failures>, accessed February 27, 2019.

DHS (U.S. Department of Homeland Security) (2018). *Crisis Event Response and Recovery Access (CERRA) Framework*. Available at <https://www.dhs.gov/publication/crisis-event-response-and-recovery-access>, accessed February 28, 2019.

FEMA (Federal Emergency Management Agency) (2004a). *Federal Guidelines for Dam Safety: Glossary of Terms (FEMA 148)*. Available at <https://fema.gov/media-library-data/20130726-1516-20490-9730/fema-148.pdf>, accessed February 28, 2019.

FEMA (2004b). *Federal Guidelines for Dam Safety: Hazard Classification System for Dams (FEMA 333)*. Available at <https://fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf>, accessed February 28, 2019.

FEMA (2010). *Comprehensive Preparedness Guide 101: Developing and Maintaining Emergency Operations Plans*. Available at <https://www.fema.gov/media-library/assets/documents/25975>, accessed February 27, 2019.

FEMA (2012). *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*. Available at <https://www.fema.gov/media-library/assets/documents/14708>, accessed February 27, 2019.

FEMA (2013a). *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams (FEMA 64)*. Available at <https://www.fema.gov/media-library/assets/documents/3357>, accessed February 28, 2019.

FEMA (2013c). *Living with Dams: Know Your Risks (FEMA P-956)*. Available at <https://www.fema.gov/media-library/assets/documents/28161>, accessed February 28, 2019.

FEMA (2013d). *National Response Framework: Second Edition*. Available at https://www.fema.gov/media-library-data/20130726-1914-25045-1246/final_national_response_framework_20130501.pdf, accessed February 28, 2019.

FEMA (2014). *Geospatial Dam Break, Rapid EAP, Consequence and Hazards GIS Toolkit (DVD)*. Available at <https://www.fema.gov/media-library/assets/documents/94670>, accessed February 28, 2019.

FEMA (2016). *Pocket Safety Guide for Dams and Impoundments, P-911*. Available at <https://www.fema.gov/media-library-data/1478633654726-9b1587e1cbe6898d38ba92c95dbf6f16/FEMAP-911.pdf>, accessed February 28, 2019.

FEMA (2017). *National Incident Management System: Third Edition*. Available at https://www.fema.gov/media-library-data/1508151197225-ced8c60378c3936adb92c1a3ee6f6564/FINAL_NIMS_2017.pdf, accessed February 27, 2019.

FEMA Dam Incident Planning Guide

FEMA (2018a). *Planning Considerations: Evacuation and Shelter in Place*. Available at <https://www.fema.gov/media-library/assets/documents/168342>, accessed February 28, 2019.

FEMA (2018b). *Revised Community Lifelines Information Sheet*. Available at <https://www.fema.gov/media-library/assets/documents/175116>, accessed February 28, 2019.

FEMA (2019a). *Types of Dams and Failures*. <https://www.fema.gov/types-dams-and-failure-modes>, accessed February 28, 2019.

FEMA (2019b). *Why Dams Fail*. <https://fema.gov/why-dams-fail>, accessed February 28, 2019.

FEMA (2019c). *National Incident Management System Main Page*. <https://www.fema.gov/national-incident-management-system>, accessed February 28, 2019.

FEMA (2019d). *HAZUS (Main Page)*. Available at <https://www.fema.gov/hazus>, accessed February 28, 2019.

FERC (Federal Energy Regulatory Commission) Division of Dam Safety and Inspections (2016). *FERC Security Program for Hydropower Projects: Revision 3A*. Available at <https://ferc.gov/industries/hydropower/safety/guidelines/security/security.pdf>

FERC (2017). *Identifying, Describing, and Classifying Potential Failure Modes*. Available at <https://www.ferc.gov/industries/hydropower/safety/initiatives/pfms/pfms.pdf?csrt=17541142006781503552>, accessed February 28, 2019.

Maryland Emergency Management Agency (undated). *Know Your Zone*. Available at <https://memama.maryland.gov/Pages/know-your-zone-md.aspx>, accessed February 28, 2019.

Montana Department of Natural Resources and Conservation (2016). *Dam Owner Intervention Toolbox*. Available at https://damsafety.org/sites/default/files/files/MDNRC%20Dam%20Owner%20Emergency%20Intervention%20Toolbox_Final.pdf, accessed February 28, 2019.

Old Dominion University (2013). *Real Time Evacuation Planning Model*. Available at <http://rtepm.vmasc.odu.edu/>, accessed February 28, 2019.

Petit, F., et al. (2015). *Analysis of Critical Infrastructure Dependencies and Interdependencies*. <https://publications.anl.gov/anlpubs/2015/06/111906.pdf>, accessed February 28, 2019.

Sea Island Software, Inc. (undated). *HURREVAC*. Available at <http://www.hurrevac.com/>, accessed February 28, 2019.

Stanford University National Performance of Dams Program (undated). *What Is A Dam Incident?* Available at <https://npdp.stanford.edu/node/41/>

FEMA Dam Incident Planning Guide

U.S. Census (2013). *2010 Census – Census Block Maps*. Available at <https://www.census.gov/geo/maps-data/maps/block/2010/>, accessed February 28, 2019.

U.S. Census (2013). *2010 Census – Census Tract Reference Maps*. Available at <https://www.census.gov/geo/maps-data/maps/2010tract.html>, accessed February 28, 2019.

USACE (U.S. Army Corps of Engineers) (2010). *May 2010 Flood Event Cumberland River Basin: 1-3 May*. Great Lakes and Ohio River Division. Available at <https://www.hSDL.org/?view&did=21310>, accessed February 27, 2019.

USACE (2015). *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies*. Available at https://silverjackets.nfrmp.us/Portals/0/doc/WarningGuidebook_USACE.pdf?ver=2015-08-10-213008-520, accessed February 28, 2019.

USACE (2018). *Guidance for Emergency Action Plans, Incident Management and Reporting, and Inundation Maps for Dams and Levee Systems*. Available at https://www.publications.usace.army.mil/Portals/76/Publications/EngineerCirculars/EC_1110-2-6074.pdf, accessed February 28, 2019.

Virginia Department of Emergency Management (undated). *Tiered Evacuation and Know Your Zone FAQs*. Available at <https://www.vaemergency.gov/wp-content/uploads/drupal/assetdownload/KnowYourZoneFAQs.pdf>, accessed February 28, 2019.

Appendix F: Resources

This list includes items not directly referenced in this document, but which may be useful in the planning process.

FEMA (2007). *Emergency Action Planning for State Regulated High-Hazard Potential Dams: Findings, Recommendations and Strategies (FEMA 608)*. Available at <https://www.fema.gov/media-library/assets/documents/12720>

FEMA (2008). *National Response Framework—Mass Evacuation Incident Annex*. Available at https://www.fema.gov/media-library-data/20130726-1825-25045-6500/mass_evacuation_incident_annex_2008.pdf

FEMA (2013). *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA P-946)*. Available at https://fema.gov/media-library-data/96171edb98e3f51ff9684a8d1f034d97/Dam_Guidance_508.pdf

FEMA (2015). *Federal Guidelines for Dam Safety Risk Management (FEMA P-1025)*. Available at <https://fema.gov/media-library-data/1423661058965-58dfcecc8d8d18b7e9b2a79ce1e83c96/FEMAP-1025.pdf>

FEMA (2016). *National Response Framework: Third Edition*. Available at <https://www.fema.gov/media-library/assets/documents/117791>

FERC (Federal Energy Regulatory Commission) (2015). *Potential Failure Modes (PFMs)*. Available at <https://www.ferc.gov/industries/hydropower/safety/initiatives/pfms.asp>

U.S. Department of the Interior, Bureau of Reclamation (2011). *Dam Safety Public Protection Guidelines*. Available at <https://usbr.gov/ssle/damsafety/documents/PPG201108.pdf>