NEW ZEALAND
Society on Large Dams

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New Zealand Dam Safety Guidelines 2024

MODULE 6
EMERGENCY PREPAREDNESS

Abstract

Dam safety objectives and principles that are applicable to the investigation, design, construction, commissioning, operation, assessment, rehabilitation, and decommissioning of dams in New Zealand are included in the Parent Document. The Parent Document also includes a glossary of terms used in these Guidelines.

This module provides a framework for emergency preparedness including the development of Emergency Action Plans (EAPs). These plans aim firstly to minimise the potential for dam failure through pre-planned intervention actions. Secondly, in the event that a dam failure cannot be prevented, the plans help to limit the effects of a dam failure on people, property and the environment. The module includes:

- An outline of emergency preparedness planning and processes.
- Recommended procedures for the development of EAPs.
- Example table of contents and reporting templates

The module is generally consistent with the Coordinated Information Management System (CIMS) that is utilised by New Zealand's Civil Defence Emergency Management (CDEM) agencies and some dam Owners for the management of emergencies. Although some terminology in this module may differ from that used in CIMS, it is consistent with the terminology used for dam safety management in other jurisdictions similar to New Zealand and adheres to the broad principles and objectives of CIMS.

This module includes limited discussion on the role of regulators in dam safety. A more comprehensive description of regulators' roles and responsibilities is provided in Module 1 (Legal Requirements).

This module includes limited discussion on the role of surveillance and monitoring in detecting issues that trigger an emergency response. Reference should be made to Module 5 (Dam Safety Management) for a more complete description of this process.

Notice to reader

Emergency Preparedness is one core element of an effective Dam Safety Management System and associated defining principles. Although this module is configured to be as self-contained as practicable from a technical standpoint, readers should familiarise themselves with the principles, objectives, and limitations outlined in the Parent Document and Module 1: Legal Requirements before considering the information in this or any other module.

Document history

Release	Date	Released with
Original	May 2015	Parent and all modules
2023	December 2023	Updates to Parent and Modules 1, 2 and 5
2024	December 2024	Updates to Parent and all Modules

Contents

1. Introduction

1.1 Principles and objectives

Emergency response procedures should be in place for all dams where there is a need to reduce the potential consequences of failure. Reducing consequences could involve procedures to reduce the potential for dam failure, and if there is a population at risk, procedures for warning and evacuation.

The emergency response procedures should provide sufficient detail to convey all necessary information and directions clearly, but not so verbose as to inhibit the reader from gaining a clear understanding of the actions to be taken. Since these procedures may need to be implemented by individuals unfamiliar with the technicalities of dam systems, they should be simple and definitive. Principle 7 in the Parent Document states that:

Effective emergency preparedness and response procedures should be in place for dams.

Historically, some procedures have used titles such as Site Emergency Response Plan, or Emergency and Civil Defence Plan. These Guidelines recommend use of the title "Emergency Action Plan" and are written as if Owners will create and maintain an Emergency Action Plan (EAP) as the primary document that outlines emergency preparation and response procedures for dam safety.

The objectives of this module are to provide guidance for the development of dam specific EAPs and outline appropriate review, testing and training programmes to confirm the ongoing effectiveness of dam specific EAPs.

Effective emergency management combines the elements of preparedness and response. Preparedness involves all actions undertaken in advance of an incident or emergency. Response involves deploying these preprepared actions to mitigate adverse consequences. EAPs are developed as part of the preparedness element and documented for rapid use in the response element. Some organisations document preparedness activities separately from the response activities, in an Emergency Preparedness Plan (EPP). The separation of preparedness and response documentation has advantages for portfolio owners in reducing duplication and is equally good practice to a single, combined EAP.

Planning for a dam safety emergency is a necessary risk management task, particularly for dam Owners where there is a potential for loss of life, heavy environmental damage, or costly restoration in the event of dam failure. An EAP, which describes the actions to be taken by a dam Owner or Operator in response to a dam safety emergency, should be prepared for all Medium and High Potential Impact Classification (PIC) dams. Guidance on the classification of dams by PIC is provided in Module 2. Nonetheless, dam Owners may choose to prepare EAPs for dams that present a lesser hazard to meet their own organisational risk management goals and objectives.

Effective emergency management relies on the establishment of clear interagency communication pathways outlined within the EAP. For interagency pathways to function effectively in an emergency, they must be pre-established before an incident occurs.

The purpose of the EAP is to coordinate information efficiently and action tasks to reduce risk and save lives. Ensuring the plan is understood by all parties involved in the dam safety emergency is supported by the following:

- Training of personnel to identify and report potential threats. This is part of the Dam Safety Management System and covered in Module 5.
- An EAP that details the actions the dam Owner or Operator will take in response to a dam safety emergency.
- A regular testing, review, maintenance, and training programme to improve and confirm the ongoing effectiveness.
- Consistency with the local emergency management framework.
- A local evacuation plan developed by CDEM agencies, prepared in coordination with and using inputs from the dam Owner, for their own purposes to warn and evacuate residents in the flood plain should this be necessary.

1.2 Scope of Module

This module provides guidance in emergency action planning for dams with respect to classifying and responding to dam safety incidents. It is **specific to situations that have the potential to endanger the integrity of the dam system and subsequently result in damage to downstream property and result in loss of life.** It is not relevant to other incidents such as personal accidents or an oil spill.

This module also does not cover the management of natural hazard events, such as large flood events or earthquakes unless **there is observed departures from expected dam performance**. Owners should develop standard operating procedures for flood management and for responding to loads on the dam within its design limits. Refer to Module 5 section 4.1 (Dam and reservoir operation and management).

The module addresses:

- Potential dam safety threats and dam safety incidents (including emergencies).
- Procedures for the development of EAPs.
- What should be included in EAPs.
- Responsibilities for maintaining and updating EAPs.

A list of reference documents is included at the end of this module to assist Owners in the development of EAPs.

1.3 What history tells us about dam safety emergencies

In most cases, dam failures result from a combination of factors, often including human error or omission (e.g. ICOLD, 1974; ICOLD, 1995). While published statistics worldwide vary slightly, there is general agreement that dam failures are most likely to initiate for one of five reasons:

1. Overtopping caused by water spilling over the top of a dam.
2. Foundation defects, including settlement and slope instability.
3. Cracking caused by movements like the natural settling of a dam.
4. Inadequate maintenance and upkeep.
5. Internal erosion (e.g. piping caused by seepage).

Emergency planning should consider the failure modes that could lead to dam failure. This need not be an exhaustive list of potential failure modes, as the subtleties between different potential failure modes are not always useful to responding staff or emergency services during an emergency. Instead, consider grouping failure modes into broader types that require similar responses (e.g. flood related, settlement related, gate damage etc).

Effective threat detection and implementation of emergency plans have prevented many dam failures. Additionally, the dissemination of warnings has significantly reduced the loss of life in numerous cases of dam failure.

Incidents are often triggered by other factors specific to the context of an individual dam. This can include human factors – for example a combination of decisions that have unintended consequences, or a failure to recognise the impact of an unusual combination of relatively usual events.

Issues can arise from automated computerised control systems for gate operations. Some lessons learned from incidents in New Zealand regarding gate control include:

- Expect remote communications and instrumentation to be affected by lightning. Extensive fault testing may be required to ensure operations are not affected.
- Redundant reservoir level instruments are particularly important where these instruments provide logic input to outlet/gate control.
- Commissioning can take a long time because it may be many years before every potential combination of inputs is replicated in the field. Bench testing and fault analysis modelling is not the same as an installed operational test and a first real live commissioning event.

- Until the system is declared fully commissioned, the EAP should include the ability to get advice from people involved with programming or maintaining the control system.

An emerging trend at time of publication of this module is the increasing number of failures and incidents involving older dams. As the average age of dams in New Zealand rises, the associated dam safety management requirements are also evolving – see Module 5 for more details.

2. Emergency management for dams

Emergency preparedness planning should be completed regularly for all dams. This is planning that allows all involved with the dam and the potential consequences of dam failure, including the Police and CDEM agencies, to be prepared for the management of a dam safety emergency. It is an important component of a Dam Safety Management System, encompassing the preparation and maintenance of an EAP, as well as regular training exercises. These exercises ensure that emergency management personnel are familiar with the EAP, understand their responsibilities, and are capable of fulfilling their duties during a dam safety emergency.

The structure of the response should be set out in the planning phase and documented in the EAP. This chapter presents the high-level concepts, definitions, and recommended structure of a response.

2.1 EAP Documentation

Where appropriate, there should be an EAP for each phase of a dam's life cycle – during construction, first filling, normal operations, rehabilitation, and decommissioning. EAPs should be controlled documents covered by appropriate procedures for distribution and the management of changes.

Both monitoring and surveillance manuals, as well as operation and maintenance procedures, should include instructions to activate the EAP when conditions fall outside of defined procedures or safe limits. This supports a seamless transition from normal operating conditions to emergency conditions. This is particularly important for plant and equipment that fulfil dam safety functions, and for visual inspections that provide opportunities to detect threats and assist in their classification.

2.2 Definitions

The following definitions, as defined in the Glossary of the Parent Document of these Guidelines, are used throughout Module 6:

Dam safety incident – A situation ('occurrence') that is beyond the scope of normal operations and may endanger the integrity of the dam system (and therefore downstream property or life). The situation needs immediate assessment and classification to determine the level of response action needed. It may or may not be an Emergency but requires a response.

Incidents may be managed internally by the Owner or may include coordination with external parties. The range of situations that are and are not incidents are shown in Figure 2.1.

Dam safety emergency – A dam safety Incident which does endanger the integrity of the dam and downstream property or life and requires immediate coordinated action with external parties.

2.3 Potential dam safety threats

Potential threats are any combination of condition(s) which falls outside of normal operation or safe limits and could endanger the safety of the dam.

Potential dam safety threats will vary depending on the hazards, risks, and characteristics of the dam and its reservoir. The EAP should be tailored to reflect these particular site-specific factors. Potential dam safety threats can be initiated by a range of conditions that include, but are not limited to:

- First filling or commissioning of a new dam or uncontrolled filling (e.g. filling of a flood detention dam).
- A flood exceeding the dam's spillway capacity.
- A landslide into the reservoir from the reservoir slopes, creating a wave that overtops the dam, or a landslide from the abutments.
- A significant earthquake with an epicentre near the dam or local shaking of a level sufficient to justify concern for the dam.
- A volcanic eruption (lava flow, ash deposit forming flow path blockages, etc.).

- Slips or washouts compromising physical access to the dam, preventing an adequate operational response to any of the above events (particularly common in the New Zealand context).
- Spillway blockage (e.g. floating debris, landslide).
- Incorrect gate operation either operator error or PLC malfunction or instrument error, or potentially no operation at all.
- Accidental damage to the dam or its appurtenant structures.
- Sabotage.
- Lack of operational knowledge, resources, or organizational factors.
- The identification of abnormal behaviours (e.g. evidence of significant seepage, erosion, slumping piping, spillway blockage, inoperable gates etc).
- Any combination of these events.

Once a potential dam safety threat has been detected, it is important that it is assessed and then classified using pre-defined criteria to trigger the appropriate response through the EAP.

2.4 Normal operations

Normal operation is where scheme components that contain and control the reservoir operate within defined *safe operating limits* and exhibit *normal behaviour*.

Safe operating limits exist when monitoring data (e.g. bore and/or uplift pressures, ground water levels, seepage, deformation survey data) and visual observations lie within expected limits based on design, historical precedence, and expected trends.

Normal behaviour in most dams can usually be determined by the absence of new and excessive:

- Change in flow in the drainage system.
- Change in leakage from uplift pressure system.
- Change in leakage through the dam blocks.
- Erosion, slumping, and/or seepage at interfaces between the dam and its abutments, foundations, and toe.
- Damage, movement, and misalignment of the dam, spillway and/or other appurtenant structures.
- Blockage and/or unreliable operation of spillway and/or other appurtenant structures.
- Loss of adequate freeboard.
- Observed anomalous behaviour.
- Restrictions on control of dam safety critical equipment.
- Curtailment of systems operating to mitigate specific dam safety threats.
- Loss of critical instrumentation or monitoring.

No specific response (other than normal scheduled dam surveillance activities) is required whilst a dam is in a normal operating condition.

Normal behaviour can be subject to the ‘normalisation of deviance’ effect, where what is once new becomes normalised without an associated understanding of what has caused the change and or what its impact is. Part of terminating an emergency response should be an update of any normal operations procedures and limits to properly account for changed conditions.

2.5 Incidents (including emergencies)

Once a potential dam safety threat beyond normal operations is detected, the situation becomes an incident and the EAP should be activated. The EAP should be used to assess and then classify the incident using pre-defined criteria. The stages beyond normal operations are shown in Figure 2.1.

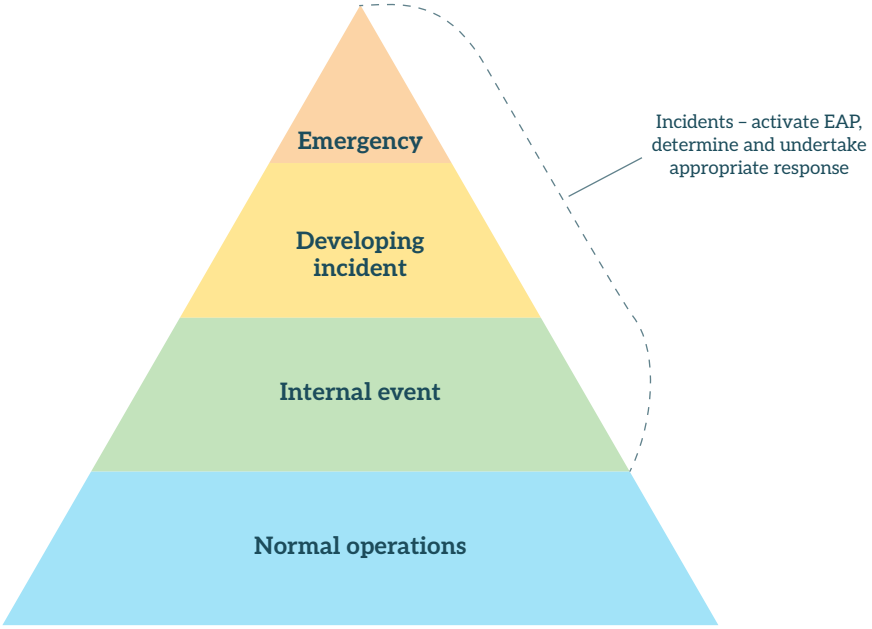

Figure 2.1: Relationship between normal operations and incidents

Three or more levels of response are recommended within EAPs, with increasing levels of urgency (Figure 2.1). The level of urgency should guide the classification of the response. Questions to help guide this classification decision are shown in Figure 2.2. These levels of classification are used to inform appropriate response:

- **Internal event (non-failure)** – Only impacts on the dam Owner and the response can be managed internally.
- **Developing incident (potential failure)** – Has the potential to affect external parties and the Police, CDEM, emergency services, and local and regional authorities should be notified of the situation.
- **Emergency (imminent failure)** – A dam safety incident which does endanger the integrity of the dam and downstream property or life and requires immediate coordinated action with external parties.

In an Emergency, the Police, CDEM, emergency services, and local and regional authorities must be notified immediately.

Note that dam Owners cannot declare civil defence emergencies; they can only be declared by people with specifically designated roles in accordance with the Civil Defence Emergency Management Act 2002. New Zealand Police (under Common Law) have the legal authority to order an evacuation and use reasonable force as necessary. Fire and Emergency New Zealand can order an evacuation if life or property is in danger, which may be the fastest response in remote or rural areas.

A flow chart showing a typical process for the management of a potential dam safety threat, incident or an emergency, is shown in Figure 2.3.

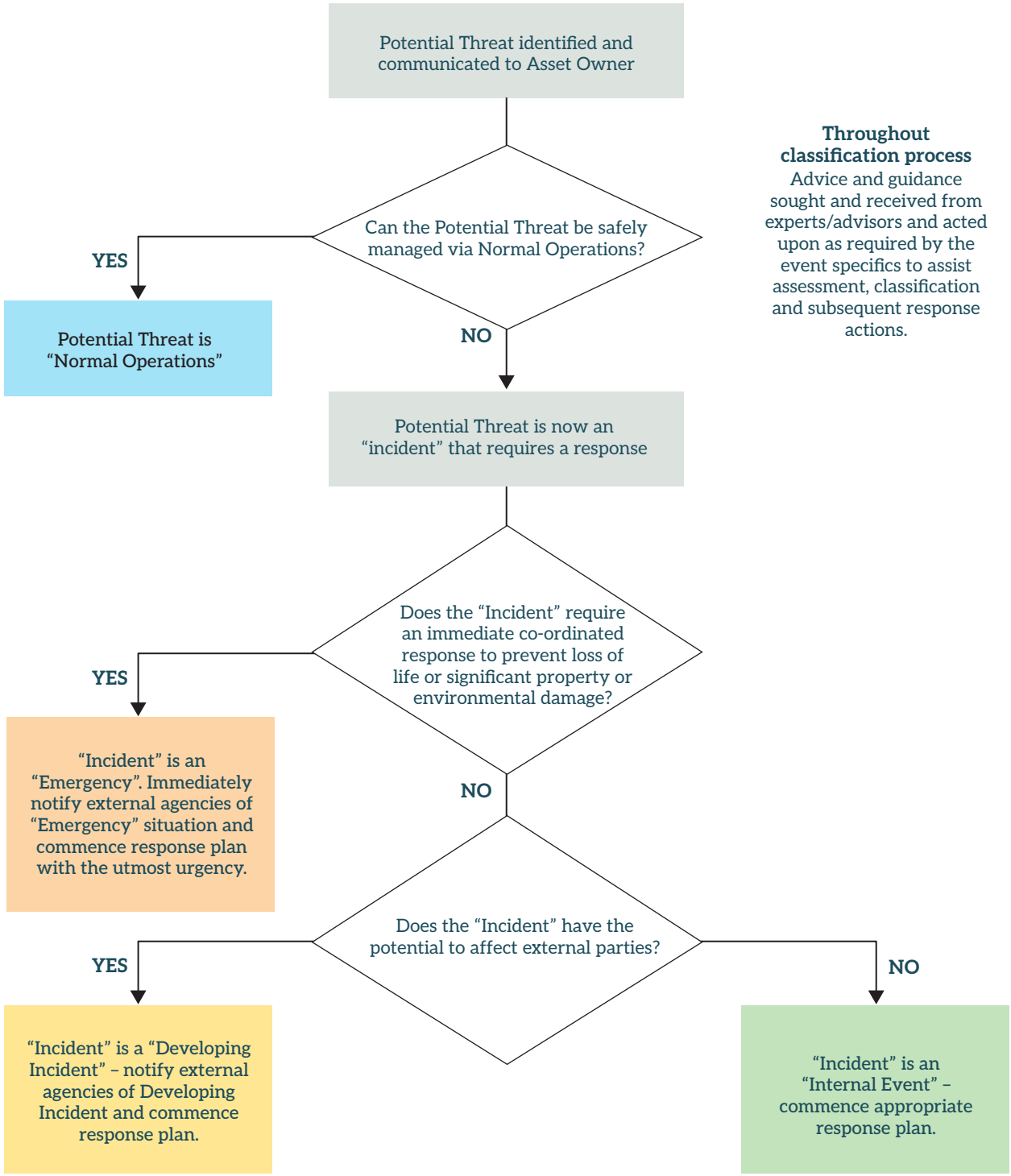

Figure 2.2: Typical classification decision tree

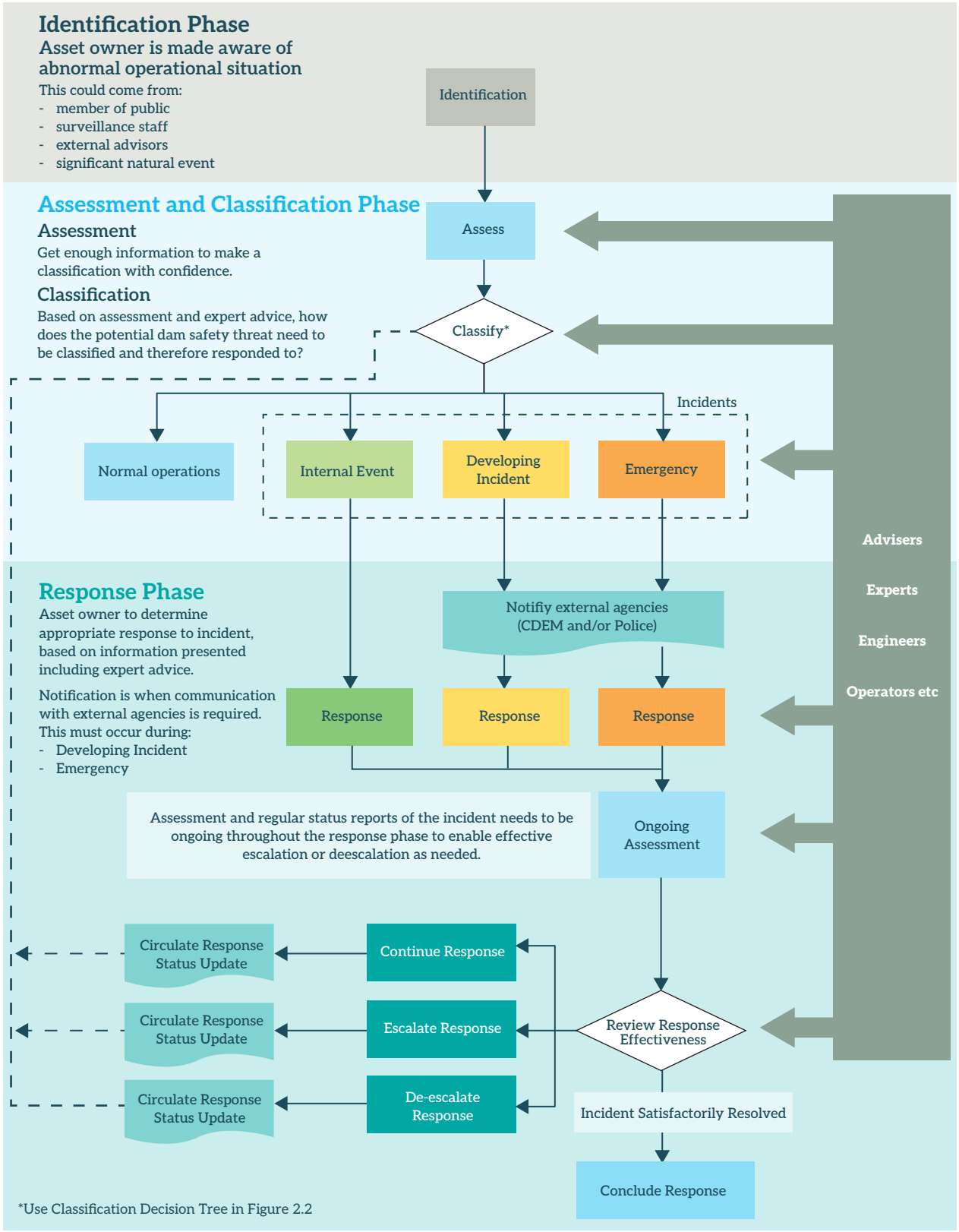

Figure 2.3: Typical process for the management of a dam safety incident

3. Community and agency engagement

3.1 Agency engagement before an emergency

Time is critical in emergency situations. Misunderstandings cost time. Prior to an emergency, owners should establish and maintain relationships and communications with key external agencies to ensure these connections are functional when needed. This will result in faster, more effective responses during an emergency.

Key external agencies in the New Zealand context are:

- **New Zealand Police** – in a fast-developing emergency that requires public evacuations, the NZ Police are likely to lead the evacuation efforts.
- **Civil Defence and Emergency Management (CDEM)** – NZ Police are likely to hand over management of the emergency to CDEM at some point in the response (or for recovery).
- **Regional council flood warning teams** – Owners of dams with significant catchment scale effects should have established lines of communication and relationships with these teams. Parties should consider sharing telemetry and the use of duty email/telephone numbers.
- **Fire & Emergency NZ** – In rural areas, the local volunteer fire brigade may be the nearest first responders capable of conducting evacuations, road closures, and other emergency actions.

Local procedures, preferences, and the roles of various organisations can differ between regions, making it essential to communicate with local agencies prior to an emergency. To avoid resource duplication or contradictory public messaging, it is important to agree on and assign a lead agency for any response requiring public engagement.

Depending on the size of the dam and the potentially inundated area following a breach, the response scale and complexity by external agencies (i.e. Police and CDEM) may need to be focused locally for smaller dams or regionally (or nationally) for larger dams. This level can be pre-defined during the EAP preparation process, helping to determine which agencies need to be contacted and at which duty centres.

Communication methods with agencies should be pre-agreed and tested. Information should be shared with agencies early, even when there is no immediate issue that requires their attention. This helps duty staff maintain situational awareness and review their response plans in advance.

Engagement with agencies can include:

- A briefing on the dam and the hazard to downstream communities.
- Agreement on which parties will handle warning and/or evacuation notifications. If responsibilities are split (e.g. the dam Owner warning nearby residents), a clear division of responsibility must be established to determine who formally notifies whom.
- Offer to assist agencies carry out evacuation planning. This may include offering to assist with evacuation maps, providing population at risk estimates, street names, and interpretation of flood mapping. However, it is recommended that agencies, not Owners, maintain ownership of the evacuation planning process.
- Exchanging of regular updates, including inclusion on each other's phone or radio testing schedules.
- Updating dam Owners' distribution lists of agency representatives, including points of contact, staff involved in the review and receipt of EAP documents, and times and dates of receipt.
- Participation in exercises and drills.
- Following and sharing social media communications.
- Providing occasional updates to agencies on the status of the dam construction (if under construction), staffing, operational arrangements or planned maintenance (if operating). This is a useful way to build and maintain inter-agency relationships.

3.2 Obligations of lifeline utilities

All dam Owners within territorial or regional authorities that supply water for potable use or generate electricity are designated as lifeline utilities under the Civil Defence Emergency Management Act 2002. They are required to "make available to the Director in writing, on request, its plan for functioning during and after an emergency". The supply of an EAP to the local CDEM office and regional CDEM Group (CDEMG) is consistent with this requirement. Other dam Owners should offer their EAPs to their relevant CDEMG for incorporation, as appropriate, within the local community emergency management plan.

3.3 Public engagement before an emergency

Community engagement can serve as both an input to (informing) emergency preparedness and output of (control measure for) the EAP. Public engagement is important for building awareness of the following concepts in the downstream community:

- The presence of the dam upstream.
- The systems the dam and its Owner have in place to maintain safety.
- The extent of the potential inundation area.
- Actions community members might need to take in an emergency.
- What the warning systems are (including 'natural warnings' such as very strong earthquakes or very large floods).

It is recommended that dam-break inundation maps (or evacuation maps) be pre-published and socialised with downstream communities. This will reduce uncertainty in the community and result in faster evacuations in an emergency. This should be part of a broader campaign to inform people about the dam, emphasising preparation for the worst-case scenario.

Engaging a public relations specialist and investing in preparation of dedicated graphics and scripts will result in smoother delivery of this information. It may be helpful to test the proposed engagement with small groups and institutions (such as schools, community associations, businesses) before rolling out to larger public forums.

Where there are a smaller number of households affected (in rural areas or down a long valley) it may be appropriate to visit these households individually and provide a household specific response plan as well as obtain contact information for delivering warnings.

4. Developing the Emergency Action Plan

4.1 Purpose of an EAP

The purpose of an EAP is to provide a pre-determined plan of actions that a dam Owner is able to implement if a dam safety incident develops. The EAP will often be triggered when a potential threat is detected through other processes, such as the monitoring and surveillance regime recommended in Module 5.

As such, an EAP should be designed to:

- Minimise the potential for dam failure following the detection of an adverse event.
- Limit the effects of a dam failure on people, property, and the environment in the event that a dam failure cannot be prevented.

An EAP should take into account the main threats contributing to potential failure modes applicable to the dam and the potential downstream consequences of the breach discharges associated with those potential failure modes. It should define and prioritise the implementation of those actions that realistically may be achieved to minimise the potential for loss of life and damage to property and the environment.

4.2 Development process

An EAP should detail the actions that the Owner and operating personnel should take in a dam safety incident. The EAP should be specific to the dam or scheme.

The nature of response actions detailed in an EAP should be informed by the failure modes for that dam. The identified failure modes should be presented in groupings that require similar responses (e.g. flood related, settlement related, gate/equipment failure etc) and response procedures provided for those groupings. Where a dam has known deficiencies that elevate the risk of a particular type of failure, consider inclusion of specific responses for that deficiency.

Where a chain of dams is located on a river system, coordination is necessary to ensure that emergency actions taken at one dam do not jeopardize the safety of a downstream dam (for releases) or, on occasion, an upstream resident or dam (for impoundments).

Where a single dam Owner has a portfolio of dams, it may be appropriate to develop a generic EAP that details common company procedures and includes, within separate appendices or reference documents, site-specific information and procedures relating to each dam. If company procedures are tested/drilled on a regular basis then testing/drilling for every dam may not be necessary.

The development of an EAP requires coordinated planning with the local site team responsible for monitoring and surveillance, operators, local (district or city) councils, regional councils (which have flood management responsibilities), and local emergency agencies.

The EAP itself should be concise. The suite of documents must be easily navigable. In an emergency, large unwieldly documents are difficult to navigate. Use of supporting addendums, procedures and appendices is recommended to keep the EAP itself concise. A quick reference guide or aid memoire may be warranted for larger facilities when the plans become large.

Consider which information in the plan will be useful for which parties involved in the management of an emergency. In this regard, an EAP could be considered to have two key components:

- The internal procedures that the dam Owner or operator carry out in the event of an incident at the dam (who does what, when).
- The information needed by external agencies (e.g. inundation maps, notification procedures, contact lists, evacuations areas, refer section 4.3) so they can develop contingency plans.

The steps in developing an EAP are generally as follows:

- Identify and collate information.
- Develop the plan.
- Put the plan into service.

4.2.1 Identify and collate information

Identify and collate the following information:

- From the community and agency engagement covered in the previous section, identify key sources, agencies, and individuals who can supply information for input into, or that have jurisdiction over, the EAP.
- Identify key individuals, consultants, and contractors from the Owner who can provide input into the EAP.
- Identify those situations or events that may require the initiation of an urgent, coordinated response. Reference should be made to the main threats which contribute to potential failure modes for the dam (refer Modules 3 and 5) and the likely consequences of a dam failure (refer Module 2).
- Identify performance or surveillance indicators which may indicate that an incident is developing.
- Identify primary and auxiliary communication systems, both internal (between Owner/operator personnel) and external (between Owner/operator personnel and external agencies).
- Identify all persons and agencies involved in the notification process (by liaison with the local CDEM Group).

4.2.2 Develop the plan

Developing the plan itself will be an iterative drafting process. The following steps are recommended (Figure 4.1):

- Draft a notification procedure. Include who should be notified, in what order, and what other actions are expected of downstream agencies. This list will provide the contact people for review of the final plan and is a chance to obtain early inputs into aspects of the plan such as roles and responsibilities.
- Circulate the notification list/procedure and obtain any feedback or early input into plan contents.
- Prepare a draft EAP – see section 5 for detailed guidance.
- Discuss the draft EAP fully with all parties included on the notification list, seeking review and comment. Continuing the engagement described in the previous section, liaise with relevant territorial and regional government agencies to ensure the EAP will have a good fit with wider community emergency plans.

Figure 4.1: Iterative process to develop an EAP

4.2.3 Put the plan into service

Putting the plan into service involves:

- Making any revisions, obtaining any necessary approvals, and circulating controlled copies of the completed EAP to those who have responsibilities under the plan.
- Carrying out tests and drills of increasing comprehensiveness – starting with simple tests such as confirming communication links, moving through to workshops to introduce personnel to the plan, and then to tabletop exercises working through scenarios (see section 5.9).

4.3 Outline of contents

The effectiveness of an EAP can be enhanced by the adoption of a uniform format that ensures all information and procedures are included and easily understood.

While an EAP should be formatted in a way that is most useful to, and consistent with, the organisation involved in its implementation, the sample format outlined in Figure 4.2 for a Medium or High PIC dam should result in a user-friendly document that facilitates a timely response to a potential or actual dam safety incident.

EMERGENCY ACTION PLAN

TABLE OF CONTENTS

EMERGENCY QUICK REFERENCE (OWNER & EMERGENCY SERVICE DISTRIBUTION)

1. Essential Dam Information (location, basic data, diagram, Owner)
2. Event Level Classification & Action Flowchart
3. Notification & Contact List
4. Evacuation Information & Map
5. Summary of Roles & Responsibilities
6. Brief Description of Event Levels (may also include classification guidance and preventative actions)
7. Summary of Preventive & Emergency Actions
8. Locally available resources

EMERGENCY RESPONSE (FOR OWNER)

1. Statement of Purpose
2. Detailed Classification Guidance (grouped by failure types)
3. Emergency Response Process
   - 3.1 Notification Procedures External Internal
   - 3.2 Preventive Actions (to prevent a breach)
   - 3.3 Emergency Actions (reduce impact of a breach)
     - Interventions
     - Cordons
     - Evacuation
   - 3.4 Termination and Documentation
4. EAP Responsibilities
   - 4.1 Owner responsibilities
   - 4.2 Technical advisor and external support responsibilities
   - 4.2 Emergency services responsibilities

5. Response Information
   - 5.1 Access to Site
   - 5.2 Response during Periods of Darkness
   - 5.3 Response during Adverse Weather Conditions
   - 5.4 Warning Systems (if used)
   - 5.5 Location(s) of Incident Control Point
   - 5.6 Safety of responders
   - 5.7 Instrumentation and observations
   - 5.8 Other relevant plans held by Owner
6. Specific Response Plans
   - 6.1 Reservoir Drawdown Plan
   - 6.2 Interventions for potential failure mode groups
   - 6.2 Plans related to confirmed deficiencies

APPENDICES

1. Drawings
2. Inundation Maps and Tables
3. Checklists and Forms

EMERGENCY PREPAREDNESS (BY OWNER)

1. Purpose of section
2. Emergency plan maintenance and training (including drills)
3. Incident response team members
4. Communication Systems
5. Emergency power supplies
6. Sources of emergency materials, supplies and equipment
7. Technical and operational support resources

DOCUMENT CONTROL: distribution lists, changes log

Figure 4.2 Sample format for an Emergency Action Plan (for a High PIC dam)

An EAP for a Medium PIC dam need not be as detailed as that for a High PIC dam but should be sufficiently detailed to address the risk to the specific downstream population and environment, and responses to any specific deficiencies.

Low PIC dams (by definition) do not normally pose a high enough hazard to warrant production of a standalone EAP. Low PIC dam Owners should be prepared for incidents and have a response plan including details of people and areas that would be impacted by a breach; however, it may not be as detailed as that above and may rely upon the Owner's existing emergency response procedures for other events.

5. Detailed guidance on EAP contents

This section gives guidance on each of the recommended sections of the EAP using the recommended, standardised example format shown above.

5.1 Emergency contact lists

The EAP should include an easy-to-find list that provides key emergency contact details.

The details should include names, roles, addresses and contact details (landline and mobile telephones numbers, email or common social media addresses/handles), and the details should be updated on a regular basis (annually is recommended for most situations) to ensure they remain current.

5.2 Identification, assessment and classification procedures

The EAP should include events or indicators that are beyond the scope of normal operations and therefore would initiate implementation of the EAP. These may be based on the design criteria adopted for the dam, the historical performance of the dam, or the results of a completed Failure Modes and Effects Analysis (FMEA).

If detected early enough, potential dam safety threats can be assessed and addressed such that any further escalation of the situation is prevented. The EAP should contain clear response expectations when potential dam safety threats are identified.

A special dam safety inspection should be carried out as quickly as possible following the identification of a potential dam safety threat. Details of special dam safety inspections are provided in section 4.6 of Module 5. Appropriate data collection and distribution (photos and videos) should take place during the assessment of the potential dam safety threat and continue until the threat has been resolved. A list of qualified dam inspectors and technical specialists, categorised by the type of dam safety threat, should be included in the key contacts list within the EAP.

The EAP is activated when the situation is beyond the scope of normal operations. The identification, assessment, and classification procedure is then used to determine the appropriate response.

The classification of level (internal event, developing incident, or emergency) occurs after receiving specialist advice and is made early enough to maximise the effectiveness of any actions. The most competent person or team available should determine the appropriate level of response.

Any hesitancy in classifying and subsequently declaring/notifying a dam safety incident could affect the effectiveness of emergency actions. Therefore, the EAP should provide clear guidance on the conditions that require a dam safety emergency to be announced, who can classify a dam safety incident, how the statement should be recorded, and what guidelines should be used to classify the incident.

Refer to Figures 2.1, 2.2, and 2.3 for a recommended set of procedures for use in classifying a dam safety incident as an internal event, developing incident, or emergency. Refer to section 2.5 regarding declarations of civil defence emergencies (as distinct from an Owner declaring a dam safety emergency).

The following factors and emergency response actions should be outlined in the EAP:

- Events and indicators that would initiate the EAP.
- The nature of the discharge (e.g. size, contents) that may be released in the event of a failure.
- Estimated times to respond to an adverse event (e.g. estimated time before failure, time for earthmoving equipment to reach site, available warning time for downstream population).
- Information from third parties (e.g. weather forecasts, river flows) that can assist in the timing of preventive actions.
- Details of any warning systems.
- Actions that can be taken to lower the reservoir, or limit reservoir inflows and maximise outflows.

- Actions that can be taken to remedy or alleviate the dam safety emergency.
- Actions to mitigate the potential effects of a dam failure.
- Actions that can be taken to save lives downstream in the event of a dam failure

5.3 Notification procedures

The first step in notification is the 'decision to notify'. This decision is particularly important for the evacuation of any population at risk. The notification procedures in the EAP should detail who has the authority to make the decision to notify and how the decision should be made according to the timing of the event (day, night, weekend). Any hesitancy in making the decision to notify could affect the effectiveness of response, potentially affecting the evacuation of any population at risk.

The Police, CDEM, and local and regional authorities should be notified of any potential emergency and immediately notified of any imminent failure.

Notification procedures must be clear and easy to follow. The EAP should include a list of all persons to be notified in the event that a dam safety emergency is announced, and clearly indicate who is to make the calls and in what priority. The number of persons to be notified by each responsible individual should be kept to a minimum. The procedure, which is often best presented in a notification flow chart or simple bulleted list of immediate notifications, should include notification to the Police, CDEM, Owner, Technical Advisors, Contractors, territorial authorities and regional authorities as appropriate. The procedure should also include individual names and position titles, office and home telephone numbers, and alternative contacts and means of communication. Copies of the notification procedure, or flow chart if prepared, should be available for all individuals having responsibilities under the EAP, and should be prominently posted at the dam and the Owner's emergency operations centre.

Early notification to the Police will allow them to determine if they have sufficient resources to respond, or if they need to call in CDEM.

CDEM may or may not decide to declare a civil defence emergency. CDEM may choose to activate and participate in or lead the response even if there is no declaration. A CDEM activation simply means that the facilities of a local or regional Emergency Operations Centre have been stood up and a staff rostered on to assist with managing the response. This often happens in the monitoring phase of heavy weather events, for example, and does not require the declaration of a civil defence emergency.

The EAP does not necessarily need to include details of briefings for the news-media but procedures for these should be pre-planned. Consideration should be given to the use of a dedicated person, skilled in media briefings, to prepare statements and provide regular updates to the news-media. Any public or media information releases should be coordinated with external agencies to avoid the release of conflicting information. Other agencies and the dam Owner should amplify and repeat the messaging from the lead agency. Once the lead agency has stood up an emergency coordination or operations centre, one of the desks in this centre will be manned by public emergency management communication specialists. This desk is called the Public Information Management function (PIM) and is responsible for providing information and safety messages to the public.

The use of multiple public warning channels should be considered as part of notification planning. Example messages and message templates should be prepared and included in the EAP. A mix of channels is necessary to achieve rapid dissemination. Traditional media (radio, television) and social media should be used. Emergency Mobile Alert 'push' notifications can be initiated by Civil Defence, NZ Police and FENZ.

5.4 Preventive actions during a developing incident (potential failure)

The EAP should include a section detailing preventive actions that can be taken both prior to and following the identification of a dam safety incident to mitigate or remedy the potential effects of a dam failure. In broad terms, such actions are likely to fall into one of the following categories: intervention to prevent dam failure, reducing the level of the hazard (lowering the reservoir level), slowing the rate of deterioration, or reducing the consequences of the failure.

Preparedness actions taken prior to the occurrence of a dam safety incident can help mitigate a dam failure or minimise its downstream effects. These actions include:

- Agreements with supporting third parties to respond at short notice with transport options, equipment, materials, or expertise.
- The stockpiling of materials and critical spare parts.
- The installation of warning systems to alert the population at risk.
- Establishing coordinated road closure and evacuation plans and procedures with Police and CDEM authorities.

Preventive or remedial actions taken during a dam safety incident may include initiating immediate reservoir drawdown (refer section 6.1) by limiting inflows and maximising outflows, placing material to staunch potential seepage erosion or piping discharges, or placing material or sand bags at low spots on a dam crest.

Failure modes and intervention actions are specific to each dam. It is important to ensure that intervention actions will 'do no harm', as some actions incorrectly applied could accelerate failure of the dam. Suitable actions, carefully considered during preparation of the EAP based on the actual geology, structure, systems, and inundation area at the specific dam, should be listed in the plan.

5.5 Emergency actions during an imminent failure

Emergency response actions taken following the announcement of a dam safety emergency (imminent failure) are intended to reduce the impact of a dam failure on the downstream population, with a primary focus on reducing or preventing loss of life. Pre-planned actions in this stage should focus on clearing the evacuation zone of people. These actions include evacuating people from the inundation area, enforcing road closures and detour plans, and establishing safe shelter areas and corridor paths. Measures should be in place to prevent people from returning to or trying to cross the evacuation zone. For large dams, these actions will be primarily led by the Police or Civil Defence who need to be provided sufficient information during the preparedness phase to pre-plan these actions. For smaller dams, the Owner may have agreed to take responsibility for notifying evacuations within a defined zone or list of properties.

The dam Owner should provide continued monitoring and regular notification of the status of the dam. Monitoring may be in person or remote depending on the circumstances. It is recommended to use written, sequentially numbered status updates, which should be circulated to the incident response team.

The Owner should continue actions with the aim of preventing or delaying a breach for as long as possible. These actions may include reservoir drawdown, buttressing the dam, raising the dam crest or staunching of flows where possible.

For all the above actions, the safety of the response teams and their movement routes should be considered. Rather than sending people into the inundation zone, it may be safer to use helicopters or drones for monitoring and access.

In rare scenarios, a controlled breach may be considered as a last resort. Scenarios that could justify a controlled breach may include:

- Accelerating reservoir drawdown.
- Managing the onset of flooding so that it occurs during daylight hours.
- Directing breach flow in a particular direction or ensuring the breach occurs at a location where erosion would be limited (e.g. a saddle dam or an area with less erodible material).

If these scenarios are applicable, it is recommended that suitable locations be pre-defined in the EAP. Overtopping does not always lead to failure and therefore each situation needs to be assessed on its merits by a suitably experienced team of people familiar with the asset and the inundation area. A controlled breach is a dangerous operation that can quickly become unmanageable and should only be undertaken as a last resort. It must be preceded by proper planning, consultation, and evacuation of the breach flow inundation area.

5.6 Emergency termination actions

The EAP should include procedures for terminating a dam safety incident and notifying the emergency services that the dam safety incident has been resolved. The emergency services are responsible for declaring an end to any public emergency response process.

Following the termination of a dam safety incident, as determined by the dam Owner and/or their Technical Advisor, the dam Owner or Technical Advisor should fully document the response in a report. The report should include discussion on:

- The event or condition that initiated activation of the EAP.
- The response actions taken by the dam Owner and all emergency service agencies.
- The extent of any damage to the dam.
- The extent and effect of any downstream inundation.
- The justification for terminating the dam safety incident.
- The strengths and weaknesses of the existing EAP including the management procedures, equipment, resources, and leadership.
- Corrective actions to address any identified weaknesses in the EAP.

5.7 EAP roles and responsibilities

The EAP should include a section describing roles and responsibilities. This section should specify the person(s) or organisation(s) responsible for the surveillance, maintenance, and operation of the dam and the person(s) and or agencies responsible for implementing various stages of the EAP. Delegated authorities for key personnel should be specified.

The availability of emergency personnel to fulfil their responsibilities during a dam safety emergency can be affected by large natural events such as floods, landslides, earthquakes and volcanic eruptions. For example, nominated emergency personnel may be directly affected by a large earthquake and unavailable to assist in the management of a dam safety emergency that arises following the earthquake. It is therefore important that EAPs incorporate a level of resilience to ensure appropriate personnel are available to assist in the management of a dam safety emergency.

5.8 Response information

5.8.1 Access to site

The description of site access should identify at least two access routes and consider the suitability of each in a variety of scenarios. The EAP should list the means for reaching the site under various conditions (e.g. road, foot, boat, helicopter, excavator or bulldozer), and the expected travel times.

Earthquakes and heavy rainstorms can cause landslides, tree falls, and bridge or culvert washouts that prevent road access for days or weeks. Poor weather can also prevent helicopter access. It is therefore important to consider the site's accessibility following (or, if practicable, in advance of) a large natural event, and to assess how access constraints might affect the availability of equipment needed to manage a dam safety incident. EAPs should therefore incorporate a level of resilience to minimise the adverse effects of access constraints. If access constraints are likely following a large natural event, it may be appropriate to store essential equipment at the site and move staff to site early. Staff may need to be prepared to stay on-site for several nights. For health and safety reasons, teams of two or three are often optimal. If the incident is prolonged, this arrangement allows for shifts to be established.

5.8.2 Response where access may be impaired

The EAP should include response procedures for any situation where access to the dam may be impaired. Access could be impaired during:

- Periods of darkness, including those caused by power failures. Appropriate responses may include establishing emergency power and lighting, limiting areas of access or inspection, or waiting until daylight.
- Adverse weather, including extremes of temperature, snow, or storms. Appropriate responses may include temporary shelters, appropriate clothing and equipment, or the use camera or video rather than manned surveillance.
- Transport disruptions. Assess whether 2WD or 4WD vehicle access is limited, and consider alternative modes of access such as bikes, foot or other options.
- Road closures. Consider appointing an appropriate organisational authority to permit access to the dam through potential road blocks if it is safe to do so. Consider accessing the dam via alternative means (bike, boat, jet ski or helicopter).
- If the dam site itself is space constrained, suitable off-site staging areas may be needed for incoming personnel, plant, or material deliveries. Consider these locations relative to transport links and flood levels.

5.8.3 Warning systems

Warning systems are sometimes installed to provide warnings to residents, campgrounds, and parks that are close to a dam. Where they are installed, full details of the warning systems and their activation, including who is responsible for any decision to activate the warning systems, should be included in the EAP.

Relying solely on siren tones as an alerting system is inadequate for ensuring comprehension among the population at risk. Sirens do not provide sufficient 'information' for people to understand the situation and the necessary actions they need to take. If a warning system is to be used, it should be accompanied by further information, such as follow up phone calls to campground staff or 'push' notifications to individuals' mobile devices.

Warning systems require regular maintenance and testing to be reliable, and to maintain public awareness of the warning signal. Effectiveness is low in populations that have not been exposed to system tests or have not been educated on what actions to take when the system activates (Kuligowski & Wakeman, 2017).

5.9 Preparedness information

The EAP should cover preparedness activities and record the occurrence of activities such as drills, exercises, and checking of emergency equipment. Activities recommended to be planned and performed on a regular basis, and details included in the EAP for reference during an emergency are:

5.9.1 EAP maintenance and training

The dam Owner is responsible for reviewing, issuing, training, and maintaining all registered copies of the EAP. It should be a controlled document.

The EAP should include provisions for appropriate review of the document, its procedures, and communications systems for currency, relevance, and operability. The review should be completed on a regular basis, at least annually, and include updating, as necessary, the names and contact details for all personnel with emergency management roles. The EAP should also be reviewed during the completion of Intermediate Dam Safety Reviews and Comprehensive Dam Safety Reviews to verify that it is current and that the information, guidance, and direction are consistent with the dam's condition and performance.

Provisions should also be included for the training of personnel involved in the activation and implementation of the EAP. This is to ensure that all personnel designated in the EAP are familiar with its elements and their responsibilities, enabling them to effectively fulfil their duties during a dam safety incident. Training exercises can range from a limited table top exercise for a specific dam safety emergency to a full-scale simulation of a dam safety emergency which includes multiple failures (domino effects).

The frequency and type of training exercises should reflect the consequences of failure and should be sufficient to maintain the Owner's readiness for a dam safety incident. It should also reflect the level of turnover in personnel having emergency preparedness responsibilities. A frequency of two to three years would be appropriate in most instances. However, in periods of significant turnover of key incident management or response roles, a much greater frequency of training or exercises is needed. From time to time, Police and CDEM officers should participate in the training to maintain their readiness for a dam safety incident and maintain coordination across all affected parties.

5.9.2 Communication systems

Full details of the internal and external communication systems, as they apply to the EAP, should be included. Commonly used communication systems (mobile phone, land line telephone and email) are vulnerable to failure or overload in the adverse conditions that may lead to a dam safety incident (e.g. earthquake, storm, heavy rainfall etc). As such, the robustness of the available communication systems should be assessed and, where appropriate, enhanced by additional communication systems.

Examples of additional communication systems are trunk radios, satellite phones, and internet messaging.

5.9.3 Emergency power supplies

Details on the location and operation of emergency power supplies (e.g. portable generators, sufficient fuel) should be included. Battery conditions need to be regularly checked for charge and the likely duration of use understood. Fuel tanks supporting dam safety critical systems (whether primary or backup) should have levels monitored or alarmed so that status can be remotely determined with sufficient time to arrange re-fuelling.

5.9.4 Sources of emergency materials, supplies and equipment

The EAP should include details on the location and availability of supplies (e.g. batteries, grout, fuel) and materials (e.g. rip rap, sand bags, filter and drainage materials) for emergency use.

The location and availability of equipment (e.g. torches, cameras, emergency lighting, earthmoving plant) and local contractors that could be mobilised in a dam safety incident should be included.

5.9.5 Sources of technical and operational support resources

In a dam safety incident, it may become necessary to obtain specialist technical support to consider dam performance trends and identify the need for any preventive actions or temporary support works. It may also become necessary to obtain additional resources for operation of the facilities (e.g. during a basin wide emergency that affects the operation of a number of dams).

Managing a dam safety incident is demanding on staff and additional resources may be required if the incident is likely to extend beyond 10 hours. Welfare considerations include rostering, additional food and drinking water, and transport for response staff. In addition, resources from outside the affected area may be appropriate in some circumstances (e.g. following a large local earthquake, on-site resources may be affected by family or other concerns).

The EAP should include a listing of technical and operational support personnel, together with their contact details.

5.10 Dam-break inundation maps and tables

Dam-break inundation maps (refer Module 2) assist in the creation of evacuation plans and communication of the risk to the evacuation agencies and downstream population. Inundation maps are usually based on worst case dam failure scenarios. In order to generate realistic maps, it is necessary to understand the actual condition of the dam (including lake level prior to collapse) and the most realistic dam breach scenarios.

Dam-break inundation maps should be included, or referred to, in all EAPs prepared for Medium and High PIC dams. They should show inundation areas at scales sufficient for the identification of areas at risk and should include inundation tables which show, at key locations:

- The arrival time of the first flood waters.
- The arrival time of the peak flood level.
- The peak flood elevation above mean sea level.

For large reservoirs, understanding inundation areas for a variety of lake levels can facilitate more efficient evacuations, rather than relying solely on full lake inundation maps. It may also be useful to express flood levels as relative depths at key locations (e.g. bridges or community appointed locations, such as previous flood height monuments) and the time at which key structures may become unusable. Regional authorities have a responsibility for regional scale natural hazard information, including flood hazard maps. If the estimated discharge from a dam failure is similar to the flood size already mapped, the existing inundation information held by the regional authority may suffice.

5.11 Evacuation maps and planning

The planning for, and ownership of, documents for public evacuations best sits with Police (and CDEM) who hold the statutory powers to order evacuations. It is recommended that Owners offer assistance (particularly in terms of interpretation, population at risk information, mapping/drafting) to agencies to create their own agency response plans. The recommended document is a draft Action Plan in the CIMS format (either consolidated or initial depending on the scale of the dam).

During an emergency, it is recommended to use pre-prepared evacuation maps as the primary tool for communicating evacuation requirements to agencies and the public. Figure 5.1 shows the difference between an inundation map and evacuation map. Interpretation of inundation maps during an emergency by people unfamiliar with them has the potential to generate confusion. A simple line defining the evacuation area using sensible, easy to locate features on the ground will result in less confusion and faster deployment of responders (Lemieux & Robinson, 2008).

For large inundation areas Police and/or CDEM should be encouraged during the preparation and consultation phase to:

- Create evacuation plans including safe zones, likely road closures and priority areas (low ground) to be evacuated. These may show routes to take (by foot as often roads become congested) to the safe zones (high ground). These evacuation maps should be included in both the EAP and in the external agency action plan.
- Create a draft initial action plan that can be used by duty offices to guide their own response if an urgent evacuation is required.

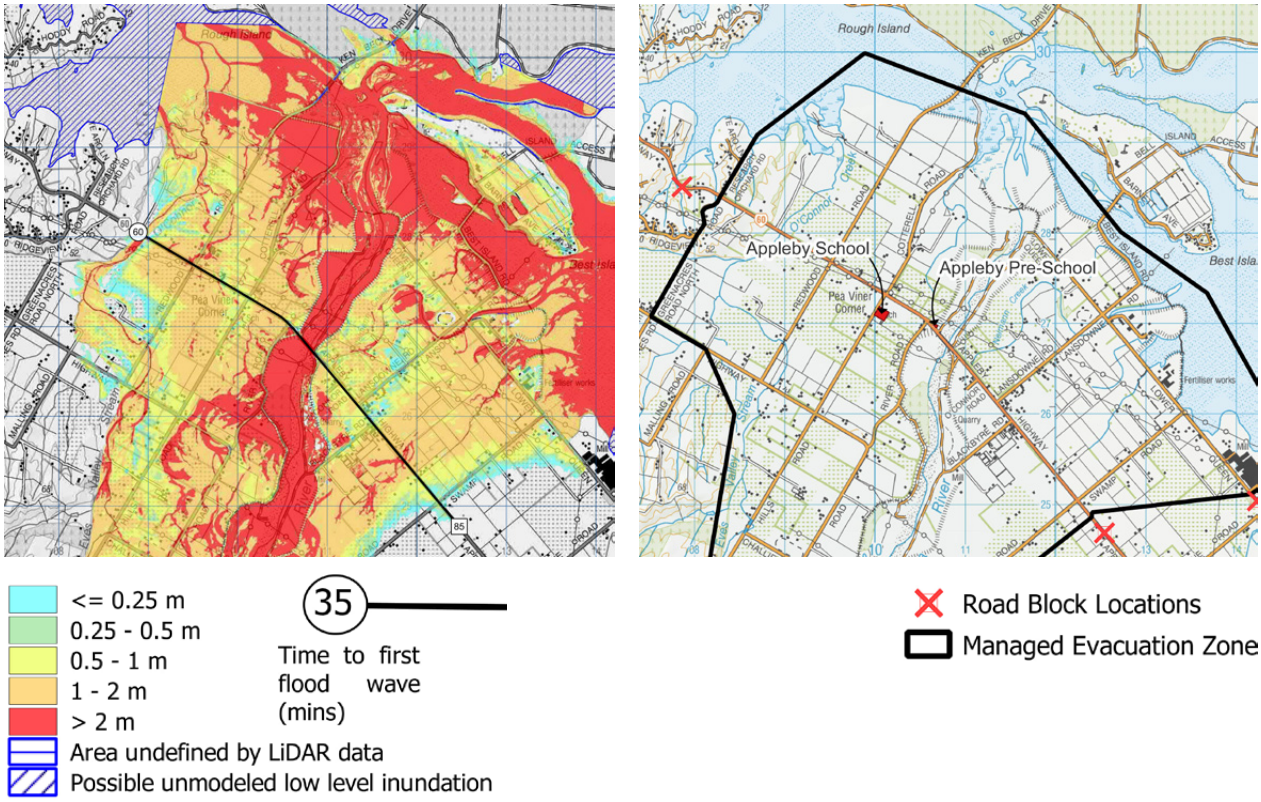

Figure 5.1: Example of inundation map (left) vs evacuation map (right).

5.12 Additional information

Additional items frequently incorporated as appendices in an EAP include:

- General site plans, drawings, and photographs.
- Details and operating instructions for gates and valves that fulfil dam safety functions.
- Dewatering plans or information for assessing reservoir dewatering options.
- Rating tables and graphs, lake management plans.
- Procedures for the recording of emergency situations (e.g. flood inspection check lists, post-earthquake check lists, emergency action log, emergency termination log).
- Procedures for using communication platforms (internal and external).
- EAP Maintenance and training, including a log of consultation and training/drills.

6. Developing response plans

6.1 Reservoir drawdown plans

For many dams or canals, a primary response to a dam safety incident may be to reduce the hazard by lowering (drawing down) the reservoir level. Depending on the characteristics of the dam safety incident and the available drawdown facilities (e.g. spillways, low level sluices) the achievable drawdown may be limited to the normal operational range of the reservoir, or it may be possible to draw down the reservoir to the invert levels of the discharge facilities.

Reservoir drawdown plans should be developed for all Medium and High PIC dams that incorporate drawdown facilities, and the plans should either be referenced or incorporated within the EAPs. Because drawdown requirements in a dam safety incident are often difficult to establish, drawdown plans should include sufficient flexibility to respond to changing conditions and contain sufficient information to assist decision makers in determining appropriate courses of action.

A reservoir drawdown plan might contain:

- Dam or canal safety conditions that could necessitate reservoir draw down (e.g. safety of public, vehicles or animals in the reservoir, embankment seepage occurring, maintenance required on usually submerged structures, testing of low level outlet equipment, bedload sediment flushing, increasing the available flood storage).
- An outline of reservoir inflows and whether or not they can be controlled.
- An outline of the available drawdown facilities, their discharge capacities and their drawdown limitations.
- Limitations on the rate of drawdown to prevent serious damage to the dam or canal (e.g. to prevent rapid drawdown failure of an upstream slope of an earth dam) and prevent instability in the abutments or the reservoir slopes including any dormant landslides. If exceeding the normal limitations is possible and justifiable under urgent scenarios, then include guidance.
- Limitations on the rate of discharge or discharge ramping rates to reduce downstream impacts (e.g. if there are damaged bridges downstream post-earthquake). If exceeding the normal limits is possible, then give guidance on when it might be appropriate to exceed these limits.
- Alternative drawdown scenarios and drawdown procedures.
- Plots of reservoir level versus time, for the alternative drawdown scenarios and procedures, which reflect drawdown and discharge limitations and clearly show drawdown progress.

6.2 Interventions for potential failure mode groups

Where there are other viable preventive actions that can be taken to reduce the likelihood of a failure mode progressing (other than drawing down the reservoir), these should be documented in an easy-to-follow procedure.

6.3 Response plans for confirmed deficiencies

Where a dam has known deficiencies, in the interim period between these being identified and being remediated, Owners should consider providing a specific response plan for the deficiency. The specific response plan might include:

- Detailed guidance on which instruments or locations in the dam require enhanced surveillance or monitoring, and why.
- Limits or restrictions to be adopted on gates or outlet works.
- Specific interventions pre-planned for the known deficiency.
- Operational constraints relevant to the deficiency e.g. reservoir level or ‘must run’ rules in hydropower lakes.
- Seasonal limits.

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