Guidelines for Developing Emergency Action Plans for Dams

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February 2016

Central Water Commission

Ministry of Water Resources,
River Development & Ganga Rejuvenation
Government of India

DRIP
Dam Rehabilitation & Improvement Project

Front Cover Photograph: Srisailam Dam, which spans the Krishna River on the border of Mahabubnagar District, Telangana and Kurnool district, Andhra Pradesh, is the second largest capacity hydroelectric plant in the country.

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Government of India
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Guidelines for Developing Emergency Action Plans for Dams was first published in May 2006. First revision in 2016 is a comprehensive revision and is the first in a series of several dam safety guidelines being developed under the Dam Rehabilitation and Improvement Project (DRIP).

Disclaimer

Implementation of an Emergency Action Plan (EAP) for Dams streamlines various activities to be undertaken by many agencies in a coordinated manner to reduce the consequences of any emergency triggered by a dam failure or a dam incident. An EAP needs to be prepared specifically for each dam and implemented by all concerned. These guidelines help in developing EAPs for Dams. Adequacy and accuracy of primary data is important in formulating an EAP and in determining the severity of the situation during a dam failure or a dam incident. The EAP template provided is only an example and in no way restricts the developer of EAP in digressing from it. The Central Dam Safety Organisation or the Central Water Commission cannot be held responsible for the efficacy of the EAP developed based on these guidelines. Appropriate discretion may be exercised while preparing and implementing an EAP.

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FOREWORD

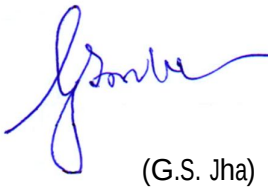
More than 80% of about 4900 large dams in India are greater than 25 years old and their health and safety are of paramount importance for sustainable utilization of these valuable assets, besides protecting people, property, and the environment. The Central Water Commission (CWC), with financial assistance from the World Bank, started the Dam Rehabilitation and Improvement Project (DRIP) to rehabilitate about 250 large dams in seven States. In addition to ensuring safety by proper upkeep of the dams, it is also necessary that we are prepared to face any emergencies caused by a dam failure. Therefore, DRIP assisted the various Implementing Agencies in preparing Emergency Action Plans. CWC had earlier published *Guidelines for Development and Implementation of Emergency Action Plans (EAP) for Dams* in May 2006. The developments that have taken place since then necessitated a relook into these Guidelines and revisions to them. This task was undertaken as part of the DRIP institutional capacity building effort.

The present *Guidelines for Developing Emergency Action Plans for Dams* describes all elements of an EAP and comprehensively covers requirements for notification flow charts, emergency conditions, inundation maps, emergency detection, evaluation and classification, emergency preparedness and implementation methodologies. Managing the contingencies caused by a failure of a dam or by uncontrolled release of water due to flooding, requires coordinated efforts of both dam owning/operating agencies and also disaster management authorities, namely District Magistrate/Collector, Armed Forces, Paramilitary Forces, Project Authorities and other Central/State Agencies. An EAP also contains inundation maps to show the disaster management authorities the critical areas for providing necessary relief and taking rescue actions in case of an emergency. For these reasons, EAPs provide a mechanism for coordination among all the agencies and defines their roles and responsibilities and the actions to be taken to minimize loss of life and damage to environment and property.

The EAP guidelines also provide a template for emergency action plans to facilitate dam owners in developing their EAPs in a consistent way. I advocate all dam owners in India to use these guidelines for developing EAPs for their dams, or for updating their existing EAPs, and for implementing them. I expect that implementation of these guidelines will improve the emergency preparedness and response capabilities to face any situation caused either by dam failures or by extremely large releases of dam water during severe weather conditions.

I compliment all the individuals who have contributed to the development of these guidelines and hope that all dam owners make use of them.

New Delhi, 15th February 2016



(G.S. Jha)
Chairman, Central Water Commission

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PREFACE

Design, construction, operation, maintenance, and inspection of dams are intended to minimize the risk of dam failures. Despite adequacies of these programs and their implementations, situations may develop sometimes leading to dam failures – structural or operational. The Central Water Commission (CWC) encourages and facilitates dam safety practices that will help reduce the risk to lives and property from the consequences of potential dam failures.

Enormous amounts of water flow out of a dam when it fails catastrophically, or when excess water is released through the spillways to protect the dam from failure during extreme weather conditions. This phenomenon adversely affects people, infrastructure, and the environment downstream of the dam. Concerted efforts are required from various organizations to protect lives and property, and to reduce damage to the environment. Emergency Action Plans help in streamlining the efforts and bring about better coordination among different agencies to execute rescue and relief activities. CWC published the *Guidelines for Development and Implementation of Emergency Action Plans (EAP) for Dams* in May 2006. Experience gained and the technological developments that have taken place since then necessitated the need for comprehensive revision of these guidelines.

CWC embarked on the Dam Rehabilitation and Improvement Project (DRIP), with financial assistance from the World Bank, to facilitate rehabilitation of about 250 large dams in seven States. DRIP also assists in preparing Emergency Action Plans for these dams. Revision of the *Guidelines for the Development of Emergency Action Plans (EAPs) for Dams* was taken up in earnest to help accomplish this task. CWC has published several guidelines relating to dam safety. Revision of two of the existing dam related guidelines and development of 11 new guidelines, along with three dam design review manuals, has been undertaken by DRIP.

Guidelines for the Development of Emergency Action Plans for Dams is the first of these documents to be released. This revision of the Guidelines includes a template for preparing an EAP so that a uniform approach for managing dam failure emergencies can be learned and followed easily and quickly by those responding to such crises. While comprehensively defining the aspects to be considered during preparation of an EAP for dams, the process has been modified to improve clarity and make implementation of response processes more straightforward. Use of the guidelines for developing EAPs for all large dams will significantly improve the Nation's emergency preparedness and response capabilities.

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LIST OF ACRONYMS

The following acronyms are used in this publication:

AAR	After Action Report
CDSO	Central Dam Safety Organisation
CWC	Central Water Commission
DDMA	District Disaster Management Authority
DRIP	Dam Rehabilitation and Improvement Project
DTM	Digital Terrain Model
EAP	Emergency Action Plan
LIDAR	Light Detection and Ranging
PAR	Population at Risk
SDSO	State Dam Safety Organisation

Chapter 1. OVERVIEW OF EMERGENCY ACTION PLANNING FOR DAMS

The primary goal of the Central Dam Safety Organisation (CDSO) of the Central Water Commission (CWC) is to encourage and facilitate dam safety practices that will help ensure operation of dams to their full capacities and intended purposes, and also to reduce the risk to lives and property from the consequences of both structural and operational dam incidents and failures. Although most dam owners have a high level of confidence in the structures they own and are certain their dams will not fail, history has shown that on occasion dams do fail and that often these failures cause extensive damage to property, and sometimes loss of life. Dam owners are responsible for keeping these threats to acceptable levels. A carefully conceived and implemented Emergency Action Plan (EAP) is one positive step dam owners can take to accomplish dam safety objectives, protect their investments, and reduce potential liabilities.

An EAP for a dam is a written document prepared by the dam owner, or the dam operator, describing a detailed plan to prevent or lessen the effects of a failure of the dam or appurtenant structures. An emergency action plan is not a substitute for proper maintenance or remedial construction, but it facilitates recognition of dam safety problems as they develop and establishes nonstructural means to minimize the risk of fatalities and reduce property damage.

The EAP is intended to interface with the emergency operation plans of other local, District and State agencies to ensure effective and timely implementation of response action. Every EAP has to be thus tailored to site-specific conditions and to the requirements of the dam owning/ operating agency and the local emergency management authorities. These guidelines define the requirements of an acceptable EAP and facilitate its preparation, distribution, annual update, testing, and periodical revision.

1.1 Why Is an Emergency Action Plan Required?

The EAPs are required to outline "who does what, where, when and how" in an emergency situation or unusual occurrence affecting the dam.

The need for EAPs was also emphasized by the Dam Safety Bill, 2010, which was introduced in the Lok Sabha on August 30, 2010, and subsequently referred to the Parliamentary Standing Committee on Water Resources for examination. Passing of the Bill was recommended by the Parliamentary Standing Committee subject to compliance of its recommendations and observations. However, with the dissolution of the 15th Lok Sabha, the Bill had come to a lapse. The enactment of the Dam Safety Bill is now required to be taken up afresh; and case is under process.

The draft Dam Safety Bill requires owners of specified dams to prepare emergency action plans that will accomplish the following:

a) *set out the procedures to be followed for the protection of persons and property upstream or downstream of the dam in the event of an actual or imminent dam failure or to mitigate the effects of the disaster;*

b) *include therein,*

   i. *in advance the type of emergencies which are likely to occur in the operation of any reservoir;*

   ii. *identification of the likely catastrophic flood in the event of any failure of the dam, along with probable areas, population, structures and installations likely to be adversely affected due to flood water released from the reservoir;*

   iii. *warning procedures, inundation maps and advance preparations for handling efficiently*

and in the best possible manner the likely adverse situations, especially to avoid loss of human life;

iv. *such other matters which may having regard to the geographical condition, size of the dam and other relevant factors as may be necessary.*

Emergency action plans thus proposed by the Dam Safety Bill will be put into effect as and when conditions arise that are likely to be hazardous to a dam or potentially hazardous to public safety, infrastructure, other property, or the environment.

The Dam Safety Bill also requires that owners of specified dams will, while preparing and updating emergency action plans, consult with all disaster management agencies and other concerned departments entrusted with disaster management and relief in the area likely to be affected. Owners of other dams in the immediate vicinity likely to be affected will also be consulted so as to bring transparency and allay any unwarranted fear on dam safety issues.

1.2 What Is the General Prce-dure for Developing an EAP?

Careful research and coordinated planning among all parties will lay the foundation for a thorough EAP. Make use of the portions of these guidelines that apply to your own dam. ***Note:*** **An EAP template is presented in Appendix A.**

An owner with several dams in the same area may develop one EAP to cover all of the dams. Such an EAP, however, would have to include a separate description for each dam, as well as a separate inundation or vicinity map (or both) and, possibly, separate notification flowcharts.

Development of an EAP generally follows the steps listed below.

Step 1. Determine the potentially inundated area by defining flood profiles downstream from the dam for conditions that may in-clude the following:

- Dam failure with the reservoir level at normal storage elevation (a so-called "fair weather" failure).
- Inflow design flood both with and with-out dam failure.
- Extremely large spillway flows resulting from severe weather and emergency conditions.

Detailed information on dam failure and inundation analyses can be found in the CDSO publication *Guidelines for Inundation Mapping of Flood Risks Associated with Dam Failures* (Doc. No. CDSO_GUD_DS_02).

Step 2. Prepare inundation maps that clearly depict the flooded areas from a dam failure. The time of arrival of wave front, maximum depth of inundation, and maximum velocity of flow may also be estimated for areas of high impact. For dams with limited downstream development, a generalized inundation map and narrative description may suffice.

Step 3. Identify situations or events that could trigger an emergency condition and require action.

Step 4. Evaluate the warning time available for the various triggering events.

Step 5. Identify all jurisdictions, agencies, and people who will be involved in the EAP. Contact the local District Disaster Management Authority (DDMA) / District Collector for assistance. Coordinate the development of the EAP with all involved parties.

Step 6. Identify primary and auxiliary communications systems, both internal (between persons at the dam) and external (between dam personnel and outside entities).

Step 7. List all the persons and entities that need notification in case of dam distress, prioritize the order of notification, and draft the notification flowcharts.

Step 8. Develop a draft of the EAP. A recommended structure for an EAP is described in the following pages and EAP template also provided in the appendices.

Step 9. Hold one or more coordination meetings with all local agencies and other parties on the notification list to receive their review and comments on the draft EAP.

Step 10. Submit a draft to the State Dam Safety Organization (SDSO) for review. For dams of national importance, the CDSO may be approached for review.

Step 11. Make any necessary revisions, obtain the necessary signatures for plan approval, and distribute the EAP to those who have responsibilities under the plan (EAP to include the Distribution List). Information about the EAP may also be made available on the websites of dam owner/ operator and the SDSO.

Step 12. Update the EAP annually for correcting the contact addresses, and share the updates with all concerned as per EAP Distribution List. Carry out a tabletop drill to test the efficacy of EAP at least once every five years. Revise the EAP, as and when required, in line with the outcomes of tabletop drill or the implementation hurdles observed during actual extreme events or other emergencies.

1.3 Outline of the EAP Five-Step Response Process

Five steps should generally be followed when an unusual or emergency incident is detected at a dam. These steps constitute the

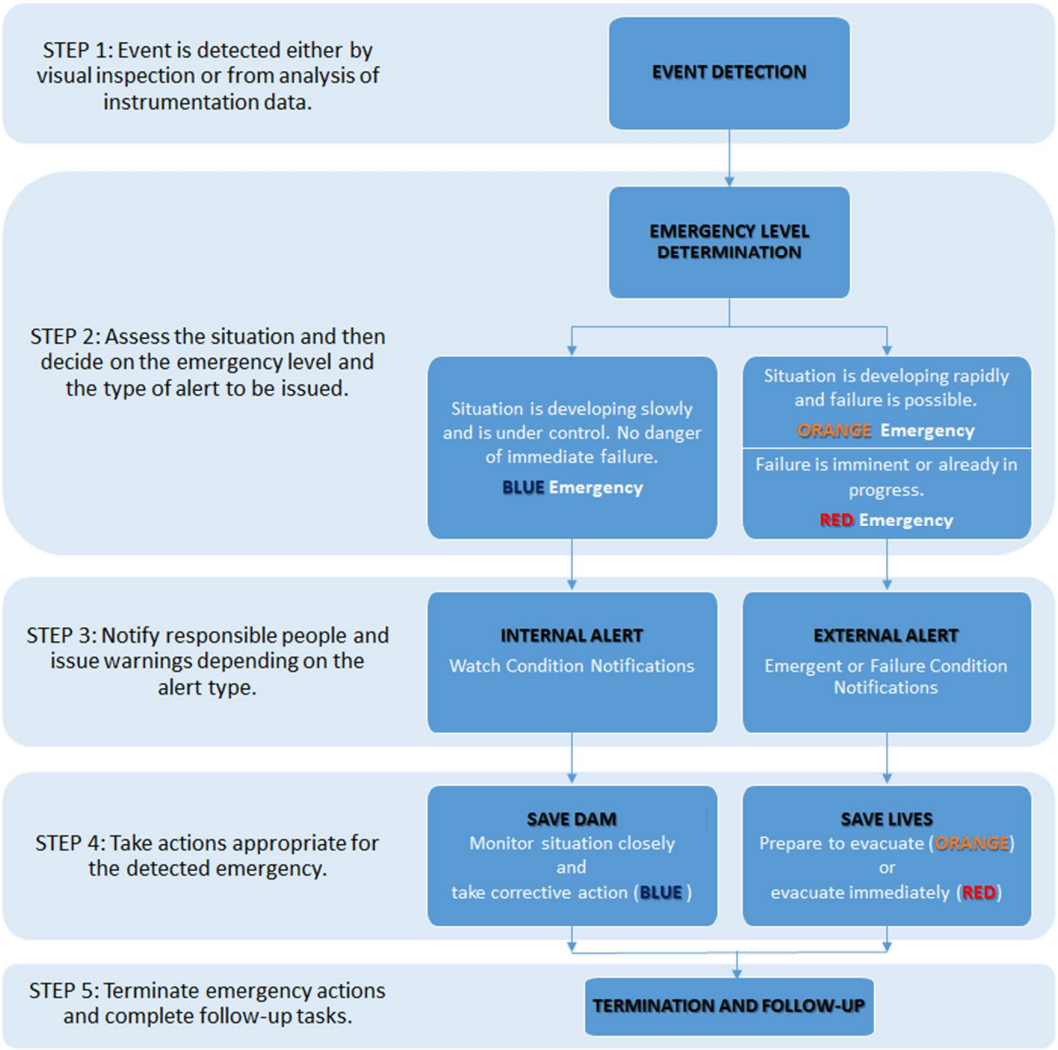

Figure 1. Flowchart showing the five-step response process of an EAP for a dam.

EAP response process as outlined below:

Step 1. Event Detection

Step 2. Emergency Level Determination

Step 3. Notification and Communication

Step 4. Actions to be Taken

Step 5. Termination and Follow-up

The five steps to take during an unusual event or emergency are illustrated in the flowchart shown in Figure 1. Responses for each alert type (Internal Alert for **BLUE** level emergency, or External Alert for **ORANGE** or **RED** level emergencies) contain all five steps. Depending on the type of alert to be issued, these steps will contain different notification lists and procedures. Careful preparation and review of all five steps will provide guidance during an unusual event or emergency. The five-step EAP response process and the three emergency alert levels are described in more detail in Chapter 2.

1.4 What Are the Elements of an EAP?

At a minimum, an EAP needs to contain the following items:

- title page
- purpose
- general description of dam
- responsibilities
- notification flowcharts
- inundation maps
- possible emergency conditions
- preventive actions to be taken
- supplies and resources
- implementation procedures

Elements of an EAP are described in detail in Chapter 3.

1.5 Making the EAP Easier to Use

The following ideas are suggested for making EAPs easier to use during an emergency:

- Place the EAP in a loose-leaf notebook so that individual pages can be replaced or removed easily. Notification Flowcharts, EAP Distribution List, and Log Sheet of Changes are the items that will be updated most often.
- Use top "hot buttons" divider tabs to make accessing important sections easier during an emergency.
- Use side divider tabs for major sections for use during training, annual reviews, and updating.
- Use headers or footers on each page that include the dam name and the date of the updated version in case the pages become separated.
- Number each copy of the final EAP and keep a record of the person who received each numbered copy to make sure that all official holders receive future updates and revisions.

1.6 Publication and Contact Information

This document along with the template EAP for dams is available on the CWC website (http://www.cwc.gov.in) and the Dam Rehabilitation and Improvement Project (DRIP) website (http://www.damsafety.in)

The *Guidelines for Inundation Mapping of Flood Risks Associated with Dam Failures* will also be available on the above websites.

For any further information contact

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1.7 Acknowledgments

In preparing these guidelines, work of others in India, the United States, and elsewhere has been drawn from liberally. Grateful appreciation is extended to the following organizations whose publications and

websites provided valuable information on EAP preparation and implementation:

- Federal Emergency Management Agency, US Department of Homeland Security
- Natural Resources Conservation Service, US Department of Agriculture
- Texas Department on Environmental Quality, Dam Safety Program
- Washington State Department of Ecology, Water Resources Program, Dam Safety Office

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Chapter 2. THE EAP FIVE-STEP RESPONSE PROCESS

Early detection and evaluation of the condition(s) or triggering event(s) that initiate or require an emergency response action are crucial. Procedures for early notification allow all persons responsible for implementing a plan to respond in a timely and effective manner. Prudent preventive or mitigating actions can then be taken to attempt to address conditions at the dam. Eventually, a decision will need to be made concerning termination of the incident, after which follow-up activities can be carried out. All of these steps, which make up the general EAP response process, are described in this chapter.

2.1 Step 1: Event Detection

Unusual conditions or incidents are unique to each dam and, to the extent possible, should be identified in the EAP. The following information should be considered for inclusion or reference in the plan to assist the dam owner/ operator in this step:

- Measures for detecting existing or potential failures
- Operating information, such as normal and abnormal reservoir level data
- Description of monitoring equipment, such as water level sensors and early warning systems
- Monitoring and instrumentation plans
- Inspection procedures
- Process for analyzing and confirming incoming data

2.2 Step 2: Emergency Level Determination

After an unusual condition or incident is detected and confirmed, the dam owner or operator will classify the condition of incident into one of the established emergency levels based on the severity of the initiating condition or triggering events. Both the dam owner and disaster management authorities should understand the emergency levels and each other's expected responses. Consistency of the emergency level categories is recommended to eliminate confusing emergency responders whose jurisdiction may contain multiple dams and dam owners.

The EAP should describe how each emergency level applies to the particular dam. Information to assist the dam owner in determining the appropriate emergency level should be developed and included in the EAP. An example table describing emergency level for different incidents is included in Appendix A.

The three dam safety emergency levels (**BLUE**, **ORANGE**, or **RED**) described below and in Table 1 are recommended. However, dam owners, in coordination with disaster management authorities, should determine the number of emergency levels required for each dam on a case-by-case basis.

2.2.1 BLUE Emergency Level

A **BLUE** emergency level is created by an unusual, slowly developing event that poses no threat to the structural stability of the dam or to its operational elements, and which does not make unviable the dam observation system. The condition will not have an off-site impact. However, the situation is one that needs to be monitored closely to make sure the condition does not worsen. If the condition does become more severe or unfavorable, the emergency status will be elevated to the next level.

Examples of conditions that would initiate a blue level emergency include the following:

- Adverse meteorological conditions;
- Detection of anomalies in:
  - dam structural elements, or;
  - dam operational elements, or
  - dam observation system.
- Existence of foundation problem

Apart from close monitoring of the developing situation, actions required for this level of emergency may involve visual inspection of all vulnerable portions and elements of the dam and appurtenant structures, and corrective actions wherever required. In many cases, these unusual events are remedied with no further action required. In cases where large flows over spillways (without endangering the dam) could cause unexpected flooding in immediate downstream areas, the downstream residents may need to be notified if flooding threatens life or property, but it should be made clear the dam is safe and is in no danger of failing.

2.2.2 ORANGE Emergency Level

An **ORANGE** emergency level occurs when a rapidly developing situation is taking place that will probably cause the dam to fail and produce a devastating flood. However, enough time is available for analysis before deciding whether or not to evacuate residents. Emergency responders in affected areas will be alerted that an unsafe situation is developing and dam failure is possible. Authorities responsible for rescue and relief shall gear up for evacuation of residents in potential inundation areas. When it is determined that there is no longer time available to implement corrective measures to prevent dam failure, the emergency status will be elevated to the highest (Red) level.

Examples of situations that would initiate an orange emergency level include the following:

- Rising reservoir levels that are approaching the top of the non-overflow section of the dam.
- Transverse cracking of an embankment.
- A verified bomb threat.

Emergency notifications should convey the fact that that time is available for analyses, decisions, and actions before the dam could fail. A failure may occur, but predetermined response actions may moderate or alleviate failure.

2.2.3 RED Emergency Level

A **RED** emergency level is triggered when dam failure is about to occur or is already in progress. Once a decision is made that there is no possibility of preventing failure, an order for evacuation of residents in potential inundation areas will be issued immediately by the incident commander or emergency responder.

Examples of situations that would initiate a red emergency level include the following:

- Imminent dam failure because of flood waters overtopping the dam crest, or because of large flows appearing from channels (piping) eroded through the embankment.
- Dam failure in progress.

For purposes of evacuation, disaster management authorities may assume the worst-case condition which is that failure has already occurred.

2.3 Step 3: Notification and Communication

After the emergency level at the dam has been decided, notifications are made in accordance with the EAP's Notification Flowcharts. Details on the use of the Notification Flowcharts and any additional contact information should be provided in the EAP.

When developing notification and communication procedures, dam owners should coordinate closely with disaster management authorities. All parties must understand that the formal declaration of public emergency by disaster management authorities can be a very difficult decision. During this step, the dam owner should provide any information that will assist in that decision. An early decision and declaration are critical to maximizing available response time.

When performing notification and communication activities, it is important that people speak in clear, nontechnical terms to ensure that those being notified understand what is happening at the dam, what the current

emergency level is, and which actions to take. To assist in this step, the EAP may include checklists and/or pre-scripted messages to help the caller adequately describe the emergency situation to disaster management authorities. Different messages can be developed for each emergency level. Examples of a notification checklist and pre-scripted messages are included in Appendix A.

After initial notification, the dam owner / operator should make periodic status reports to the affected emergency authorities and other stakeholders in accordance with the Notification Flowcharts and associated procedures. If it appears that the situation is continuing to deteriorate despite actions being taken to moderate or alleviate failure, local authorities may decide to change their course of action. Depending on the location of downstream residents and the estimated time required to warn them, the evacuating agencies may consider early evacuation or continued warnings until the emergency has passed.

2.4 Step 4: Actions to be Taken

After the initial notifications have been made, the dam owner / operator will act to save the dam and minimize impacts to life, property, and the environment. During this step, there is a continuous process of action taking, assessing the status of the situation, and keeping others informed through communication channels established during the initial notifications.

The EAP may go through multiple emergency levels during Steps 2 and 3 as the situation improves or deteriorates. The dam owner / operator should develop tables that include specific actions for minimizing impacts of dam safety incidents. Additional information related to response actions may also be provided in the dam operating manuals and instructions.

During an incident, safety and security measures should be implemented to secure the affected operational areas at the dam to protect operations personnel and the public, and permit an effective performance of emergency response actions.

2.5 Step 5: Termination and Follow-up

The EAP should explain the expected termination and follow-up procedures for dam safety incidents and emergencies. This step should explain the process to follow and the criteria for determining that the incident at the dam has been resolved.

A Dam Emergency Termination Log may be developed and used to document conditions and decisions. An example log form is provided in Appendix A.

Generally, the dam owner / operator, or the dam safety expert, is responsible for notifying the authorities that the condition of the dam has been stabilized. Disaster management officials are responsible for declaring an end to the public emergency response. Following the termination of an incident, the dam owner / operator, in coordination with disaster management authorities, should conduct an evaluation that includes all affected participants. At a minimum, the following should be discussed and evaluated in an after-action review:

- Events or conditions leading up to, during, and following the incident
- Significant actions taken by each participant and improvements for future emergencies
- All strengths and deficiencies found in the incident management process, materials, equipment, staffing levels, and leadership
- Corrective actions identified and a planned course of action to implement recommendations

The results of the after-action review should be documented in an After Action Report (AAR) and used as a basis for revising the EAP. The dam owner / operator should participate in the after-action review and the development of the AAR.

Table 1. Description of Emergency Alert Levels and Notification Types

Type of alert	Emergency level	Situation	Actions to be taken
INTERNAL ALERT (Watch Condition Notifications)	**BLUE**	Existence of anomalies or events that are either harmless or might compromise to some degree the structural or operational safety of the dam or the dam observation system. The situation is stable or is developing extremely slowly. Existing problems must lead to the belief that no serious consequences are expected downstream of the dam, and impacts (if any) will be small and confining to immediate downstream areas of the dam. Events leading to such a slowly developing situation include the following: 1. Existence of adverse meteorological conditions; 2. Existence of minor foundation problems	1. Issue Watch Condition notifications with a **BLUE** emergency level alert. 2. Monitor situation closely. 3. Take corrective measures to solve the problem.
EXTERNAL ALERT (Failure Condition Notifications)	**ORANGE**	Situations with a high probability of dam failure, with the belief that it might not be possible to control the situation and might cause serious consequences downstream of the dam. Events leading to such a rapidly developing situation include the following: 1. Detection of severe anomalies in- dam structural elements, or- in dam operational elements 2. Existence of severe foundation problems 3. Occurrence of extremely large floods Under these conditions the dam owner or operator might call for assistance from outside agencies. "Some amount of time" will be available for analysis, decisions, and mitigation before off-site impact will probably occur.	1. Issue Failure Condition notifications with an **ORANGE** emergency level alert. 2. Take corrective emergency measures to solve the problem. 3. Warning – Population downstream of the dam to prepare for evacuation.
	RED	Situation of inevitable catastrophe described as follows: 1. Imminent dam failure because of flood waters overtopping the dam crest, or appearance of large flows through channels (piping) eroded through the embankment. 2. Dam failure in progress. No time will be available for analysis, decisions, and mitigation to be made before downstream impacts occur.	1. Issue Failure Condition notifications with a **RED** emergency level alert. 2. Issue the most severe evacuation warning. Focus on evacuating first those most at risk. 3. Warning – Immediate evacuation.

Chapter 3. ELEMENTS OF AN EMERGENCY ACTION PLAN

Suggested elements of an EAP are described in this chapter. Including all of these items in an EAP will guarantee that all of the steps of the EAP response process described in Chapter 2 will be covered, thereby providing uniform, comprehensive, and consistent dam emergency action planning.

3.1 Title Page

The title page must include the following information:

- "Emergency Action Plan" title heading
- Official dam name as well as other names (if any) by which the dam is commonly known
- Project Identification Code (if a "large" dam, as specified in the National Register of Large Dams)
- Name of the dam owner / operator.
- Name of the organization that prepared the EAP.
- Date on which the EAP was published or revised (along with number of revision), and the date on which it was last updated.

3.2 Introduction

The introduction must briefly describe the purpose of the EAP and provide general information about the dam and the areas that would probably be flooded by uncontrolled outflow from the reservoir or by large spillway releases during emergencies.

3.2.1 Purpose

The purpose of an EAP is to provide a systematic means to carry out the following activities:

- Identify emergency conditions threatening a dam.
- Expedite effective responses so as to prevent a dam failure.
- Prevent or reduce loss of life and property damage should a dam failure occur.

This purpose must be stated concisely in the EAP.

3.2.2 General Description of Dam

A description of the dam and its location must include the following at a minimum:

- Official name of the dam, and other names by which it is commonly known.
- Name of stream obstructed by the dam.
- Location of dam including geographic coordinates (latitude and longitude, in decimal degrees).
- Year of starting of dam construction; year of first impoundment; and year of dam commissioning.
- Seismic Zone.
- Names of other dams on the same stream in immediate upstream or downstream vicinity.
- Dam owner's name, address, and phone number.
- Dam operator's name, address, and phone number (if different from dam owner).
- Type of dam (earth-fill or rock-fill embankment, concrete or masonry gravity, concrete or masonry buttress, concrete arch, and so on).
- Size classification.
- Description of potential downstream hazards (population centers, industrial development, transportation infrastructure, and so on).
- Dam height, length, crest width, embankment slopes (upstream and downstream), and so on.
- Spillway types and capacities.

- Elevation at top of dam and spillway crest.
- Normal and maximum storage volumes.
- Reservoir surface area.

3.2.3 General Description of the Downstream Inundation Areas

A general description needs to be provided of areas downstream of the dam that will be inundated by floods resulting from breaching or from large releases through spillways to protect the dam from failure during extreme weather conditions. The following features should be noted:

- Large population centers.
- Significant industrial development such as factories, power plants, and so on.
- Significant transportation infrastructure such as significant highways, railways, and bridge crossings, as well as power lines and pipelines.

3.2.4 Responsibilities

This section of the EAP must identify all of the following information:

- Person(s) responsible for the operation and maintenance of the dam.
- Person(s) responsible for observing the dam during extreme flooding events, during holidays, on weekends, and during normal conditions.
- Person(s) responsible for implementing each of the required phases of the EAP.
- Person(s) in charge of emergency response.
- Communication and coordination channels.
- Location of the incident command center or emergency operating center.
- Lines of succession and assumptions of responsibility necessary to ensure uninterrupted emergency-response actions under any conditions.

3.3 Notification Flowcharts

Dam owners/ operators are responsible for identifying distress conditions at the dam and notifying all the affected political jurisdictions and appropriate state and central agencies of such conditions and the possible consequences. Use notification flowcharts to identify the jurisdictions and agencies.

Notification flowcharts must be located near the front of the EAP and be clearly marked with tabs or other means.

3.3.1 Emergency Conditions and Notifications

The following two emergency conditions are put into effect depending on the emergency level (**BLUE**, **ORANGE**, or **RED**):

- **Watch Condition** – Initiated by **BLUE** emergency level for which dam failure is not likely to occur if the situation is monitored or corrected promptly.
- **Failure Condition** – Initiated by **ORANGE** or **RED** emergency levels for which dam failure is highly probable, or the failure has become imminent or already ongoing.

3.3.2 Flowchart Elements

A minimum of two notification flowcharts are needed (one for each of the emergency conditions) showing the people to whom warnings are to be issued during an emergency and the order in which they are to be contacted. The flowcharts must clearly summarize the following information:

- Who is responsible for notifying each owner representative and public official?
- Who is to be notified?
- The order in which people or offices are to be notified.
- Individual names; position titles; office, home, mobile, and 24-hour telephone numbers; alternative contacts; and means of communication.

3.3.3 Notification Responsibility

It is normally the responsibility of local governments or law enforcement agencies, upon receiving such notification, to warn the public, make recommendations about evacuation, carry out the evacuations, and offer shelter to area residents. However, in some cases it will be more appropriate for the dam owner to warn certain persons instead of, or in addition to, relying on local government officials, particularly with small dams that may only affect a few people.

3.4 Inundation Maps

An inundation map is used to depict areas that could flood if a dam fails, and must be included in the EAP. If appropriate for the level of effort used in calculations, inundation maps should also show the time to flood (the time from the breach to the time that critical structures are flooded) and the time to peak flow.

The detail and complexity of inundation mapping depends on the expected impact of a dam failure flood on downstream population and infrastructure. For small and intermediate dams with limited downstream development, a narrative description of the affected areas and a generalized inundation map noting the potentially impacted downstream structures may suffice. For large and many intermediate-size dams, or for small dams with substantial development downstream, detailed inundation maps will be fundamentally important.

The following discussion describes the different types of inundation maps and how they are used in evacuation planning.

3.4.1 Approximate Inundation Maps

Development in the floodplain below some dams is sparse and the expense of preparing detailed inundation maps is not warranted. Instead, a description of the potential flooding and an approximate inundation map with pertinent information at key locations will suffice.

The Survey of India is responsible for all topographic control, surveys and mapping of India. Survey of India topographic maps, city street maps, or maps from free internet map services (such as Google Maps, Bing Maps, Yahoo Maps, and Map Quest) often have sufficient detail for use when preparing approximate inundation maps. Aerial photographs and satellite images can also be used as a background for inundation maps if they are reasonably clear when displayed at an appropriate scale.

3.4.2 Detailed Inundation Maps

A detailed inundation map is prepared using the results of a simplified or full breach analysis carried out by a professional engineer. Whenever communities or significant numbers of dwellings are located in the floodplain downstream of a dam, or for large dams with complex floodplains, detailed inundation maps are usually needed for the development of an adequate evacuation plan.

These maps should show an outline of the area that would be inundated in the event of a dam failure at sufficient scale and in enough detail to identify areas, including dwellings, roads, low-water crossings, and other critical structures (schools, assisted-living facilities, hospitals, etc.) likely to be directly affected.

Information must also be included on approximate depth of flooding and velocity of flows along with travel time for floods to reach specific locations. (Inundation mapping is described in greater detail in the CDSO publication *Guidelines for Inundation Mapping of Flood Risks Associated with Dam Failures, Doc. No. CDSO-GUD-DS-02).* Generally, mapping involves superimposing the inundation area outline on an existing map, aerial photograph, or satellite image. Clarity and simplicity of the displayed inundation areas are of utmost importance.

The best available maps, aerial photographs, or satellite images are recommended for use as a basis for detailed inundation maps. Highly accurate Light Detection and

Ranging (LIDAR) elevation data should be used where available to develop digital terrain models (DTM), to carry out hydraulic calculations, and to display flood inundation areas.

Lines delineating the inundated areas should be thick enough or distinct in form (for example, solid, dashed, dotted) to identify the dam-failure inundation limits as the main feature of the map, but not so bold that they mask features that would be inundated by a dam failure.

However, note that published maps might not include all recent physical development. Therefore; proper measures should be taken to ensure that significant existing structures located within inundations areas are identified.

Because local officials are likely to use the inundation maps for evacuation, a note should be included stating the following:

> "Because of the method, procedures, and assumptions used to determine the flooded areas, the limits of flooding shown and flood-wave travel times are approximate and should be used only as a guideline for establishing evacuation zones. Areas inundated in an actual event will depend on actual failure conditions and may differ from areas shown on the maps."

3.4.3 Progressive Refinement of Inundation Maps

The cost of detailed studies needed to delineate areas that would be inundated by a dam breach flood is consistently cited as the primary impediment to EAP development. For this reason, a tiered approach to EAP development will be used to establish an initial dam hazard potential classification and to produce dam breach inundation zone mapping. However, the tiered approach is not used to determine the appropriate flood magnitude to use in a dam failure analysis. Instead, it is used to determine the appropriate level of complexity in assessing, modeling, and mapping of a dam failure flood based on a dam's hazard potential, size, and the complexity of the downstream area under investigation.

The level of analysis for the tiered approach correlates the sophistication and accuracy of the analyses with the scale and complexity of the dam and downstream area under investigation. Therefore, analysis of high-hazard potential dams located upstream of populated areas or hydraulically complex floodplains should use more sophisticated modeling and additional sensitivity studies to assess properly the consequences of a dam failure. On the other hand, analysis of low-hazard potential dams situated upstream of sparsely populated areas may rely on more approximate methods of analyses.

In general, as the sophistication of the modeling increases, so does the level of effort, time, and cost needed to carry out the analysis. Guidance for deciding on the tier level for dam failure inundation modeling and mapping is presented in Figure 2, which provides a logical combination of methods to be used when carrying out a study. The dam failure analysis should be continued downstream to a point where the flood no longer poses a risk to life and property damage, such as the confluence with a large river or reservoir with the capacity to store the flood waters.

3.5 Emergency Detection, Evaluation, and Classification

An EAP must indicate procedures and list conditions, triggering events, and measures for timely and reliable detection, evaluation, and classification of an existing or potential emergency. The EAP must also incorporate an assessment of the dam, including its vulnerability to all the appropriate known emergency conditions (such as security threats, severe thunderstorms with lightning and excessive rains, tropical cyclones, and earthquakes) as well as a list and explanation of problem indicators for emergency detection.

Dam owners / operators are required to monitor regularly the conditions of their

Tier Level	Applications	Breach parameter prediction	Peak breach discharge prediction	Downstream routing of breach outflow hydrograph	Downstream risk evaluation
Tier 1 – Basic level screening and simple analysis using low resolution terrain data (for example, SRTM, ASTER, or 30 m INTERMAP).	• First level screening for significant or high-hazard dams • Low-hazard potential dams	Empirical formulas.	Empirical formulas if inflow design flood hydrograph is not available, otherwise unsteady flow routing through modeled breach.	GeoDam-BREACH, SMPDBK, HEC-HMS, or other simplified approaches.	Peak discharge, water-surface elevation, and flood wave travel time.
Tier 2 – Intermediate level of analysis using medium resolution terrain data (for example, 10 m INTERMAP or Lidar).	• Large significant-hazard dams • All high-hazard dams	Empirical formulas.	Unsteady flow routing through modeled breach.	HEC-HMS, HEC-RAS, MIKE-11 or similar one-dimensional (1D) unsteady flow numerical models.	Peak discharge, water-surface elevation, flood wave travel time, and approximate PAR assessment.
Tier 3 – Advanced level of analysis using high resolution Lidar terrain data.	• Significant hazard dams with complex downstream flooding • High-hazard dams with large population at risk (PAR).	Empirical equations, WinDAM-B, or causal embankment erosion numerical models (one- or two-dimensional)	Unsteady flow routing through modeled breach.	One- or two-dimensional (2D) unsteady flow numerical models.	Peak discharge, water-surface elevation, flood wave travel time, and detailed PAR assessment.

Figure 2. Tiered approach to dam breach inundation mapping for use in EAPs.

dams and correct any deficiencies. The plan must include a routine inspection schedule and name of the person or position responsible for the inspection. It should also emphasize indicators of the onset of problems that might cause dam failure, such as the following:

- Slumping, sloughing, or slides on the dam or the abutments.
- Cloudy or dirty seepage or seepage with an increase in flow, boils, piping, or bogs.
- Seepage around conduits.
- Cracks, settlement, misalignment, or sinkholes.
- Erosion or riprap displacement.
- Animal burrows.
- Growth of trees and brush.
- Failure of operating equipment.
- Abnormal instrument readings.
- Leakage of water into the intake tower or drop inlet.
- Undermining of spillways.
- Overtopping of the dam.
- Forecast of extremely high inflow.

The EAP must indicate what action will be taken and what resources will be used when a situation or indicator is observed, and how quickly the problem will be reported. Records relating to any of the indicators listed above must be kept to determine if changes are occurring. Good record-keeping will enable informed assessments of the problems and decisions regarding implementation of the EAP. However, if dam failure is highly probable, all applicable notification procedures and emergency actions should be implemented immediately.

Emergencies are classified according to their severity and urgency. The EAP must provide classification levels that the dam owner or operator and the DDMA can understand, to reduce the possibility of them under- or

overreacting to an emergency. List the anticipated emergency conditions, such as:

- **BLUE emergency level** – This is a "watch" condition initiated when a problem has been detected at the dam that requires constant monitoring but is manageable by dam personnel. The "watch" condition will continue until the problem is corrected or the condition is elevated to a "possible dam failure," and the appropriate warning is issued.
- **ORANGE emergency level** - The owner or the operator has determined that there is a high probability of failure of the dam and an uncontrollable release from the reservoir. However, time is available for analysis, decisions, and actions before the dam could fail; such actions may moderate or alleviate failure.
- **RED emergency level** - The dam is about to fail or has already failed. A flood wave is either currently or will soon be moving downstream. Destruction can be expected from the flood wave and the evacuation of downstream areas should be carried out in accordance with local plans.

There may be cases where some of the population settlements are located very close to the dam, and the time available after red emergency notification may not be sufficient for their evacuation. In such cases and for the mentioned limited settlements, preparation for evacuation and the actual evacuation may be linked with the **BLUE** level and **ORANGE** level emergency alerts respectively.

For large dams, owners may want to include a section related to emergency water release, which is a release in excess of normal that could flood certain downstream areas.

3.6 Preparedness

The EAP must describe preparedness actions to be taken both before and following the development of emergency conditions and must identify ways of preparing for an emergency, increasing response readiness in a uniform and coordinated manner, and helping to reduce the effects of a dam failure. The goal is maximum readiness to respond in minimum time.

Preparedness actions involve the installation of equipment or the establishment of procedures for one or more of the following purposes:

- Preventing emergency conditions from developing, if possible, or warning of the development of emergency situations.
- Facilitating the operation of the dam to limit impacts in an emergency situation.
- Minimizing the extent of damage resulting from any emergency situations that develop.

Because of uncertainties about their effectiveness, preparedness actions designed to be implemented during an emergency situation are usually carried out at the same time as notification is made of an impending failure. Preparedness actions that occur during or after an emergency are considered emergency repairs and should be undertaken under the direction of the owner's professional engineer or contractor.

The SDSO (and CDSO in case of dams of national importance or in cases where substantial impacts are anticipated) should be notified of action being taken as soon as the emergency situation allows, but no more than 12 hours after the emergency is discovered. In addition, as soon as the emergency is over, the owner's professional engineer must develop plans for permanent repairs.

There are several types of preparedness actions that must be contained within the EAP, including the following:

- Surveillance. At dams that are normally unattended, give special consideration to providing for full-time surveillance during and after emergencies such as a major flood or earthquake. Because an EAP has little value unless it can be implemented quickly, surveillance at the

dam helps ensure enough time to warn the public.

- Response during weekends and holidays. Identify the personnel who will be present and specific actions that are required for emergency response on weekends and holidays.
- Response during periods of darkness and adverse weather. Describe the actions to be taken to illuminate the spillway and distressed areas and to facilitate the operation of gates or other emergency equipment.
- Access to the site. Identify primary and secondary routes for reaching the site under various conditions. Special attention should be given if the main access road crosses the downstream channel, which could be closed by floodwaters.
- Alternative systems of communication. Identify alternative channels of communication to be used in case of failure of the primary system or other systems.
- Lower the reservoir water level. If applicable, describe when and how this action will be taken.

3.6.1 Preparedness for sudden controlled releases from Dam

An updated Reservoir operation Manual, prescribing standard operating procedures for the day to day as well as emergency operations of dam, shall be available with the dam owner/ operator. The manual shall spell out all possible scenarios of operation of spillway gates and other outlet gates keeping in perspective the elevation-storage cure of the reservoir; the annual inflow pattern of the reservoir; the annual water demand pattern of the project; and in case of hydropower projects, the power demand and impact load rejection of generating units.

In vulnerable areas involving high impacts of sudden spillway releases, the dam owner shall mark danger levels at appropriate places and set up permanent warning posts (in English, Hindi and local languages) visible to the naked eyes from reasonable distances. Movable barriers may also be installed to prevent entry of vehicles in such areas during passage of flood. If required, areas of high risks (very close to dam location) shall be fenced to bar free access of people. Development of the river-front tourism shall be allowed only at safe locations; and in all such places ample care shall be taken to prominently notify risks associated with sudden release of water from the dam. Tourists entering the vulnerable zones may also be forewarned of the possible danger of sudden dam releases through SMSs.

A foolproof warning system to alert downstream habitats before release of water from the dam spillways shall be put in place. The warning may be given through speakers, sirens or hooters adequately in advance of dam releases (minimum 15 minutes). The warning system shall be backed up by alternate power sources so as to avoid its malfunctioning in case of power failure. The sirens/ hooters shall be distinguishable from other common sounds (such as from VIP vehicles, fire brigades, ambulances etc.). Regular inspections shall be carried out for ensuring all time functioning of the warning system, and periodical mock drills shall also be planned for ensuring their efficacy.

3.7 Supplies and Resources

The EAP should identify the following supplies and resources:

- Support capabilities, such as personnel or organizations (including the dam owner's engineer) that can render assistance, and the procedures for contacting them.
- The location of supplies and equipment available for use in remedial actions, preferably as close as possible to the dam.
- Procedures for emergency procurement of supplies and equipment needed for remedial actions.
- Remedial construction and other activities that should be done to prevent a

failure of the dam, and who will carry them out.

For each applicable item, include specific contact names along with their function, their business or agency, and contact information.

3.8 Implementation

After the draft EAP is completed, and before final approval, it should be submitted to the SDSO for review and comment. For dams of national importance, the CDSO may be approached for review. After review comments are received, the EAP should be revised as needed and steps then taken to implement it.

Copies of the completed EAP, including the inundation maps, should be provided to the SDSO and to appropriate local officials as per EAP Distribution List.

Briefings with local officials should be scheduled to facilitate the incorporation of information on dam-failure planning in the disaster management plans of local governments.

3.8.1 Updating

Update the EAP promptly after each change in personnel involved or in their contact information. Likewise, when there is a significant change in dam operation, downstream development, or other conditions that affect the EAP, a comprehensive review of the adequacy of the plan should be carried out with local disaster management officials. The comprehensive review should also be carried out if EAP implementation hurdles are observed during actual extreme events or other emergencies.

At least once a year the dam owner should update the EAP for correcting contact addresses. At least once in five years the dam owner should carry out table top drill to test the efficacy of EAP and to identify requirements of its revision. The dam owner should distribute copies of the updated/ revised portions to all concerned as per EAP Distribution List. If no updates/ revisions are found to be necessary, the owner should distribute written notifications stating that the EAP has been reviewed and that no updates/ revisions have been adopted or implemented.

A procedure needs to be established to ensure that all copies of the EAP are properly amended immediately following the updates/ revisions.

3.8.2 Location

A copy of the complete up-to-date EAP must be available to the dam operator, the DDMA, the SDSO, and other local officials. The location of each copy should be stated in the EAP.

3.8.3 Approval

Include a form on which the dam owner and local disaster management coordinator sign a statement that they have reviewed the EAP and concur with the notification procedures.

3.8.4 Testing

The dam owner should test and review the EAP periodically. The level of detail and frequency of reviewing depend on the size of the facility and the complexity of the downstream setting. For small dams and others with only a few homes in the downstream inundation areas, a simple review of the EAP, including validating phone numbers on the notification flowcharts, may suffice.

For dams with significant development downstream, a more detailed review is appropriate, such as developing a drill for dam personnel that rehearses the EAP. Note that state and local officials must be consulted before performing any test of the EAP.

The minimal test and review should be completed annually to keep the owner's employees familiar with the EAP and to eliminate any potential problems. At the same time, the notification procedures must be updated to include any changes in names and telephone numbers of personnel, local

officials, and downstream residents, and to include any new problems. Revisions of the EAP should be provided to the SDSO and to appropriate state and local government officials.

It is strongly suggested that the dam owner conduct a tabletop drill at least once every five years in the form of a meeting with state and local disaster management officials in a conference room. The drill will begin with a description of a simulated event and proceed to discussions among the participants to evaluate the EAP and response procedures, and to resolve concerns about coordination and responsibilities. The owner must advise the SDSO and the state and local disaster management officials well in advance of the time, date, and location of the drill.

3.8.5 Training

Training of the people involved in the EAP should ensure that they are thoroughly familiar with all elements of the plan, the availability of equipment, and their responsibilities and duties. Again, the level of detail involved in training depends on the size and complexity of a dam. For small dams with simple EAPs, training may simply involve having responsible persons read the EAP and submit written confirmations annually.

In the case of larger, more complex dams, training will be much more involved. Schedule training for employees associated with the dam to familiarize them with the EAP by addressing the following elements of the plan:

- How to use the EAP;
- How to identify the severity of a problem;
- How to use the notification procedures and the communication equipment;
- What resources are available;
- The importance of employees' roles during emergencies; and
- The importance of updating downstream information.

Train enough people to guarantee adequate coverage at all times. Drills simulating dam failures are excellent training mechanisms for ensuring readiness. It is advisable to cross-train people for more than one responsible position. Keep a record of training completed by key personnel.

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Appendix A. TEMPLATE FOR AN EMERGENCY ACTION PLAN FOR DAMS

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Emergency Action Plan

[Name] Dam

[Project Identification Code]

Prepared for

[Dam Owner Name]

Prepared by

[Name]

[Date]

[Name] Dam

Project ID Code [##########]

Place

Emergency Action Plan for [Name] Dam was published in [Month] [Year]. This is the [Number] revision in [Month] [Year] as updated in [Month] [Year].

Disclaimer

Every effort has been taken to estimate the severity of flooding and inundation areas likely to be affected by [Name of Dam] in an emergency condition. These estimates are based on available primary and secondary data. Every effort has been made to foresee varied emergency possibilities and develop appropriate notification procedures for timely rescue and relief operations. However, implementation of the Emergency Action Plan (EAP) involves many agencies, who are required to work in a coordinated manner to reduce the consequences of the emergency triggered by the dam site condition. Effectiveness of the rescue and relief operations depend on many factors including the adequacy and accuracy of the estimation of the severity of flooding, coordinated efforts of all the agencies involved in rescue and relief efforts and availability of facilities like power, telephones, road communications, etc. EAP Developer may therefore, not be held responsible for the efficacy of the EAP.

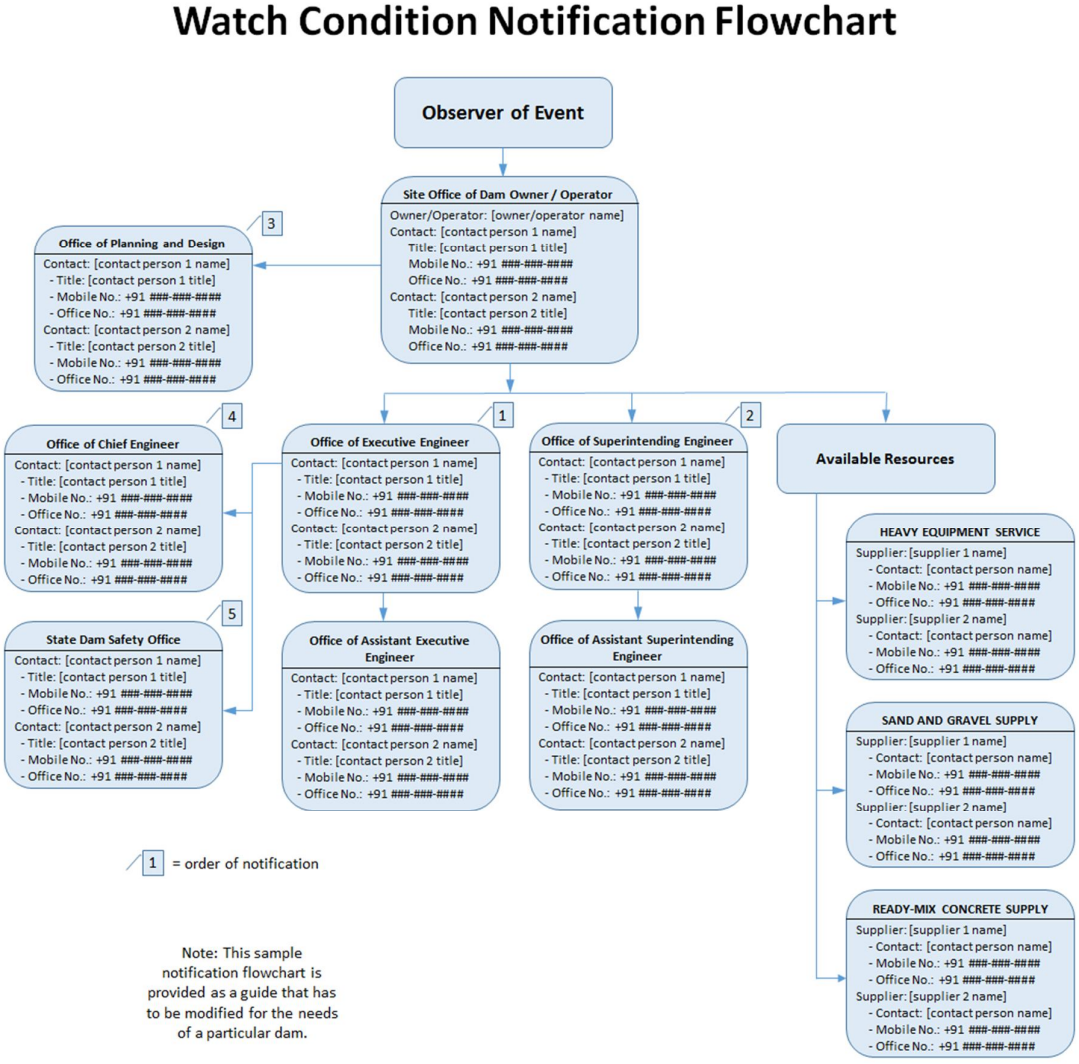
For any information, please contact:
[Name],
[Designation],
[Organization],
[Address],
[Place],
[Phone].

Emergency Action Plan

[Name] Dam

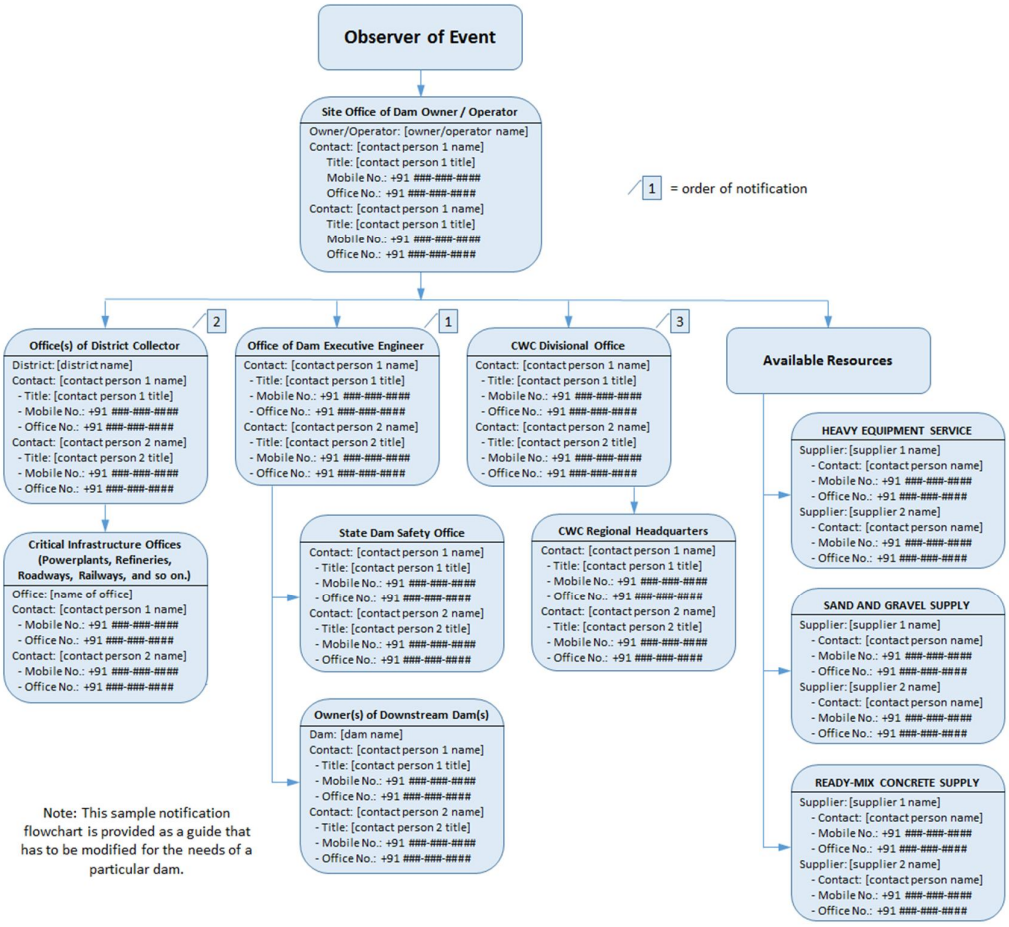
[Dam Owner]

Contents



Sample internal alert (watch condition) notification flowchart.

Failure Condition Notification Flowchart



Sample external alert (failure condition) notification flowchart.

[Name] Dam

Project ID Code [##########]

EAP Distribution List

A copy of the EAP has been provided to the following people:

Authority	Name, Title, Phone	Address
Dam Owner(s) and Representatives		
Dam Operator		
State Dam Safety Organisation	[Name of Contact] Phone +91 ###-###-####	
State Public Works Department	[Name of Contact] Phone +91 ###-###-####	
District Disaster Management Authority [AAA District]	[Name of Contact] Phone +91 ###-###-####	
District Public Works Department [AAA District]	[Name of Contact] Phone +91 ###-###-####	
Engineer [Company Name]	[Name of Contact] Phone +91 ###-###-####	

Note: Include information for all districts and other administrative subdivisions within the inundation area.

[Name] Dam

Project ID Code [##########]

Log Sheet of Changes

The following changes have been made to the EAP and revisions have been provided to the people shown on the EAP Distribution List.

Date	Change Made	Signature

[Name] Dam
Project ID Code [##########]
Approval and Implementation

This Emergency Action Plan is hereby approved. This plan is effective immediately and supersedes all previous editions.

_____
[Signature]

_____ _____
[Name and Title of Appropriate Manager for Owner] Date

I have received a copy of this Emergency Action Plan and concur with the notification procedures.

_____
[Signature(s)]

_____ _____
[Name and Title of Person(s) in charge of Emergency Response] Date

Emergency Action Plan

[Name] Dam

Project ID Code [##########]

1. Purpose

The purpose of this Emergency Action Plan (EAP) is to identify emergency situations that could threaten [Name] Dam and to plan for an expedited, effective response to prevent failure of the dam and warn downstream residents of impending danger. This plan defines the notification procedures to be followed in the event of a potentially hazardous situation. The procedures are intended to protect lives and prevent property damage from an excessive release of water from the dam spillways or an uncontrolled outflow of water from the breached portion of dam.

2. Dam Description

2.1. General

[Name] Dam and Reservoir are owned and operated by [Dam Owner]. It is located on [Stream] in [Name] District, approximately [##] kilometres [direction] of [City], [State]. [Stream] is a tributary of the [Name of Main Tributary], located in the [Name] River Basin. The dam was completed in [year] and was constructed under Project No. [####] granted to Owner in [year]. The reservoir was constructed to serve as [purpose].

A vicinity map showing the location of the dam is presented in Tab 1. Inundation maps showing the areas subject to flooding as a result of a dam failure are provided in Tab 2. The inundation area is described in further detail in the Inundation Area section of the report. Lastly, a description of the dam, its spillways, and other features are outlined in the Dam Description in Tab 3.

2.2. Reservoir Operations

[The purpose of this section is to identify features and controls on the dam that would be used to release water and to explain how they would be implemented during an emergency. If the dam does not have any controls, the statement "Releases from the reservoir are uncontrolled" will suffice.]

3. Responsibilities

3.1. Dam Owner's Responsibilities

The dam owner, [Dam Owner], is responsible for all dam operation and maintenance. The EAP will not designate a specific person for a specific responsibility but instead will designate the person's duties or job description.

The [Dam Owner's Emergency Planning Manager] is the first line of dam observers and is the person responsible for initiating implementation of the EAP.

The [Title] is responsible for collecting weather forecasts and the inflow forecasts and alerting of any potential emergency situation.

The [Title] is responsible for conducting routine dam maintenance, such as annual weed control, conducting dam integrity inspections, and notifying [Dam Owner] of any potential emergency situations.

The [Title] is responsible for contacting emergency personnel should a dam failure be imminent.

The [Dam Owner's Emergency Planning Manager] is responsible for updating the EAP. An annual EAP review will be conducted to ensure that contact names and numbers are current on the Notification Flowcharts.

The [Title] is responsible for directing specific, incident appropriate actions during an emergency, such as opening or closing water outlets and remedial construction activities such as earth moving, etc. Specific scenarios are not listed in this EAP.

3.2. Responsibilities for Notification

The [Title] is responsible for inspecting the dam in a potential emergency such as the potential threat of high waters or a tropical cyclone. The [Title] will contact the [AAA District or AAA City Police] and District Magistrate/Collector.

If warranted, the [Title] will notify the State and District Disaster Management Authorities. The [AAA District or AAA City Police] will notify downstream residents. The [AAA District or AAA City] District Magistrate/Collector will implement the Notification Flowchart for regional and state disaster management contacts.

3.3. Emergency Operations Center

In the event of a **failure condition**, the [Dam Owner's Emergency Planning Manager] will activate the Emergency Operations Center to serve as the main distribution center for warning and evacuation activities. The Emergency Operations Center will be established at the [Location of office]. The [Dam Owner's Emergency Planning Manager] will be responsible for initiating actions from this location.

3.4. Responsibilities for Evacuation

The [AAA District Disaster Management Authority or AAA City Police] are responsible for initiating evacuations.

3.5. Responsibilities for Duration, Security, Termination, and Follow-up

The [Title] is responsible for monitoring of emergency situations at the dam and keeping authorities informed, based on the Notification Flowcharts.

The [Title] and the [title of District Magistrate/Collector] are responsible for declaring that an emergency at the dam is terminated. Applicable authorities will be notified based on the Notification Flowcharts.

The [Title] will ensure that a follow-up evaluation is completed by all participants after the emergency. The results of the evaluation should be documented in a written report and filed with the EAP.

3.6. Communications

Local officials and downstream residents will be notified by landline telephone, if available; otherwise via cell phones or emergency personnel (in person or using their radios). The various networks for emergency use include the networks of the following:

- The [AAA District Police] or [AAA City Police]
- The [BBB District Police] or [BBB City Police]
- The [CCC District Police] or [CCC City Police]
- The [State] Disaster Management Authority
- The [State] Ministry of Road Transport and Highways

Sample public announcements appear in Tab 4. Verification or authentication of the situation can be made by contacting the [Dam owner's Emergency Planning Manager] and the [AAA District], [BBB District], and [CCC District] and/or [City of AAA], [City of BBB], and [City of CCC] disaster management officials. Television, Radio and bulk SMS facilities of the local Mo-

bile Network Operators can be used as much as possible to notify area residents of the possible dangers. Public announcements are to be issued by the concerned District Disaster Management officials or the [Dam Owner] public affairs officer.

4. Emergency Detection, Evaluation, and Classification

4.1. Emergency Detection

A. Situations

Many dam conditions can lead to emergency situations, not all of which will necessitate the implementation of the EAP. However, if any of them occur, the appropriate actions must be taken.

- Severe Storms/Inclement Weather: Although generally not in themselves a threat to the dam, severe storms and other inclement weather conditions can contribute to an existing problem and hinder any remediation efforts. Severe storms also cause the uncontrolled release of floodwater, and increase flow in already rain-swollen areas.
- Tropical cyclones: Tropical cyclones do occur in the area, with the potential for structural damage to the dam, possibly resulting in its failure. If a tropical cyclone has struck in the area, an inspection of the dam for any signs of damage will be appropriate.
- Earthquakes: [Dam Name] is located in the seismic zone [Number]. An earthquake is a possibility, and appropriate post-earthquake inspections should be performed.
- Sabotage: A threat to damage the dam has been made. Appropriate actions must be taken to protect the dam.

B. Signs of Failure

The [Title] is responsible for conducting routine inspections and identifying conditions that could indicate the onset of problems leading to a dam failure. The early identification of potentially dangerous conditions can allow time for the implementation of EAPs. It is important to understand how distress can develop into failure. With appropriate action, distress need not lead to a catastrophic failure of the dam. The following sections describe some of the different types of failure which could lead to a dam failure.

- Seepage Failure: Although all earthen embankments allow some minor seepage through the dam or the foundation, excessive, uncontrolled seepage can result in piping (the movement of embankment material in the seepage flow) and lead to failure. Piping can occur for years at a slow rate. If the piping has progressed to a dangerous level, it will be evident by increased flow or the discharge of muddy water (or both). At that stage, immediate action to stop the piping is needed. Fully developed piping is difficult to control and is very likely to result in failure. A whirlpool in the reservoir is a sign of uncontrollable piping and necessitates immediate emergency action.
- Embankment or Foundation Sliding: Sliding is usually first apparent when cracks or bulges in the embankment appear. Slides with progressive movement can cause failure of the embankment.
- Structural Failure: The structural failure or collapse of any non-overflow portion of the dam, spillway or spillway gates could result in loss of the reservoir. A structural failure of a portion of the spillway could cause piping and possibly embankment failure.

- Overtopping Failure: Overtopping of the embankment results in erosion of the dam crest. Once erosion begins, it is very difficult to stop.

4.2. Emergency Evaluation and Classification

This section lists the conditions and actions which may be used to classify the level of emergency response, as a guide for the [Dam Owner's Emergency Planning Manager]. Specific dam observations and corresponding emergency classification levels can be found in the Evidence of Distress table in Tab 5.

Internal Alert Condition BLUE – A "watch" condition. A problem has been detected at the dam that requires constant monitoring. At this time, the distress condition is manageable by dam personnel. The [Dam Owner's Emergency Planning Manager] will be responsible for monitoring and repair as soon as possible and implementing the appropriate Notification Flowchart. The following is a list of conditions that would initiate this condition:

- Cloudy or dirty seepage or seepage with an increase in flow, boils, piping, or bogs
- Seepage around conduits
- Large sinkholes with corresponding seepage anywhere on the embankment or downstream from the toe
- Any slide that degrades the crest of the embankment or that is progressively increasing in size
- Cracking or movement of any concrete structure
- An increase in the reservoir level leading to engagement of the emergency spillway
- Exceptionally heavy rainfall in the catchment of the dam reservoir

External Alert Condition ORANGE – This is indicative of a dam condition that is progressively getting worse; and there is a high probability of dam failure. Although there is no immediate danger, the dam could fail if conditions continue to deteriorate. The [Dam Owner's Emergency Planning Manager] will be responsible for initiating immediate repairs, including lowering the reservoir if appropriate and implementing the appropriate Notification Flowchart. The following is a list of conditions that would initiate this condition:

- Large boils, increasing in size and flow rate, especially if there is flowing muddy water
- Significantly increasing seepage, especially flowing muddy water
- Slides involving a large mass of material that impairs the crest of the dam and is continuing to move
- Sinkholes with seepage flowing muddy water
- Large cracks, movement or failure of a portion of any major concrete structure that forms an integral part of the dam
- An increase in the reservoir level to near the top of the dam
- Overtopping of a dam that is not designed for overtopping
- Near to 'Design Flood' inflow forecast

External Alert Conditions RED – These are "failure" conditions. Either the dam is in immediate danger of failing or has already failed. No time remains to implement measures to prevent failure. Evacuate immediately. Evacuation efforts will continue until the situation is stabilized.

The [Dam Owner's Emergency Planning Manager] is responsible for implementing the appropriate Notification Flowchart. The following is a list of conditions that would initiate "imminent dam failure" or "dam failure" conditions:

- Rapidly increasing boils or the presence of new, significantly flowing boils, particularly muddy ones near previously identified ones
- Rapidly increasing seepage, especially flowing muddy water
- Slides involving a large mass of material or which have degraded the crest of the embankment to a level that approaches the water surface level, or if significant seepage is observed through the slide area
- Settlement that is predicted to degrade to the reservoir level
- Cracks that extend to the reservoir level
- Significant movement or failure of any structure that forms an integral part of the dam
- Overtopping of an earthen dam
- Uncontrollable release of the reservoir

4.3. Previously Known Problems

[Identify any known problems with the dam such as those outlined in previous dam safety inspections.]

5. Preparedness

Preparedness actions are to be taken both before and following the development of emergency conditions and should identify ways of preparing for an emergency, increasing response readiness in a uniform and coordinated manner, and helping to reduce the effects of a dam failure. The following are some steps that could prevent or delay failure after an emergency is first discovered.

Surveillance: [Title] will monitor the dam during emergency situations such as a severe storm event.

Response on forecast of excessive inflow: [Title] will respond to situation of excessive inflow forecast by way of controlled spillway releases after ascertaining the reliability of the forecast.

Response during weekends and holidays: [Title] will be available for emergency response during weekends and holidays and can be present at the dam site within [# minutes] of detection of an emergency condition.

Response during periods of darkness and adverse weather: [Title] will arrange for access to generators and lights to adequately monitor the situation. [Title] will be able to access the site during adverse weather conditions by [method of access – that is, by foot, utility vehicle, or some other means].

Access to the site: Alternate access routes should be planned in the event of an emergency at the dam. [Example: The road across the dam is a gravel roadway with grassed edges which should allow discharge across the road rendering this route inaccessible. The north and east alternate routes should be used instead under such conditions. All-weather access to the downstream toe of the dam will also be unavailable. For developing situations near the downstream toe of the dam, gravel may need to be brought in to stabilize a road in that area.]

Preventive measures can be taken in an emergency to prevent the catastrophic failure of the dam, but such repairs should be undertaken with extreme caution. The repairs are only temporary, and a permanent repair should be designed by an engineer as soon as possible.

The following actions should only be undertaken under the direction of a professional engineer or contractor. In all cases, the appropriate Notification Flowchart must be implemented and the personnel of the SDSO must be notified.

Consider the following preparedness actions if the dam's integrity is threatened by:

Seepage Failure

- Plug the flow with whatever material is available (hay, bentonite, or plastic) if the entrance is in the reservoir.
- Lower the water level in the reservoir by using the low flow outlet and pumping if necessary, until the flow decreases to a non-erosive velocity or until it stops. Place an inverted filter (a protective layer of sand and gravel) on the exit area to hold the material
  in place.
- Continue operating at a lower level until a repair is made.

Embankment or Foundation Sliding

- Lower the water level in the reservoir by using the low flow outlet and pumping if necessary at a rate and to an elevation considered safe, given the slide condition.
- Stabilize the slide, if on the downstream slope, by weighting the toe area below the slide with soil, rock, or gravel.
- Continue operating at a lower level until a repair is made.

Structural Failure

- Implement temporary measures to protect the damaged structure, such as placing rock riprap in the damaged area.
- Lower the water level to a safe elevation through the low flow outlet and by pumping if necessary.

6. Supplies and Resources

6.1. Contracts

Should [Dam Owner] personnel and resources prove to be inadequate during an emergency, requests will be made for assistance from other local jurisdictions, other agencies, and industry, as needed. Such assistance may include equipment, supplies, or personnel. All agreements will be entered into by authorized officials and should be in writing whenever possible. The [Dam Owner's Emergency Planning Manager] shall have the authority to enter into agreements as deemed necessary to prevent the failure of the dam.

6.2. Equipment and Supplies

Equipment that is available for use and local contractors that can be contacted to provide equipment during an emergency event are listed in Tab 6.

6.3. Reports

Technical Data

Pre-monsoon and post-monsoon inspections of the dam will be made to evaluate its structural safety, stability, and operational adequacy. In the event of an abnormal occurrence, reference to these reports, particularly the photographs, can be beneficial in the evaluation of a potential problem.

Technical records such as drawings and inspection reports should be stored and carefully maintained at the [Dam Owner] Site offices. Alternate personnel will be familiar with the location of the documents in the event of an emergency situation.

Emergency Operations Center Activity Log

Any unusual or emergency condition should be documented, including the following:

- Activation or deactivation of emergency facilities
- Emergency notifications to other local governments and to state and central government agencies
- Significant changes in the emergency
- Major commitments of resources or requests for additional resources from external sources
- Telephone calls should be recorded in chronological order
- Issuance of protective action recommendations to the public
- Evacuations
- Casualties
- Termination of the incident

Costs of the Emergency Operations Center

For major emergencies, the emergency operations center will maintain detailed records of costs expended. These records may be used to recover costs from the responsible party or insurers, or as a basis for requesting financial assistance for certain allowable response and recovery costs from the state or central government. Documented costs should include:

- Personnel costs, especially overtime
- Equipment operation
- Equipment leasing and rental
- Contract services to support emergency operations
- Specialized supplies expended in emergency operations

7. Inundation Area

The inundation map illustrates the areas subject to flooding from a failure of the dam, and can be found in Tab 2. The map was prepared using the results of a full breach analysis.

After examining the results of the breach analysis of [Name] Dam, it has been determined that there were a significant number of structures that could be affected due to a design flood or sunny-day dam breach. These structures are located along the [Stream], the [Stream], and the [Stream]. [City or Town] can suffer a significant impact from a breach of the dam. In addition,

water resulting from a breach, and associated damages, can, under certain circumstances, travel down the [Stream] affecting [City or Town].

The breach analysis contains profiles of the peak flood levels expected, as well as an estimation of the time from the beginning of the breach to the peak flood elevations. A comparison of the areas that are likely to be flooded with the plots showing the times from the start of the breach to the flooding shows the areas of evacuation and the time constraints involved. Figures in the breach analysis include information on the estimated impact of flooding on the bridges along the [Stream], the [Stream], and the [Stream]. These structures may suffer such impacts before the peak elevation of the flood wave.

7.1. Local Evacuation Plan

If imminent failure of the dam with uncontrolled downstream flooding is anticipated, local disaster management and law enforcement personnel should notify those downstream, for evacuation in the most expedient manner possible. The organizations and personnel on the Notification Flowchart should be contacted immediately. Local law enforcement officials, along with local mobile network operators, radio and television stations can best spread the notice for evacuation. The immediate impact will be to areas along [Stream] downstream of the dam. For sunny-day and design flood breaches, the following actions should be taken:

- Barricading all bridges that could possibly be flooded to prevent access to the affected area. These bridges include the [Stream] crossings of [Highway or Road]. See the Inundation Map in Tab 2 to determine appropriate barricade locations.
- The District Disaster Management office can assist with the notification of all persons and agencies involved, with the possibility of additional support—including contacting others not accessible by radio or telephone.
- District officials are generally familiar with developed areas in their jurisdiction. Such knowledge, coupled with the requirements of state law that they respond to disasters, make them the logical officials to be notified and to spread the warning message to all areas subject to flooding.

8. Implementation

8.1. Development

The draft EAP was sent to the SDSO for review, and agency comments were incorporated into this document, a copy of which is currently on file with the SDSO.

8.2. Updating

Copies of the EAP have been provided to the appropriate persons and the EAP has been approved and signed by the owner and the person(s) in charge of emergency response, as shown on the Distribution List and Approval and Implementation sheets at the front of the report. This plan will be reviewed and updated annually by [Dam Owner's Emergency Planning Manager] and personnel from local disaster management agencies in conjunction with [Dam Owner's Emergency Planning Manager]'s annual maintenance inspection of the dam. The [Dam Owner's Emergency Planning Manager] will review and complete all items on the Annual EAP Evaluation Checklist in Tab 7. After the annual update is complete, a new Approval and Implementation sheet will be attached and the annual update will be documented on the Plan Review and Update sheet in Tab 8.

If revisions to the EAP are made as a result of the annual update, such changes will be recorded on the Log Sheet of Changes form at the front of the report. A copy of the updated portions of the EAP will be sent to the SDSO and all other concerned as per the EAP Distribution List. If

the EAP was reviewed and revisions were not required, the [Dam Owner] will submit written notification to all concerned that no updates to the EAP have been adopted or implemented.

8.3. Testing

A table top drill will be conducted at least once every five years. The table top drill involves a meeting of [Dam Owner's Emergency Planning Manager] with local and state disaster management officials in a conference room. The drill begins with a description of a simulated event and proceeds with discussions by the participants to evaluate the EAP and response procedures, and to resolve concerns regarding coordination and responsibilities. Any problems identified during a drill should be included in revisions to the EAP. Records of training and drills will be maintained in Tab 9.

8.4. Training

All people involved in the EAP will be trained to ensure that they are thoroughly familiar with its elements, the availability of equipment, and their responsibilities and duties under the plan. Personnel will be trained in problem detection, evaluation, and appropriate corrective measures. This training is essential for proper evaluation of developing situations at all levels of responsibility. Training records will be maintained in Tab 9.

Tab 1

Vicinity Map

The purpose of the vicinity map is to show the location of the dam and surrounding roads that provide access to the dam. Survey of India topographic maps, district road maps, city street maps, or free Internet mapping applications such as Google Maps, Bing, Yahoo, or Map Quest can be used to produce the vicinity map. An example is shown below.

The vicinity map must include the following features:

- Show the location of the dam in relation to major roads (national and state highways, district roads, village roads etc.), intersections, and landmarks in the area.
- Label all applicable street names.
- Label the dam.
- Include a north arrow.
- Scale the map appropriately to ensure all applicable features are visible. Include a scale bar.

Sample Vicinity Map

Tab 2

Inundation Map

An inundation map is used to depict areas that could potentially flood if a dam fails. The inundation map should be used for evacuation planning. All dams require an inundation map, but the level of detail required on the map depends on the size of the dam and complexity of the floodplain conditions. Use the best available maps, including Survey of India topographic maps, district road maps, city street maps, aerial photography, and other sources of topographic information. At a minimum, the inundation map for a dam should include the following:

Detailed Inundation Map (For dams with significant numbers of structures downstream or complex floodplains. Must be prepared using the results of a full breach analysis carried out by a professional engineer):

- Label the dam.
- Label all applicable street names.
- Label all applicable river/stream names.
- Include a north arrow.
- Scale the map appropriately to ensure all applicable features are visible. Include a scale bar.
- Use Survey of India topographic maps, aerial photography, and other sources of topographic information to show the affected areas of development.
- Label the potential hazards that could be affected by a dam failure.
    - Call out affected roads and low-water crossings.
    - Label potentially affected structures with street addresses. If the inundation area includes dense development, individual labels for affected structures are not required. Label developed areas, critical structures, and major roads as needed such as district subdivision (block) names, schools, hospitals, highways, and so on.
- Clearly delineate the boundary of the inundation area. Do not show any non-emergency simulation results on the inundation map that is included with the EAP. Only show "fair weather failure", "inflow design flood with or without failure" and "other extremely large spillway flows" results.
- Label the time to flood (time from the breach to the time critical structures and roads are flooded).
- Label the time to peak flow.
- Include a note that states "Because of the method, procedures, and assumptions used to determine the flooded areas; the limits of flooding shown and flood wave travel times are approximate and should be used only as a guideline for establishing evacuation zones. Areas inundated in an actual event will depend on actual failure conditions and may differ from areas shown on the maps."

Tab 3

Dam Description

Official Dam Name (1): _____

Name of Stream: _____

Dam Location: _____

Latitude/Longitude: _____

Seismic Zone: _____ Year of Starting of Dam Construction: _____

Year of First Impoundment: _____ Year of Commissioning of Dam Project: _____

Name of Immediate Upstream Dam: _____ Name of Immediate Downstream Dam: _____

Dam Owner (2): _____ Phone Number: _____

Dam Owner's Address: _____

Embankment

Type	_____ (ex.–earthen embankment)
Year Constructed	_____
Length	_____metres
Maximum Height	_____metres
Top Width	_____metres
Top of Embankment Elevation	_____metres-msl
Drainage Area	_____square kilometres

Main Spillway (3)

Type	_____ (ex.–Uncontrolled ogee weir)
Location	_____ (ex.–Right abutment)
Crest Length	_____metres
Crest Elevation	_____metres
Capacity	_____cumecs

Emergency Spillway

Type	_____ (ex.–Broad-crested weir)
Location	_____ (ex.–Left abutment)
Crest Length	_____metres
Crest Elevation	_____metres-msl
Capacity	_____cumecs

Inlet-Outlet Works

Type	_____
Location	_____ (ex.–Right end of the dam)
Invert Elevation (Inlet)	_____metres-msl (bottom of pipe)
Invert Elevation (Outlet)	_____ metres-msl (bottom of pipe)
Capacity	_____cumecs

Reservoir

Elev. Top of Conservation Pool	_____metres-msl
Capacity Conservation Pool (Normal Pool)	_____millions of cubic metres
Capacity at Top of Dam (Maximum)	_____millions of cubic metres
Surface Area	_____hectares

(1) If the dam is known by more than one name, it is recommended that all names be listed (that is, the official name appearing in the National Register of Large Dams, and other names by which the dam is commonly known.)

(2) Also give details of Dam Operator, if different from the Dam Owner.

(3) If the dam has multiple spillways, create additional subsections as necessary to include information on all spillways.

Tab 4

Sample Public Announcements

Note: These messages are communicated to downstream residents to alert the public of impending danger. The [Dam Owner] should coordinate with the India Meteorological Department, the [District Name] Disaster Management Authority, and the District Magistrates/Collectors for [AAA, BBB, and CCC District] prior to release. Messages can be communicated via radio, television, bulk SMSs of local mobile networks, and other media outlets.

Announcement for a Slowly Developing "Watch" Condition (BLUE Emergency Level)

[Dam Owner] has declared a BLUE Level "Watch" condition for [Name] Dam, Project Identification Code [##########] as of [time and date]. [Briefly describe the problem or condition.] Although there is no immediate danger of the dam failing, [Describe what actions are being taken to monitor and control the situation.] [State the quantity of any releases from the reservoir.]

Announcement for a Worsening "Watch" Condition (BLUE Emergency Level)

[Dam Owner] has declared a BLUE Level "Watch" condition for [Name] Dam, Project Identification Code [##########] as of [time and date]. [Briefly describe the problem or condition.] Although there is no immediate danger of the dam failing a possibility now exists that the dam will fail if correction efforts are unsuccessful. Describe what actions are being taken to monitor and correct the situation.] [State the quantity of any releases from the reservoir]. Additional news will be made available as soon as it is received.

Announcement for a Probable "Failure" Condition (ORANGE Emergency Level)

Urgent! This is an emergency message. [Dam Owner] has announced that [Name] Dam, Project Identification Code [##########] is probably going to fail. [Describe what actions are being taken to monitor and control the situation.] It is possible that the dam will fail in [##] hours. Residents in low lying areas along the [Stream], the [Stream], and the [Stream], as well as the town of [Name], should prepare for immediate evacuation. Additional news will be made available as soon as it is received.

Announcement of an Impending "Failure" Condition (RED Emergency Level)

Emergency! This is an emergency message. [Name] Dam, Project Identification Code [Dam Name] is going to fail at any moment. Residents who have not yet done so should immediately evacuate the city of [Name] and low-lying areas along the [Stream], the [Stream], and the [Stream]. The flood waters have already reached [Highway] and [Road]. Additional news will be made available as soon as it is received.

Announcement of an Ongoing "Failure" Condition (RED Emergency Level)

Emergency! This is an emergency message. [Name] Dam, Project Identification Code [Dam Name] failed at [time and date]. Residents who have not yet done so should immediately evacuate the city of [Name] and low-lying areas along the [Stream], the [Stream], and the [Stream]. The flood waters have already reached [Highway] and [Road]. Additional news will be made available as soon as it is received.

Tab 5

Evidence of Distress

General observation	Specific observation	Emergency condition level	Emergency action	Equipment, material, and supplies	Data to record
Boils	Small boils, no increase of water flow, flowing clear water.	BLUE	Closely check all of downstream toe, especially in the vicinity of boil for additional boils, wet spots, sinkholes, or seepage. Closely monitor entire area for changes or flow rate increases.	None	Site and location, approximate flow
	Large or additional boils near previously identified ones, without increasing flow rate, but carrying small amount of soil particles.	BLUE	Initiate 24-hour surveillance. Monitor as described above. Construct sandbag ring dikes around boils, to cover them with water to retard the movement of soil particles. Filter cloth may be used to retard soil movement, but do not retard the flow of water.	Sandbags, filter cloth	Site and location, approximate flow
	Large or additional boils near previously identified ones, increasing flow rate, carrying soil particles.	ORANGE	Continue 24-hour surveillance. Continue monitoring and remedial action as described above. Initiate emergency lowering of the reservoir. Issue a warning to downstream residents.	Sandbags, pump	Site and location, approximate flow
	Rapidly increasing size of boils and flow increasing and muddy water.	RED	Downstream evacuation. Employ all available equipment to attempt to construct a large ring dike around the boil area.	Dozer, shovels, source of earth fill	Site and location, approximate flow
Seepage	Minor seepage of clear water at toe, on slope of embankment, or at the abutments.	BLUE	Closely check entire embankment for other seepage areas. Use wooden stakes or flagging to delineate seepage area. Try to channel and measure flow. Look for upstream whirlpools.	Wooden stakes, flagging	Site, location, approximate flow
	Additional seepage areas observed flowing clear water and /or increasing flow rate.	BLUE	Initiate 24-hour surveillance. Monitor as described above. Construct measuring weir and channel all seepage through weir. Attempt to determine source of seepage.	Dozer, shovels	Site, location, approximate flow
	Seriously or rapidly	ORANGE	Continue 24-hour monitor-	Dozer,	Site lo-

General observation	Specific observation	Emergency condition level	Emergency action	Equipment, material, and supplies	Data to record
	increasing seepage, under-seepage, or drain flow.		ing and remedial action as described above. Initiate emergency lowering of the reservoir. Construct a large ring dike around the seepage area.	shovels, source of fill material	cation, approximate flow
	Additional seepage areas with rapid increase in flow and muddy water.	**RED**	Downstream evacuation. Employ all available equipment to attempt to construct a large ring dike around the seepage area.	Dozer, shovels, source of fill material	Site location, approximate flow
Slides or severe erosion	Skin slide or slough on slope of embankment. No further movement of slide and embankment crest not degraded.	**BLUE**	Examine rest of embankment for other slides. Place stakes in slide material and adjacent to it for determining if further movement is taking place.	Stakes, tape measure	Distance between stakes
	Slide or erosion involving large mass of material, crest of embankment is degraded, no movement or very slow continuing movement.	**BLUE**	Initiate 24-hour surveillance. Mobilize all available resources and equipment for repair operations to increase freeboard and to protect the exposed embankment material. Start filling sandbags and stockpile near slide area.	Dozer, shovels, sources of fill material, sandbags	Distance between stakes
	Slide or erosion involving large mass of material, crest of embankment is degraded, progressively increasing in size.	**ORANGE**	Continue monitoring and remedial actions as described above. Place additional material at the toe of the slope to stop the slide.	Dozer, shovels, source of fill material, pump	Distance between stakes
	Slide or erosion involving large mass of material, crest of embankment is severely degraded, movement of slide is continuing and may reach pool level.	**RED**	Downstream evacuation. Utilize all available equipment and personnel to sandbag the degraded slide area to prevent it from overtopping.	Dozer, shovels, sandbags, pump	Distance between stakes
Sinkholes	Sinkholes anywhere on the embankment or within 150 metres downstream from the toe.	**BLUE**	Carefully walk the entire embankment and downstream area looking for additional sinkholes, movement, or seepage.	Stakes, flagging	Size, location

General observation	Specific observation	Emergency condition level	Emergency action	Equipment, material, and supplies	Data to record
	Sinkholes with corresponding seepage anywhere on the embankment or downstream from the toe.	BLUE	Initiate 24-hour surveillance. Monitor as above. Construct sandbag dike around the seepage exit point to reduce the flow rate. Start filling sandbags and stockpile near sinkhole.	Dozer, shovels, pump	Size, location
	Large sinkholes with corresponding seepage anywhere on the embankment or downstream from the toe.	ORANGE	Continue monitoring and remedial action as described above. Utilize sandbags to increase the freeboard on the dam if necessary.	Sandbags, dozer, pump	Size, location
	Sinkholes rapidly getting worse, seepage flowing muddy water and increasing flow.	RED	Downstream evacuation. Utilize all available equipment and personnel to attempt to construct a large ring dike around the area.	Dozer, shovels, pump	Size, location
Settlement	Obvious settlement of the crest of the embankment, especially adjacent to concrete structures.	BLUE	Look for bulges on slope or changes in crest alignment.	None	Size, location
	Settlement of crest of embankment that is progressing, especially adjacent to concrete structures or if any corresponding seepage is present.	BLUE	Initiate 24-hour surveillance. Mobilize all available resources for repair operations to increase freeboard. Fill and stockpile sandbags. Identify any boils near settlement points for flowing material and pursue action for boils.	Sandbags, dozer, shovels, source of fill material	Size, location
	Settlement of crest of embankment that is rapidly progressing especially adjacent to concrete structures or if any corresponding seepage is flowing muddy water or increasing flow.	ORANGE	Continue monitoring and remedial actions as described above. Use sandbags to increase the freeboard on the dam if necessary.	Sandbags, shovels, dozer, source of fill material	Size, location
	Progressing settlement that is expected to degrade the embankment to	RED	Downstream evacuation. Utilize all available equipment and personnel to build up the crest in the area that	Dozer, shovels, source of fill mate-	Size, location

General observation	Specific observation	Emergency condition level	Emergency action	Equipment, material, and supplies	Data to record
	reservoir level.		is settling. Identify any boils near settlement points for flowing material and pursue action for boils.	rial, sandbags	
Cracking	Cracks in the embankment crest or on slopes.	BLUE	Walk on entire crest and slope and check for additional cracking.	Stakes, tape measure	Size, location
	Numerous cracks in crest that are enlarging, especially those perpendicular to the centerline of the dam.	BLUE	Initiate 24-hour surveillance. Carefully monitor and measure cracking to determine the speed and extent of the problem. Mobilize to fill cracks. Cracks parallel to the centerline indicate a slide. Follow remedial action for slides.	Stakes, tape measure, dozer, shovels, source of fill material	Size, location
	Large cracks in the crest that are rapidly enlarging, especially those perpendicular to the centerline of the dam.	ORANGE	Continue monitoring and remedial action as described above.	Dozer, shovels, source of fill material	Size, location
	Cracking that extends to pool elevation.	RED	Downstream evacuation. Continue remedial actions as described above.	Dozer, shovels, source of fill material	Size, location
Cracking or movement of concrete structure	Minor cracking and/or movement.	BLUE	Immediately install measuring device to monitor movement.	Crack Monitors, stakes, tape measure	Size, location
	Significant cracking and /or movement.	BLUE	Initiate 24-hour surveillance. Lower burlap on upstream face of crack to reduce flow of soil particles. Dump large rock on downstream of moving concrete structure monolith to resist the movement.	Burlap, rock, dozer, shovels	Size, location, flow rate
	Serious cracking and /or movement	ORANGE	Prepare for evacuation. Continue monitoring and remedial action as described above.	Dozer, rock, burlap, crack monitors	Size, movement, flow rate
	Major cracking and /or movement	RED	Downstream evacuation. Dam failure is imminent.	Dozer, shovels,	Size, location,

General observation	Specific observation	Emergency condition level	Emergency action	Equipment, material, and supplies	Data to record
			Continue monitoring and remedial actions as described above.	rock	flow rate
Upstream whirlpool	Whirlpool in the lake in the vicinity of the embankment	**RED**	Downstream evacuation. Attempt to plug the entrance of the whirlpool with riprap from the slope of the embankment. Search downstream for an exit point and construct a ring dike to retard the flow of soil particles.	Dozer, fill material, sandbags, filter cloth, straw, rocks	Size, location, flow rate
Malfunction of gate	Structural member of a gate or gate operator broken or severely damaged so as to prevent operation of the gate	**ORANGE**	Initiate 24-hour surveillance. Immediately place stop logs in front of gate and initiate necessary actions to get gate repaired.	Crane and welder	Type of problem, location
Rapidly rising lake	Lake level rising and rain continuing	**BLUE**	Initiate 24-hour surveillance of lake level and rainfall. Generate inflow forecasts every 12 hours.		Lake level, rainfall
Overtopping	Water flowing over the dam and lake continuing to rise. No significant erosion of downstream embankment.	**ORANGE**	Prepare for evacuation. Continue monitoring. Generate inflow forecasts every 3 hours.	Dozer, fill material, sandbags, filter cloth, rocks	Lake level, rainfall
	Water flowing over the dam, the lake continuing to rise, and significant erosion of downstream embankment with development of head-cuts encroaching on the dam crest, or significant movement of sections of concrete or masonry portions of the dam.	**RED**	Immediate evacuation. Dam failure is imminent or ongoing.	Cameras.	Status of breach formation. Width of breach as it enlarges.

Tab 6

Supplies and Resources

The following equipment and supplies may be necessary for use during a dam emergency. Contact information for local contractors who can provide the following items during an emergency is listed below. For supplies owned by the dam owner, the dam owner's name and the specific location of the supplies have been denoted.

Equipment/Supplies	Location
Backhoes Dump trucks Portable welding equipment Generators Bulldozers Excavators Loaders Motor graders	[Names, addresses, and phone numbers of contractors]
Crane	[Names, addresses, and phone numbers of contractors]
Sandbags	[Names, addresses, and phone numbers of suppliers]
Rock riprap	[Names, addresses, and phone numbers of suppliers]
Fill Material	[Names, addresses, and phone numbers of suppliers]
Other:	[Names, addresses, and phone numbers of suppliers]

Tab 7

Annual EAP Evaluation Checklist

Was the annual dam inspection conducted?	□ Yes □ No	If yes, has the EAP been revised to include any signs of failures observed during the inspection?	□ Yes □ No
Was weed clearing, animal burrow removal, or other maintenance required?	□ Yes □ No	If yes, describe actions taken and date:	
Was the outlet gate operable?	□ Yes □ No	If no, describe actions taken and date:	
Does the Notification Flowcharts require revision? (Note that revision of the contact information will not require EAP approval; however, the revised contact information pages will need to be redistributed as replacement pages.)	□ Yes □ No	If yes, list the dates of the contact information revision and redistribution:	
Was annual training or a tabletop drill conducted?	□ Yes □ No	Circle: training drill Date conducted:	
Are inspection and training records included in the EAP?	□ Yes □ No		
Was the EAP reviewed?	□ Yes □ No	If yes, review date:	
Were changes required to the EAP?	□ Yes □ No	If yes, date of revised EAP approval:	

_____ _____

[Name and Title of Appropriate Manager for Owner] Date

Tab 8

Plan Review and Update

This plan will be reviewed and updated annually and tabletop drills will be carried out at least once every five years. Document these reviews below.

Date of review: _____ Participants:

Date of review: _____ Participants:

Date of review: _____ Participants:

Date of review: _____ Participants:

Date of tabletop drill: _____ Participants:

Tab 9

Training Record

Use this form to record training sessions. File the completed form in the appropriate Tab of the EAP. All items in the EAP should be thoroughly reviewed during training. Appropriate [Dam Owner] employees and EAP team members should attend a training session annually (or participate in a simulated drill).

TRAINING LOCATION:	
DATE: TIME: INSTRUCTOR:	
CLASS SIGN-IN:	
Type of Simulation Conducted:	Circle Emergency Type: Emergency water release Watch condition Possible dam failure Imminent dam failure Actual dam failure
Comments, Results of Drill:	
Revisions Needed to EAP Based on Results of Drill? □ Yes □ No If yes, list revisions required:	

Appendix B. GLOSSARY OF TERMS FOR DAM SAFETY

This page has been left blank intentionally.

Glossary of Terms for Dam Safety

The purpose of this glossary is to establish a common vocabulary of dam safety terms for use within and among Central and State Government agencies. Terms have been included that are generic and apply to all dams, regardless of size, owner, or location.

Abutment – The part of the valley side against which the dam is constructed. The left and right abutments of a dam are defined with the observer looking downstream from the dam.

Appurtenant work – Structures associated with the dam including the following:

a) Spillways, either in the dam or separate therefrom;
b) Reservoir and its rim;
c) Low-level outlet works and water conduits such as tunnels, pipelines or penstocks, either through the dam or its abutments or reservoir rim;
d) Hydro-mechanical equipment including gates, valves, hoists, and elevators;
e) Energy dissipation and river training works; and
f) Other associated structures acting integrally with dam body.

Auxiliary 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.

Barrage – While the term barrage is borrowed from the French word meaning "dam" in general, its usage in English refers to a type of low-head, dam that consists of a number of large gates that can be opened or closed to control the amount of water passing through the structure, and thus regulate and stabilize river water elevation upstream for use diverting flow for irrigation and other purposes.

Boil – A disruption of the soil surface due to water discharging from below the surface. Eroded soil may be deposited in the form of a ring (miniature volcano) around the disruption.

Breach – An excavation or opening, either controlled or a result of a failure of the dam, through a dam or spillway that is capable of completely draining the reservoir down to the approximate original topography so the dam will no longer impound water, or partially draining the reservoir to lower impounding capacity. An uncontrolled breach is generally associated with the partial or total failure of the dam.

Breach analysis – The determination of the most likely uncontrolled release of water from a dam (magnitude, duration, and location), using accepted engineering practice, to evaluate downstream hazard potential.

Breach inundation area – An area that would be flooded as a result of a dam failure.

Chimney drain – A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Cofferdam – A temporary structure enclosing all or part of the construction area that construction can proceed in the dry. A diversion cofferdam diverts a stream into a pipe, channel, tunnel, or other watercourse.

Compaction – Mechanical action that increases soil density by reducing voids.

Concrete lift –The vertical distance between successive horizontal construction joints.

Conduit – A closed channel to convey water through, around, or under a dam.

Construction joint – The interface between two successive placements or pours of concrete where bond, and not permanent separation, is intended.

Construction – Building a proposed dam and appurtenant structures capable of storing water.

Contact grouting – Filling, with cement grout, any voids existing at the contact of two zones of different materials, i.e., be-

tween a concrete tunnel lining and the surrounding rock.

Core wall – A wall built of relatively impervious material, usually of concrete or asphaltic concrete in the body of an embankment dam to prevent seepage.

Cutoff trench – A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam.

Cutoff wall – A wall of impervious material usually of concrete, asphaltic concrete, or steel sheet piling constructed in the foundation and abutments to reduce seepage beneath and adjacent to the dam.

Dam – Any artificial barrier including appurtenant works constructed across rivers or tributaries thereof with a view to impound or divert water; includes barrage, weir and similar water impounding structures but does not include water conveyance structures such as canal, aqueduct and navigation channel and flow regulation structures such as flood embankment, dike and guide bund.

Dam failure – Failures in the structures or operation of a dam which may lead to uncontrolled release of impounded water resulting in downstream flooding affecting the life and property of the people.

Dam incident – All problems occurring to a dam that have not degraded into 'dam failure' and including the following:

a) Structural damage to the dam and appurtenant works;
b) Unusual readings of instruments in the dam;
c) Unusual seepage or leakage through the dam body;
d) Change in the seepage or leakage regime;
e) Boiling or artesian conditions noticed below an earth dam;
f) Stoppage or reduction in seepage or leakage from the foundation or body of the dam into any of the galleries, for dams with such galleries;
g) Malfunctioning or inappropriate operation of gates;
h) Occurrence of any flood, the peak of which exceeds the available flood discharge capacity or 70% of the approved design flood;
i) Occurrence of a flood, which resulted in encroachment on the available freeboard, or the approved design freeboard;
j) Erosion in the near vicinity, up to five hundred meters, downstream of the spillway, waste weir, etc.; and
k) Any other event that prudence suggests would have a significant unfavorable impact on dam safety.

Dam inspection – On site examination of all components of dam and its appurtenances by one or more persons trained in this respect and includes examination of non-overflow portion, spillways, abutments, stilling basin, piers, bridge, downstream toe, drainage galleries, operation of mechanical systems (including gates and its components, drive units, cranes), interior of outlet conduits, instrumentation records and record-keeping arrangements of instruments.

Dam owner – The Central Government or a State Government or public sector undertaking or local authority or company and any or all of such persons or organisations, who own, control, operate, or maintain a specified dam.

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

Design water level – The maximum water elevation, including the flood surcharge, that a dam is designed to withstand.

Design wind – The most severe wind that is reasonably possible at a particular reservoir for generating wind setup and run-up. The determination will generally include the results of meteorological studies that combine wind velocity, duration, direction and seasonal distribution characteristics in realistic manner.

Diversion dam – A dam built to divert water from a waterway or stream into a different watercourse.

Earth-fill dam – An embankment dam in which more than 50% of the total volume is formed of compacted earth layers.

Effective crest of the dam – The elevation of the lowest point on the crest (top) of the dam, excluding spillways.

Embankment dam – Any dam constructed of excavated natural materials, such as both earth-fill and rock-fill dams, or of industrial waste materials, such as a tailings dam.

Embankment zone – An area or portion of an embankment dam constructed using similar materials and similar construction and compaction methods throughout.

Emergency action plan (EAP) – A written document prepared by the dam owner or the owner's professional engineer describing a detailed plan to prevent or lessen the effects of a failure of the dam or appurtenant structures.

Emergency condition level – The following three emergency condition levels are considered:

1. **BLUE** – An event has taken place that is developing slowly and needs to be monitored closely. Immediate correction action is required.
2. **ORANGE** – Dam failure is highly probable but might be avoided with corrective actions.
3. **RED** – Dam failure is imminent or ongoing.

Emergency repairs – Any repairs that are considered to be temporary in nature and that are necessary to preserve the integrity of the dam and prevent a possible failure of the dam.

Emergency spillway – An auxiliary spillway designed to pass a large, but infrequent, volume of flood flow, with a crest elevation higher than the principal spillway or normal operating level.

Failure mode – A potential failure mode is a physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the dam or appurtenant structures design, the construction, the materials incorporated, the operations and maintenance, or aging process, which can lead to an uncontrolled release of the reservoir.

Fetch – The-straight-line distance across a body of water subject to wind forces. The fetch is one of the factors used in calculating wave heights in a reservoir.

Filter – One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flap gate – A gate hinged along one edge, usually either the top or bottom edge. Examples of bottom-hinged flap gates are tilting gates and fish belly gates so called from their shape in cross section.

Flashboards – Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but intended to be quickly removed, tripped, or fail in the event of a flood.

Flip bucket – An energy dissipater located at the downstream end of a spillway and shaped so that water flowing at a high velocity is deflected upwards in a trajectory away from the foundation of the spillway.

Flood hydrograph – A graph showing, for a given point on a stream, the discharge, height, or other characteristic of a flood with respect to time.

Freeboard – Vertical distance between a specified stillwater (or other) reservoir sur-

face elevation and the top of the dam, without camber.

Gabion – Rectangular-shaped baskets or mattresses fabricated from wire mesh, filled with rock, and assembled to form overflow weirs, hydraulic drops, and overtopping protection for small embankment dams. Gabion baskets are generally stacked in a stair-stepped fashion, while mattresses are generally placed parallel to a slope. Gabions have advantages over loose riprap because of their modularity and rock confinement properties, thus providing erosion protection with less rock and with smaller rock sizes than loose riprap.

Gallery – A passageway in the body of a dam used for inspection, foundation grouting, and/or drainage.

Gate – A movable water barrier for the control of water.

Geomembrane – An essentially impermeable geosynthetic composed of one or more synthetic sheets.

Geosynthetic – A planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system.

Geotextile – Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations, or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Gravity dam – A dam constructed of concrete and/or masonry that relies on its weight and internal strength for stability.

Grout – A fluidized material that is injected into soil, rock, concrete, or other construction material to seal openings and to lower the permeability and/or provide additional structural strength. There are four major types of grouting materials: chemical; cement; clay; and bitumen.

Grout blanket – An area of the foundation systematically grouted to a uniform shallow depth.

Grout cap – A concrete filled trench or pad encompassing all grout lines constructed to impede surface leakage and to provide anchorage for grout connections.

Grout curtain – One or more zones, usually thin, in the foundation into which grout is injected to reduce seepage under or around a dam.

Hazard potential – The possible adverse incremental consequences that result from the release of water or stored contents because of failure or incorrect operation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. There may also be impacts for an area upstream of the dam from effects of backwater flooding or landslides around the reservoir perimeter.

Hazard potential classification – A measure of the potential for loss of life, property damage, or economic impact in the area downstream of the dam in the event of a failure or malfunction of the dam or appurtenant structures. The hazard classification does not represent the physical condition of the dam.

Height of dam – The difference in elevation between the natural bed of the watercourse or the lowest point on the downstream toe of the dam, whichever is lower, and the effective crest of the dam.

Hydraulic fracturing – Hydraulic fracturing in soils is a tensile parting that is created because of increased fluid pressure. Initiation and/or propagation cracks in the core sections of earthen dams because of hydraulic fracturing affect adversely structural safety of the dams.

Hydraulic gradient – The change in total hydraulic pressure per unit distance of flow.

Hydrology – One of the earth sciences that encompasses the natural occurrence, distri-

bution, movement, and properties of the waters of the earth and their environmental relationships.

Hydrometeorology – The study of the atmospheric and land-surface phases of the hydrologic cycle with emphasis on the interrelationships involved.

Hydrostatic pressure – The pressure exerted by water at rest.

Inclinometer – An instrument, usually consisting of a metal or plastic casing inserted in a drill hole and a sensitive monitor either lowered into the casing or fixed within the casing. This measures at different points the casing's inclination to the vertical. The system may be used to measure settlement.

Inflow design flood –The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.

Instrumentation – An arrangement of devices installed into or near dams that provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

Internal erosion – A general term used to describe all of the various erosional processes where water moves internally through or adjacent to the soil zones of embankment dams and foundation, except for the specific process referred to as 'backward erosion piping'. The term internal erosion is used in place of a variety of terms that have been used to describe various erosional processes, such as scour, suffosion, concentrated leak piping, and others.

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. For breach analyses, this map should also show the time to flood arrival, and maximum water-surface elevations and flow rates.

Large dam – A dam which is above 15 m in height, measured from the lowest portion of the general foundation area to the top of dam; or a dam between 10 m to 15 m in height and that satisfies at least one of the following, namely

a) The length of crest is not less than 500 m;
b) The capacity of the reservoir formed by the dam is not less than one million cubic meters;
c) The maximum flood discharge dealt with by the dam is not less than 2000 m^3/s;
d) The dam has particularly difficult foundation problems; or
e) The dam is of unusual design.

Liquefaction – A condition whereby soil undergoes continued deformation at a constant low residual stress or with low residual resistance, due to the buildup and maintenance of high pore-water pressures, which reduces the effective confining pressure to a very low value. Pore pressure buildup leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence will depend on the void ratio or relative density of a cohesionless soil and the confining pressure.

Loss of life – Human fatalities that would result from a failure of the dam, without considering the mitigation of loss of life that could occur with evacuation or other emergency actions.

Low level outlet (bottom outlet) – An opening at a low level from a reservoir generally used for emptying or for scouring sediment and sometimes for irrigation releases.

Maintenance – Those tasks that are generally recurring and are necessary to keep the dam and appurtenant structures in a sound condition and free from defect or damage that could hinder the dam's functions as designed, including adjacent areas that also could affect the function and operation of the dam.

Maintenance inspection – Visual inspection of the dam and appurtenant structures by the owner or owner's representative to detect apparent signs of deterioration, other deficiencies, or any other areas of concern.

Masonry dam – Any dam constructed mainly of stone, brick, or concrete blocks pointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

Maximum storage capacity – The volume, in millions of cubic metres (Mm^3), of the impoundment created by the dam at the effective crest of the dam; only water that can be stored above natural ground level or that could be released by failure of the dam is considered in assessing the storage volume; the maximum storage capacity may decrease over time due to sedimentation or increase if the reservoir is dredged.

Maximum wind – The most severe wind for generating waves that is reasonably possible at a particular reservoir. The determination will generally include results of meteorological studies that combine wind velocity, duration, direction, fetch, and seasonal distribution characteristics in a realistic manner.

Meteorology – The science that deals with the atmosphere and atmospheric phenomena, the study of weather, particularly storms and the rainfall they produce.

Normal storage capacity – The volume, in millions of cubic metres (Mm^3), of the impoundment created by the dam at the lowest uncontrolled spillway crest elevation, or at the maximum elevation of the reservoir at the normal (non-flooding) operating level.

Outlet – A conduit or pipe controlled by a gate or valve, or a siphon, that is used to release impounded water from the reservoir.

Outlet gate – A gate controlling the flow of water through a reservoir outlet.

Outlet works – A dam appurtenance that provides release of water (generally controlled) from a reservoir.

Parapet wall – A solid wall built along the top of a dam (upstream or downstream edge) used for ornamentation, for safety of vehicles and pedestrians, or to prevent overtopping caused by wave runup.

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

Penstock – A pressurized pipeline or shaft between the reservoir and hydraulic machinery.

Phreatic surface – The free surface of water seeping at atmospheric pressure through soil or rock.

Piezometer – An instrument used to measure water levels or pore water pressures in embankments, foundations, abutments, soil, rock, or concrete.

Piping – The progressive development of internal erosion by seepage.

Plunge pool – A natural or artificially created pool that dissipates the energy of free falling water.

Pressure relief pipes – Pipes used to relieve uplift or pore water pressure in a dam foundation or in the dam structure.

Probable Maximum Flood – The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin under study.

Probable Maximum Precipitation – Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of the year.

Principal spillway – The primary or initial spillway engaged during a rainfall runoff event that is designed to pass normal flows.

Proposed dam – Any dam not yet under construction.

Radial gate – A gate with a curved upstream plate and radial arms hinged to piers

or other supporting structure. Also known as tainter gate.

Repairs – Any work done on a dam that may affect the integrity, safety, and operation of the dam.

Reservoir – Any water spread which contains impounded water.

Reservoir Storage – The retention of water or delay of runoff in a reservoir either by planned operation, as in a reservoir, or by temporary filling in the progression of a flood wave. Specific types of storage in reservoirs are defined as follows:

a) Active storage – The volume of the reservoir that is available for some use such as power generation, irrigation, flood control, water supply, etc. The bottom elevation is the minimum operating level.
b) Dead storage – The storage that lies below the invert of the lowest outlet and that, therefore, cannot readily be withdrawn from the reservoir.
c) Flood surcharge – The storage volume between the top of the active storage and the design water level.
d) Inactive storage – The storage volume of a reservoir between the crest of the invert of the lowest outlet and the minimum operating level.
e) Live storage – The sum of the active- and the inactive storage.
f) Reservoir capacity – The sum of the dead and live storage of the reservoir.
g) Surcharge – The volume or space in a reservoir between the controlled retention water level and the maximum water level. Flood surcharge cannot be retained in the reservoir but will flow out of the reservoir until the controlled retention water level is reached.

Riprap – A layer of large rock, precast blocks, bags of cement, or other suitable material, generally placed on an embankment or along a watercourse as protection against wave action, erosion, or scour.

Risk analysis – A procedure to identify and quantify risks by establishing potential failure modes, providing numerical estimates of the likelihood of an event in a specified time period, and estimating the magnitude of the consequences. The risk analysis should include all potential events that would cause unintentional release of stored water from the reservoir.

Risk assessment – The process of deciding whether existing risks are tolerable and present risk control measures are adequate and, if not, whether alternative risk control measures are justified. Risk assessment incorporates the risk analysis and risk evaluation phases.

Rock anchor – A steel rod or cable placed in a hole drilled in rock, held in position by grout, mechanical means, or both. In principle, the same as a rock bolt, but usually the rock anchor is more than 4 meters long.

Rock bolt – A tensioned reinforcement element consisting of a steel rod, a mechanical or grouted anchorage, and a plate and nut for tensioning or for retaining tension applied by direct pull or by torqueing.

Rock reinforcement – The placement of rock bolts, un-tensioned rock dowels, pr-stressed rock anchors, or wire tendons in a rock mass to reinforce and mobilize the rock's natural competency to support itself.

Rock-fill dam – An embankment dam in which more than 50% of the total volume is comprised of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

Roller compacted concrete dam – A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers.

Rubble dam – A stone masonry dam in which the stones are not shaped or coursed.

Saddle dam (or dike) – A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

Safe manner – Operating and maintaining a dam in sound condition, free from defect or

damage that could hinder the dam's functions as designed.

Scour – The loss of material occurring at an erosional surface, where a concentrated flow is located, such as a crack through a dam or the dam/foundation contact. Continued flow causes the erosion to progress, creating a larger and larger eroded area.

Seepage – The internal movement of water that may take place through a dam, the foundation or the abutments, often emerging at ground level lower down the slope.

Seiche – An oscillating wave in a reservoir caused by a landslide into the reservoir or earthquake-induced ground accelerations or fault offset or meteorological event.

Settlement – The vertical downward movement of a structure or its foundation.

Sinkhole – A depression, indicating subsurface settlement or particle movement, typically having clearly defined boundaries with a sharp offset.

Significant wave height – Average height of the one-third highest individual waves. May be estimated from wind speed, fetch length, and wind duration

Siphon – An inverted U-shaped pipe or conduit, filled until atmospheric pressure is sufficient to force water from a reservoir over an embankment dam and out of the other end.

Slide – Movement of a mass of earth down a slope on the embankment or abutment of a dam.

Slide gate – A gate that can be opened or closed by sliding in supporting guides.

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.

Stilling basin – A basin constructed to dissipate the energy of rapidly flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.

Stillwater level – The elevation that a water surface would assume if all wave actions were absent.

Stoplogs – Large logs, timbers, or steel beams placed on top of each other with their ends held in guides on each side of a channel or conduit so as to provide a cheaper or more easily handled means of temporary closure than a bulkhead gate.

Toe drain – A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Toe of 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.

Top thickness (top width) – The thickness or width of a dam at the level of the top of dam (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams, and width is used for other dams.

Trash rack – A device located at an intake to prevent floating or submerged debris from entering the intake.

Uplift – The hydrostatic force of water exerted on or underneath a structure, tending to cause a displacement of the structure.

Vicinity map – A map that shows the location of the dam and surrounding roads that provide access to the dam. This map should display the location of the dam in relation to major roads and streets, and should include a north arrow and scale bar.

Volume of dam – The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. Portions of power plants,

locks, spillway, etc., are included only if they are needed for structural stability of the dam.

Watershed – The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam.

Watershed divide – The divide or boundary between catchment areas (or drainage areas).

Wave protection – Riprap, concrete, or other armoring on the upstream face of an embankment dam to protect against scouring or erosion due to wave action.

Wave runup – Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

Weir – A barrier across a stream designed to alter its flow characteristics. In most cases, weirs take the form of obstructions smaller than conventional dams, pooling water behind them while also allowing it to flow steadily over their tops.

Weir, broad-crested – An overflow structure on which the nappe is supported for an appreciable length in the direction of flow.

Weir, measuring – A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

Weir, ogee – A reverse curve, shaped like an elongated letter "S." The downstream faces of overflow spillways are often made to this shape.

Wind setup – The vertical rise in the stillwater level at the face of a structure or embankment caused by wind stresses on the surface of the water.

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Central Dam Safety Organisation
Central Water Commission

Vision

To remain as a premier organisation with best technical and managerial expertise for providing advisory services on matters relating to dam safety.

Mission

To provide expert services to State Dam Safety Organisations, dam owners, dam operating agencies and others concerned for ensuring safe functioning of dams with a view to protect human life, property and the environment.

Values

Integrity: Act with integrity and honesty in all our actions and practices.

Commitment: Ensure good working conditions for employees and encourage professional excellence.

Transparency: Ensure clear, accurate and complete information in communications with stakeholders and take all decisions openly based on reliable information.

Quality of service: Provide state-of-the-art technical and managerial services within agreed time frame.

Striving towards excellence: Promote continual improvement as an integral part of our working and strive towards excellence in all our endeavours.

Quality Policy

We provide technical and managerial assistance to dam owners and State Dam Safety Organisations for proper surveillance, inspection, operation and maintenance of all dams and appurtenant works in India to ensure safe functioning of dams and protecting human life, property and the environment.

We develop and nurture competent manpower and equip ourselves with state of the art technical infrastructure to provide expert services to all stakeholders.

We continually improve our systems, processes and services to ensure satisfaction of our customers.

DRIP
Dam Rehabilitation & Improvement Project