Chapter 14

EMERGENCY ACTION PLANNING

14.1 PURPOSE

Emergency action planning for dams includes establishing procedures and identifying potential actions and resources for responding to a condition of impending or actual dam failure. Guidelines published by the Federal Emergency Management Agency (FEMA; 2004a, 2004b) provide general information on hazard-potential classification and emergency action planning for dams. The guidance presented in this chapter is divided into two parts: (1) Emergency Action Plan (EAP) preparation and (2) emergency remedial actions that a facility Owner/Operator can take independent of responsibilities defined in the EAP to prevent an embankment/impoundment failure or to reduce potential damage in the event that a failure does occur.

EAP preparation is addressed in Section 14.2. The intent is to provide an understanding of what an EAP is, when one should be prepared, and recommended practice for preparation. However, it should be understood that EAPs are generally submitted to state agencies for review and approval and must meet the requirements of the state (or states) in which the facility and potential inundation area are located. In addition to state guidance, FEMA (2004b) and the Natural Resources Conservation Service (NRCS, 2007b) have developed guidelines for EAP preparation, and some states may be using or may adopt these or similar guidelines. If a facility is not under state jurisdiction, then the aforementioned federal guidelines should be useful. The first step in EAP preparation for any site should be to determine what guidelines are applicable. While the guidelines presented herein are recommended practice, some of the information presented may not be applicable in all instances. Most states have a specific structure and format that should be followed.

EAP preparation is a prudent practice for significant- and high-hazard-potential dams and the Owner/Operator typically has specific responsibilities related to notification of authorities in the event of development of an emergency situation. However, there may be additional actions that can be taken by the Owner/Operator that will possibly prevent or minimize damage due to a failure. Potential actions for several emergency scenarios are discussed in Section 14.3.

14.2 EMERGENCY ACTION PLAN PREPARATION

14.2.1 Background

Structures that impound large volumes of water or tailings slurries represent a potential danger to inhabitants of low-lying areas located downstream. Some notable dam failures that have occurred

in the U.S. and the resulting loss of life are presented in Table 14.1. It was the sudden failure of the Buffalo Creek Dam on February 26, 1972 during a period of heavy rainfall that elevated national awareness of the potential danger associated with coal refuse impoundments and led to a program of tailings dam and impoundment inspections and hazard classification, as well as MSHA's current coal refuse impoundment regulations.

TABLE 14.1 HISTORICAL U.S. DAM FAILURES

Year	Dam	Location	Deaths
1889	South Fork	Pennsylvania	2209
1972	Buffalo Creek	West Virginia	125
1972	Canyon Lake	South Dakota	139
1976	Teton	Idaho	11
1977	Toccoa Falls	Georgia	39

Today most states regulate non-federal dams within their boundaries. This regulation normally entails: (1) classification as to hazard potential level, (2) design and construction requirements, and (3) periodic inspections. Impounding coal refuse embankments and dams are classified as to hazard potential in accordance with a system comparable to that adopted by FEMA, as discussed in Section 3.1. There may be some variation in the number of hazard level categories and the terminology from state to state, but all state classification systems are generally consistent with the FEMA system. It should be noted that the hazard potential level is strictly a function of the potential consequences of a dam failure and is not related to the construction of the dam, its condition, or its susceptibility to failure.

Dams or impounding embankments that have significant or high hazard potential in accordance with the FEMA (or state equivalent) hazard classification system should have an EAP in place. These are structures that, if they were to fail, would likely cause loss of life or significant property damage. An EAP is a document that establishes emergency procedures to be followed in the event of a catastrophic failure of the structure leading to rapid downstream flooding. While some significant and high hazard potential dams in the U.S. may not currently have EAPs in place, they are generally being required for coal refuse impoundments and dams by state dam safety regulatory agencies. FEMA (2004b) in the Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners (FEMA 64) indicates that each high and significant hazard dam should have an EAP; MSHA has encouraged mine operators to prepare EAPs consistent with FEMA 64.

It should also be noted that 30 CFR § 50 requires mine operators to immediately notify MSHA of accidents. Conditions that constitute an accident are defined under 30 CFR § 50.2. One of the definitions of accident indicated in 30 CFR § 50.2(h) (10) is, "An unstable condition at an impoundment, refuse pile, or culm bank which requires emergency action in order to prevent failure, or which causes individuals to evacuate an area, or failure of an impoundment, refuse pile, or culm bank."

While not equivalent to the requirements for an EAP, MSHA's regulations under 30 CFR § 77.216-3 do require inspections of coal company dams at specified intervals for hazardous conditions and that actions be taken when a potentially hazardous condition develops, including: (1) notification of the MSHA District Manager, (2) notification and preparation for evacuation, if necessary, of coal miners who may be affected from coal mine property, and (3) examination of the structure by a qualified

person at least every 8 hours. These regulations should be reviewed as part of the preparation of an EAP, particularly as related to identification of hazardous conditions and mine personnel responsible for notification. Since a dam failure can impact persons living well away from mine property, an EAP must take into account the entire downstream area that will potentially be affected.

A possible mode of failure for an impounding coal refuse embankment is breakthrough of the impoundment into underground mine workings unrelated to dam failure. This can result in flooding of the mine workings and release of flood flows at a mine opening relatively far from the impounding embankment. EAPs for postulated dam failures involve a postulated dam breach and downstream release. FEMA and state regulations and guidelines are tailored to this type of event. However, if a breakthrough is plausible, an evaluation of such a release and the potential consequences should be made. Such a study may involve many conservative assumptions related to the size and timing of the breakthrough and analyses of flow through the breakthrough to determine the location and extent of possible flooding. The result should be an inundation map for the area that would be affected by flooding. All other aspects of EAP preparation would remain essentially the same.

14.2.2 Federal Guidelines for Dam Safety

The Interagency Committee on Dam Safety (ICODS) was established in the late 1970s to address dam safety issues. ICODS is chaired by FEMA and comprises the federal departments and agencies (including MSHA) that have responsibility for dams and dam safety.

EAP guidelines and a suggested format for use by the ICODS agencies are provided in FEMA (2004b) cited above. Some states have adopted the ICODS guidelines for EAP preparation, while others have developed their own guidelines and plan formats. In any case, the FEMA publication is recommended reading for anyone that is preparing an EAP. Also the NRCS (2007b) has developed a sample EAP and an electronic "fillable form" template" for preparation of EAPs. This template and related documents are available on the NRCS web site.

In the discussion that follows, EAP preparation and content are discussed in general terms and no specific format guidelines are presented. The appropriate state regulatory agency for each dam should be contacted to determine specific EAP format, submittal procedures, and approval requirements.

14.2.3 Basic Elements of an EAP

The following list of basic EAP elements is an expansion and refinement of a list originally developed by FEMA (2004b) and reflects some typical state requirements:

- Physical description of dam – A physical description and accurate location of the dam and related hydraulic structures with a map should be provided.
- Potentially inundated area – The maximum extent and arrival times for inundation resulting from postulated dam breaches should be clearly indicated on a map that shows the mining facilities, dam, downstream channel, important highways and streets, homes, businesses and any other critical facilities (e.g., hospitals, nursing homes, day-care centers) that could be affected by a dam failure. Locations of reception centers and treatment facilities designated in the EAP and locations of road blocks/traffic control points and evacuation routes should also be shown on the inundation map.
- Implementation triggers and emergency responses – Conditions that initiate implementation of emergency response procedures should be clearly indicated in the EAP (e.g., reservoir elevations, spillway flow depths, or visible conditions of distress). Emergency response activities associated with the implementation triggers should be delineated. The NRCS Fillable Form Template (NRCS, 2007b) provides useful information on trigger conditions.

- Notification requirements – The responsibilities for notification should be clearly delineated. The notification hierarchy is frequently presented in a flowchart format, but other formats may be used consistent with state requirements. The important factor is that each plan participant has a clear understanding of his or her notification responsibilities.
- Participant responsibilities – Responsibilities of each plan participant should be clearly indicated in the EAP. Typical key responsibilities include the owner's responsibility to notify appropriate agencies when there is a threat of dam failure, responsibility of local emergency management officials for warning and evacuating affected persons, requirements for police/fire departments for installing road blocks and/or managing traffic at specific locations, EMS/ambulance services responsibilities for transporting the injured, and the responsibilities of emergency service providers relative to operation of reception and treatment centers.
- EAP public notices and copies – Notices indicating the location of publicly available EAP copies may be required to be posted in public places such as municipal buildings, fire departments (social halls), tax offices, and other locations accessible to the public.
- Exercises/training – Some states require that EAPs have provisions for exercises and/or training while others do not. Exercises and training sessions are an effective way to provide EAP participants with a clearer understanding of their responsibilities and required actions.
- Plan maintenance – EAPs are normally required to be updated on a regular basis – typically one to five years. All elements of an EAP should be periodically reviewed and updated as needed to reflect changes in regulatory requirements, mine facilities, the dam and related structures, inundation area, street and highway infrastructure, plan participants and telephone numbers, and other key information. Some states require periodic evaluation of downstream development to determine whether changes have occurred that could affect the dam's hazard classification and EAP contents. Optimally, the names of key plan participants and contact information should be updated annually or as changes occur.
- EAP Appendices – Supporting documents should be provided in appendices to the EAP. The contents of the EAP appendices will vary depending on state requirements.

The submittal and approval process for an EAP will vary from state to state, but a typical scenario might involve submittal of a draft to the county EMA for review and approval followed by review by state environmental and emergency management agencies. During this period, plan participants are also made aware of the EAP preparation and have the opportunity to provide input. Comments based on the reviews are addressed and the final version, once final approval is obtained from the state, is distributed to the plan participants.

14.2.4 Dam Inspection and Inundation Area Reconnaissance

The first step in the preparation of an EAP normally involves a field inspection of the dam or impounding embankment and a reconnaissance of the downstream area that would potentially be flooded as the result of a catastrophic failure.

14.2.4.1 Dam Inspection

A dam inspection should be performed in sufficient detail to allow a reasonable determination of critical sections and parameters for dam breach modeling. If the inspection is being performed to satisfy

state annual (or other inspection frequency) requirements, then it should be detailed enough that the applicable state inspection forms can be fully completed. In addition to the dam, reservoir areas that could be overtopped or subject to instability should also be evaluated. The purpose of the inspection is not only to identify areas of concern, but also to evaluate features or conditions that may warrant special consideration in the dam breach analysis (e.g., overtopping threat at a saddleback ridge forming the impoundment or potentially rapid failure associated with a seepage area).

14.2.4.2 Downstream Channel Reconnaissance

Prior to the performance of a dam breach analysis, the channel downstream from the dam should be explored and features that might affect flow conditions following a dam breach should be accurately documented. For example, channel constrictions or other conditions that could cause a backwater effect should be noted. Cross-section data should be obtained at such locations for incorporation into the dam breach analysis model (Section 9.9). Also, if adequate cross-section data cannot be obtained from topographic maps, field surveys of cross sections should be performed. Floodplain conditions such as heavy brush or the presence of flow retarding structures (e.g., natural valley contractions, bridges, railroad and highway fills) should be noted and should be appropriately reflected in the dam breach model channel roughness parameters.

The downstream channel reconnaissance should also include notation of critical facilities that would likely be affected by flooding both on and off the mine property. At the mine property, areas that are staffed or are critical access points for personnel (e.g., mine structures, shafts, pits, utility stations, etc.) should be noted. Additionally, public structures such as hospitals, schools, day-care centers, nursing homes, utility plants and substations, emergency service provider bases, and industrial firms with large numbers of employees should be noted. Other conditions such as street locations and intersections not shown or incorrectly indicated on available maps should be noted so that the inundation map reflects current conditions.

14.2.4.3 Physical Description

A description of the impounding structure and its construction, related hydraulic structures, and other information such as observations relative to the potential inundation area, should be provided in the EAP. This description should be based upon data from the dam inspection and downstream channel reconnaissance, as appropriate.

14.2.5 Inundation Map Preparation

14.2.5.1 Causes of Dam Failures

There are many possible causes for dam failure and/or sudden impoundment release. Possibilities include:

- Overtopping of the dam caused by reservoir inflows that exceed the total combined storage and spillway capacity.
- Piping and internal erosion of the foundation or embankment materials.
- Structural failure of the dam embankment resulting from an earthquake.
- Movement and/or failure of the foundation supporting the dam.
- Failure of an upstream dam or major landslide into the reservoir.
- Inadequate maintenance leading to loss of spillway capacity or structural weakness.
- Breakthrough of an impoundment into mine workings and subsequent release downstream.

The first two items in the list account for most actual dam failures.

14.2.5.2 Dam Breach Analysis

Consistent with the above, there are two modes of dam breach that are most commonly analyzed for determination of downstream inundation due to dam failure. These are: (1) overtopping of the dam due to inadequate spillway capacity during the inflow design flood (IDF) and (2) dam failure under normal conditions (i.e., normal pool in the reservoir and normal inflow to the reservoir). The latter condition is sometimes referred to as a "sunny day" failure. Breach development and determination of the outflow and resulting inundation from a breached dam or embankment are discussed in Section 9.9.

14.2.5.3 Inundation Map

The inundation map facilitates notification and evacuation of persons in the flooded area through graphical presentation of the flood limits. The inundation limit for emergency planning purposes is the maximum extent of flooding based upon the most critical dam failure scenario. For the IDF condition, the downstream limit of inundation mapping is typically determined as the point at which the flow level returns to within a specified vertical distance of the flow without dam breach (e.g., one or two feet). For a "sunny day" failure, the downstream limit of inundation mapping should be the point at which flow is wholly contained within the stream channel banks.

The limits of inundation should be plotted on a topographic map that clearly indicates the locations of streets and other roadways and any critical facilities that would be flooded. Use of semi-transparent shading to show the extent of inundation is recommended. Typically, inundation maps are developed from U.S. Geological Survey (USGS) topographic maps. The scale of an inundation map typically varies depending upon the density of streets and associated structures. Urban areas normally require considerably more map detail than less populated areas.

The inundation map should also clearly show locations where roadblocks/traffic control will be needed. Responsibilities for operation of these roadblocks/traffic control points may be delineated in a separate table, depending upon state requirements. The inundation map should indicate the location of any reception centers and/or treatment facilities identified in the EAP. Evacuation routes (delineated by arrows indicating the direction of evacuation) should be clearly marked on the inundation map. It is also recommended that the arrival times (in relation to the time of breach) for the leading edge and peak discharge associated with the flood wave be shown on the inundation map. If this information cannot be presented on the inundation map, it may be provided in a separate table. A portion of a typical inundation map is shown in Figure 14.1.

14.2.6 Participant Responsibilities

An EAP must clearly define the responsibilities of all parties that would be involved in a dam failure scenario. These parties include the dam owner (or designated representative); state, county and local emergency management officials; emergency service providers (police, fire, EMS, Red Cross); elected officials; radio and television stations; school systems; state transportation agencies; public transit authorities; railroads; and parties such as nursing home operators and large businesses that would be inundated.

The EAP should indicate that the dam owner or designated representative is responsible for monitoring the dam in any situation where catastrophic failure is a possibility. The owner or designated representative should be responsible for initiating the notification process (e.g., notifying applicable state agencies, the MSHA district manager, the County Emergency Management Agency (EMA), the County 911 center and the National Weather Service (NWS)). Further discussion of notification responsibilities is provided in Section 14.2.8.

The responsibilities of each participant organization or individual should be clearly delineated. For example, a police department or sheriff's office might set up a mobile communication station (squad

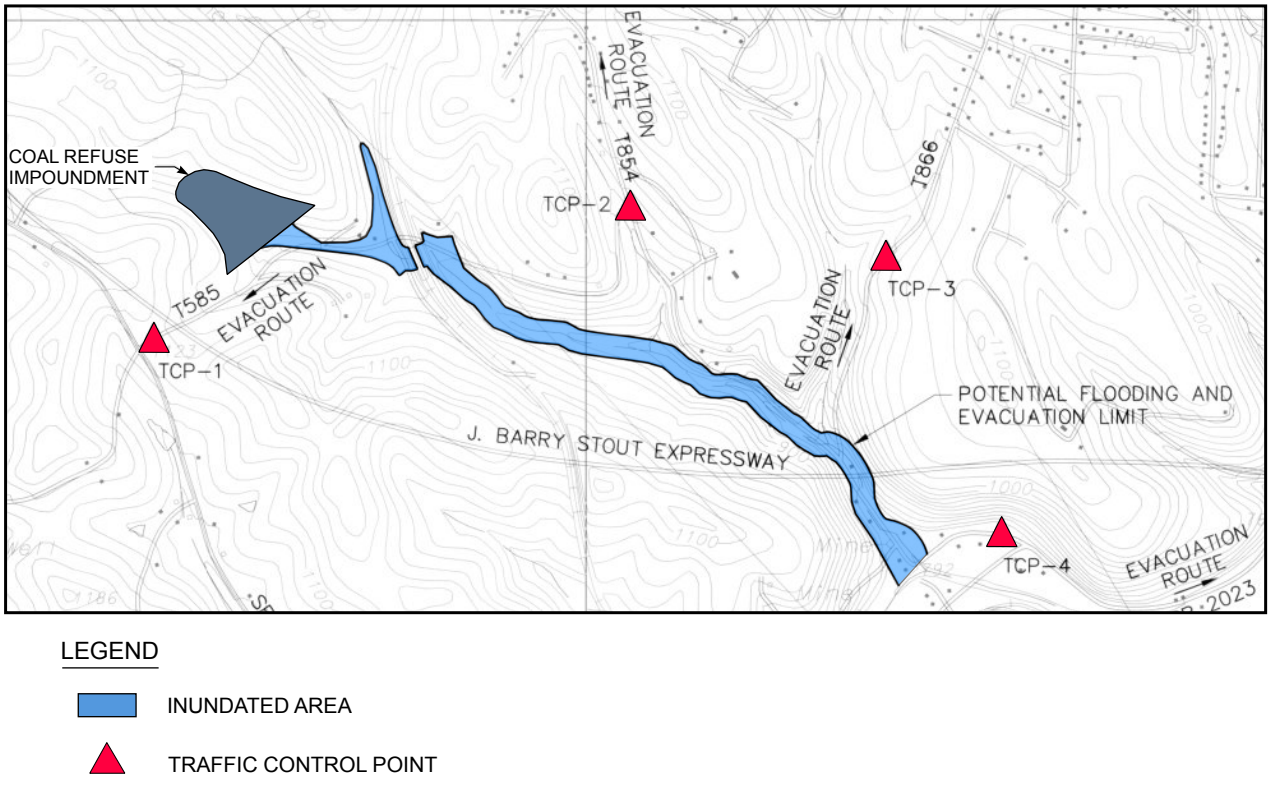

FIGURE 14.1 INUNDATION MAP FOR COAL REFUSE IMPOUNDMENT

car) at the dam, operate several traffic control points, and be responsible for evacuation. Local Emergency Management Coordinators (EMCs) are typically responsible for maintaining contact with the County EMA, notifying local elected officials and utility services, coordinating evacuation efforts, and developing damage assessments.

14.2.7 Implementation Triggers and Emergency Responses

As indicated in the previous section, the dam owner or designated representative is responsible for monitoring the dam in the event that certain conditions occur that could eventually lead to failure. The extent of the monitoring may vary from part-time to continuous depending upon the severity of the dam breach threat. The EAP should clearly indicate what event or events are associated with a specific monitoring level and what conditions will trigger implementation of plan emergency responses. Triggers for monitoring are frequently tied to the occurrence of large amounts of rainfall in a short period of time. Continuous monitoring should be implemented in the event of a condition such as observed piping, significant slope movement, or the failure of a structural component of the dam.

Once monitoring has been initiated, triggers that implement emergency actions will typically be in the form of a specified water surface elevation below the embankment crest, a specified flow depth in the emergency spillway or other easily measurable parameter. However, any observation of a condition that could lead to dam failure or other sudden release of water or slurry from the impoundment, such as a breakthrough into an underground mine, should also trigger the process. The dam owner or designated representative is responsible for assessing the situation and, if an emergency condition is identified, providing notification to implement the emergency procedures in the EAP. Others who might assist in the assessment of site conditions and the need for notification, such as state dam safety officials and MSHA, may or may not be available to provide input.

Table 14.2 presents guidance related to conditions that may be triggers for monitoring and for implementation of an EAP, as adapted from NRCS (2007b). Such conditions may include blockage of the

TABLE 14.2 GUIDANCE FOR EAP EVENTS AND SITUATIONS

Event	Situation	Monitoring or Trigger Level
Overtopping	• Impoundment level is rising and approaching specified depth below embankment crest (minimum freeboard elevation)	1
	• Impoundment water level above specified depth below embankment crest (e.g., 1 foot)	2
	• Water is flowing over the dam	3
	• Water is flowing over an abutment or saddleback rim of impoundment	3
Spillway Erosion or Blockage	• Water starting to flow through emergency spillway	1
	• Emergency spillway flowing with bottom erosion advancing toward control section	2
	• Emergency spillway blocked by significant debris or landslide material with impoundment level approaching minimum freeboard elevation	2
	• Emergency spillway flowing with erosion at control section	3
Seepage	• New seepage areas or increased discharge from internal drain outlet within or near dam	1
	• New seepage areas or internal drain discharge with cloudy flow and increasing flow rate	2
	• Seepage at greater than a specified flow rate or causing erosion of the dam or foundation	3
Mine Discharge	• New mine discharge in the immediate vicinity of impoundment	1
	• New mine discharge in the immediate vicinity of impoundment with cloudy flow and increasing flow rate	2
	• Mine discharge at greater than specified flow rate	3
Sinkholes	• Observation of new sinkhole in impoundment area or on embankment	2
	• Rapidly enlarging sinkhole	3
Embankment and Abutment Cracking	• New cracks in the embankment or abutments at greater than specified width	1
	• New cracks in the embankment with associated seepage	2
	• New cracks in the abutment with seepage and increasing flow rate	2
Embankment Movement	• Observed movement/slippage of embankment toe, slope, or crest	1
	• Sudden or rapidly proceeding slides at embankment slope	3
	• Sudden or rapidly proceeding subsidence at embankment crest	3
Instruments	• Instrument readings beyond specified values	1
Flood	• Rainfall or snowmelt predicted to be above specified level	1
Earthquake	• Measurable earthquake felt or recorded within specified distance of dam	1

Monitoring or Trigger Levels: 1. Non-emergency, unusual event – slowly developing
2. Potential dam failure situation – rapidly developing
3. Urgent situation, dam failure appears to be imminent or is in progress

(ADAPTED FROM NRCS, 2007b)

principal or emergency spillway, significant sloughing or slope failure in the dam embankment, overtopping or severe erosion, structural failure of a dam component, occurrence of sinkholes, cracking in the embankment, or other event that could lead to catastrophic failure. At sites where underground mine workings are present, elevated mine pool levels or mine discharges may also be triggers.

NRCS (2007b) recommends establishing emergency levels for identifying monitoring and response actions ranging from an initial level associated with a slowly developing, unusual (non-emergency) event to an advanced level associated with potential imminent failure or a failure in progress. While establishment of such levels may be useful to dam owners and operators in responding to dam emergencies, some states do not currently require that this be done.

It is recommended that emergency responses be identified for each implementation trigger. In addition to notification requirements, as subsequently discussed, other actions ranging from continued monitoring to preventative measures may be appropriate. It may also be useful to identify in the EAP additional personnel, sources of construction materials, and contractors that can be utilized in an emergency situation. This information may also be provided in the Operation and Maintenance Plan.

14.2.8 Notification Requirements

Notification of plan participants should be carried out in a systematic manner such that the most critical notifications are made immediately following a triggering event. Each plan participant must know his or her responsibilities for contacting other participants, including the preferred order of contact. The contact information should allow for communication on a 24-hour-per-day, seven-day-per-week basis. Contact information should be kept up to date as personnel or telephone numbers change. FEMA recommends that a flowchart be prepared that illustrates the notification process and each individual's notification responsibilities. FEMA's suggested format places the notification flowchart at the very front of the EAP. Some states have adopted the FEMA-recommended format (referred to as the ICODS format), while other states do not employ an actual flowchart, but instead use a structured text format to convey the same information.

Regardless of the location of a dam and the applicable state regulations, the important factor is that each participant's contact responsibilities, including the preferred order of contact, are clearly indicated in some manner. Typically the dam Owner or Owner's representative is responsible for contacting applicable state agencies, the County EMA/911 Center, MSHA and possibly the NWS. The County EMA/911 Center typically is responsible for contacting local EMCs, police and fire departments, EMS and ambulance services, local media, and other institutions, as appropriate. The EAP notification chart should be posted in prominent locations at the mine site for ready access during an emergency.

14.2.9 EAP Public Copies

It may be a requirement that copies of an EAP be made available to the public at locations such as state and local emergency management agency offices, public libraries, the dam owner's office or other locations with public access. These locations may be part of the specified content for the EAP. Also, local emergency response organizations are a good source of information. It is important that all versions of the EAP regardless of location or media be updated at regular intervals, as required by the appropriate regulatory agency.

14.2.10 Exercises/Training

States may or may not require that EAP exercises be performed on a regular basis or that participant training be performed. FEMA (2004b) defines five levels of exercise that may be employed to maintain an enhanced state of readiness for an actual emergency. The five exercise levels are:

1. Orientation seminar – This lowest exercise level involves bringing together the primary entities with a role or interest in the EAP (typically the dam owner and state and local emergency management agencies) to discuss the EAP. The primary purpose of an orientation seminar is for the participants to become familiar with the EAP and their roles/responsibilities. The orientation seminar may be used for planning a higher level exercise. Mine operators are encouraged to hold face-to-face meetings with local emergency management personnel to develop a working relationship so that their first contact is not during an actual emergency.
2. Drill – A drill is the lowest exercise level that involves actual exercise components. A drill typically involves in-house training for EAP participants.
3. Tabletop exercise – A tabletop exercise is typically a meeting of the dam owner and state and local emergency management officials in a conference room environment. A tabletop exercise begins with a description of a simulated event followed by discussions among participants of the EAP response procedures. Tabletop exercises are normally conducted in an informal, relaxed environment.
4. Functional exercise – A functional exercise is the highest level exercise that does not involve full activation of key plan participants or actual evacuation of downstream inhabitants. A functional exercise is intended to allow an evaluation of the ability of the dam owner and emergency management officials to perform their EAP responsibilities. A secondary objective is to improve coordination among EAP participants.
5. Full-scale exercise – A full-scale exercise involves the most realistic simulation of an actual emergency event. A full-scale exercise is intended to evaluate the operational capability of all aspects of and participants in the EAP interactively in a stressful environment with actual mobilization of personnel and resources. The participants "play out" their roles in a dynamic environment that provides the highest degree of realism possible. A full-scale exercise may involve actual evacuation of residents that would be in the downstream inundation area.

Typical state requirements are equivalent to the tabletop exercise level or lower. Exercises at any level will enhance the ability of EAP participants to perform their emergency function in the event of a dam breach.

14.2.11 Plan Maintenance

An EAP should be updated at regular intervals. Ideally, the names of key plan participants and contact information should be updated annually or as changes occur. The interval for regular updating varies from state to state, generally ranging between one and five years. EAP updates should be prepared by or have appropriate input from an engineer familiar with the impoundment and EAP preparation and should reflect any changes to the state's EAP content and format requirements since the previous submittal.

Any changes to the dam and related structures and any changes that will affect the inundation map should be identified. For mine facilities where impoundment capacity has increased as a result of disposal plan modifications and staged construction, dam breach analyses should be reviewed and updated and, if necessary, a new inundation map should be prepared. Also, if there are changes to design bases such as a state-mandated increase in the IDF, a new dam breach analysis should be performed and a new inundation map should be prepared.

The scope of work for an EAP update should include a reconnaissance of the inundation area to determine if any new facilities (e.g., mining operation, day care center, nursing home, large business) are located in the inundation area and will be significantly affected. Also new highways or streets and

changes to existing highways and streets should be noted and the appropriate changes made to the EAP. Plans for roadblocks and traffic control should be reviewed. Evacuation routes should also be reviewed to make certain that they are still appropriate.

Personnel or positions previously identified in an EAP may have changed and updates should be made as necessary. Agencies such as the Red Cross should be contacted to verify that reception and treatment center information is current. Any information provided in the EAP that is no longer applicable should be removed or an update provided.

14.2.12 EAP Appendices

Supporting documents should be provided in appendices to the EAP. Depending upon individual state requirements, these could include:

- Calculation brief for the dam breach analysis, determination of downstream inundation area, and flood wave arrival times.
- A map showing the location of the dam and highways and streets that must be traveled to reach the dam with accompanying written directions.
- An inundation map providing limits of the extent of flooding and key information such as roadblock locations, reception and treatment center locations, evacuation routes, and other important data such as flood wave travel times to critical areas.
- Tables indicating responsibility for roadblocks and/or traffic management points (e.g., state highway patrol station, local police department, local fire department) shown on the inundation map.
- Roster of participating agencies, personnel and phone numbers.
- Notification flowchart indicating each participant's responsibilities relative to contacting other participants in the EAP.
- Check-off sheets to document when persons/agencies/responders were notified relative to plan implementation.
- Announcements to be read on radio and television when the EAP is implemented.
- Public notices for posting indicating where copies of the EAP are available to the public for review.

14.3 PREPARATION FOR POTENTIAL EMERGENCY REMEDIAL ACTIONS

When an emergency situation develops at an impounding embankment/dam, implementation of appropriate remedial actions could possibly delay, moderate or even prevent the structure from failing. Potential emergency management actions and responsibilities should be delineated in the Operation and Maintenance Plan (Section 11.1.4) so that personnel qualified and responsible for implementing theses remedial actions are better equipped to assess the situation and to implement appropriate responses. Emergency situations should be evaluated at the earliest indication of a possible problem by an engineer familiar with dam safety who can recommend an appropriate course of action.

A potential failure mode analysis (PFMA), as discussed in Section 12.1.1, can help in the identification of equipment, materials and potential remedial actions needed for responding to an emergency. Potential sources of equipment and materials should be identified and documented in the Operation and Maintenance Plan. In some situations, aggregate stockpiles (excess materials for scheduled drain or filter construction) may be available on site and may be useful in an emergency. Also, sources of emergency power for lighting or equipment operation can be identified. Potential emergency remedial actions that may be appropriate for emergency situations and should potentially be included

in the Emergency Management section of the Operation and Maintenance Plan are discussed in the following subsections. The designer or other dam safety engineer should assess whether these emergency remedial actions are applicable to their site.

14.3.1 Potential Overtopping During a Storm

The following actions should be considered in the event of a severe storm where the water level in the impoundment is increasing and is approaching the crest of the embankment:

- Placing additional material along the crest to increase freeboard. This will have the effect of temporarily allowing more water to be stored and will allow more water to flow through the spillway.
- Providing erosion-resistant protection for the downstream slope by placing riprap, rockfill, or other material in erosion-prone areas.
- Terminating pumping of water or slurry into the impoundment until the emergency situation abates.
- Lowering the water level by pumping or siphoning water out of the impoundment.
- Creating additional spillway capacity by making a controlled cut or breach in a saddle area or in a low embankment section where the foundation materials are erosion resistant and adding supplemental erosion protection where needed. The potential for the cut area to rapidly erode and release the reservoir should be considered before taking this action.

14.3.2 Movement or Sliding of the Embankment

If there is movement or sliding of an impounding embankment, the following actions should be considered:

- Placing stakes or pins and recording and evaluating the amount of movement versus time. Movement of a slope will generally accelerate prior to complete failure. Other monitoring could include piezometers and seepage weirs (record and evaluate).
- Lowering the water level at a rate and to an elevation considered to be safer given the slide condition.
- Stabilizing the slide by buttressing the toe area with additional rockfill, mine waste, spoil, or soil. If the buttress material does not have characteristics that will allow it to act as a filter and drain, available sources of other materials to perform the function in combination with the buttress material, as appropriate, should be identified.
- Lowering the phreatic surface by placing impermeable material on the upstream slope.
- Restoring lost freeboard, if necessary, by placing sandbags or by filling in the top of the slide. Note that this action will further load the sliding mass if it is not offset by buttressing of the toe area.

14.3.3 Internal Erosion or Piping through the Dam, Foundation or Abutments

If seepage through a dam or its foundation or abutments is detected and is found to be increasing at a rate that could threaten the stability of the dam, the following actions should be considered:

- Moving the slurry discharge point so that fines are deposited in the reservoir near the area where the problem seepage is most likely originating. For example, there may be a whirlpool in the reservoir, or seepage may be visible at an abutment.

- Lowering the impoundment water level until the flow decreases to a non-erosive velocity or until it ceases. The water level should remain lowered until corrective action is taken.
- Plugging the reservoir side of the flow area with material (e.g., hay bales, bentonite, or other materials) if the entrance to the leak is in the reservoir basin.
- Placing a weighted filter over the exit area to hold the materials in place. Preferably, several feet of a protective sand filter should be placed. The sand layer can be weighted with additional material. If sand is not readily available, a geotextile could also be used for the filter layer.
- Isolating the area where the seepage is originating, if possible, by constructing a perimeter dike around the area.
- Monitoring seepage relative to quantity and suspended solids.

14.3.4 Excessive Seepage and a High Level of Saturation in the Embankment

If wet areas are detected on the downstream face of an embankment along with a high phreatic surface indicating a high level of saturation and reduced embankment stability, the following actions should be considered:

- Monitoring frequently for signs of slides, cracking or concentrated seepage. Recording and evaluating piezometer readings and seepage weir flow measurements.
- Relocating the slurry discharge line to the extent possible to develop a delta and push free water back away from the upstream slope of the embankment.
- Lowering the water level in the reservoir to a safer level.
- Operating at a reduced level until the situation is evaluated.
- Lowering the phreatic surface by placing impermeable material on the upstream slope.

14.3.5 Spillway Failure or Erosion that Could Cause a Dam Breach

If an impoundment spillway fails or its capacity is reduced, or if there is erosion progressing such that a dam breach could result, the following actions should be considered:

- Providing temporary protection at the point of erosion by placing sandbags, rip-rap materials, or plastic sheets anchored with sandbags.
- Lowering the water level to a safe elevation. If an outlet is not available, pumping, siphoning, or a controlled breach may be required.
- Continuing operation at a lowered water level to minimize spillway flow.

14.3.6 Excessive Settlement or Subsidence of the Embankment

If excessive settlements are observed in the embankment or actual subsidence is detected, the following actions should be considered:

- Lowering the impoundment water level until the situation can be evaluated by: (1) releasing it through the primary spillway or by pumping, (2) siphoning, or (3) a controlled breach.
- Temporarily restoring freeboard, if necessary, by placing additional material such as mine waste, spoil, sandbags, etc. along the crest.
- Watching for increased seepage and internal erosion due to cracks resulting from differential movements. If observed, the actions indicated above should be employed.

- Checking for indications of damage to the decant conduit resulting from differential movement.

14.3.7 Formation of a Sinkhole on the Crest or Face of the Dam

In the event of observation of a sinkhole at the embankment crest or on one of the faces of the dam, the following actions should be considered:

- Lowering the impoundment water level.
- Checking the area downstream of the sinkhole to identify where material is being carried out. The measures indicated in Section 14.3.3 above for stopping or reducing internal erosion should be considered.

14.3.8 Earthquake

Subsequent to the occurrence of an earthquake that could potentially have damaged site structures, the following actions should be considered for each impounding embankment:

- Conducting an overall visual inspection of the dam and monitoring instrumentation.
- If the embankment has any upstream construction, the seismic shaking may have caused high pore-water pressures in the loose fines. Embankment faces should be checked for signs of sliding, and the crest should be observed for indications of settlement.
- Evaluating instrumentation data. Piezometer readings should be taken and compared to normal readings. The situation should be monitored until elevated pore-water pressures have dissipated. The impoundment water level should be lowered, if necessary.
- If settlement has occurred, it should be determined if measures should be taken so that the design storm can still be accommodated.