

Avoiding Disaster: Assuring Warning Compliance

Abstract

Using dam failure case studies, this presentation provides guidance on what needs to be done to assure that people will respond appropriately in the event of a dam failure.

During the 1970's, several lethal dam failures occurred in the United States: Buffalo Creek Coal Waste Dam, Canyon Lake Dam, Teton Dam, Laurel Run Dam and Kelly Barnes Dam. These failures led to the realization that emergency preparedness was deficient and by the end of the decade guidelines calling for the preparation of emergency action plans and dam failure inundation maps had been developed.

The availability of emergency action plans does not guarantee that warnings will be issued. The issuance of warnings does not guarantee that people will move out of harms way. Approximately 50 reasons why people may not evacuate have been identified. These reasons are related to the warning message, people's interpretation of the message, and problems in reaching a safe destination.

Suggestions for improving emergency action planning and warning compliance will be given. These will include:

- Making better use of inundation maps and studies. We need to know more than that "low lying areas" will be flooded.
- Providing a means for people to confirm that the danger is real and that evacuation is needed. Many people will not evacuate until they receive this confirmation
- Using every available method to disseminate the warning messages.
- Improving warning message content.

The 1970's: A Decade of Lethal Dam Failures

Emergency action planning for dams started in earnest in the 1970's after a rash of particularly lethal dam failures. The table below provides summary data on U.S. dam failures including Teton Dam and all failures that caused more than 25 fatalities. In addition to the failure of Teton Dam, the largest dam that ever failed in the United States, four dam failures occurred in the 1970's with more than 25 fatalities. These failures were a wake-up-call that something needed to be done to improve the safety of the nation's dams.

U.S. Dam Failures: Teton Dam and those with more than 25 fatalities

Dam Name and Location	Failed in:	Age (Yrs)	Failure Cause	Deaths
Mill River Dam (a.k.a. Williamsburg Dam) MA	1874	9	Seepage carried away fill, then embankment sliding, and collapse of core wall	138
South Fork Dam (a.k.a. Johnstown Dam) PA	1889	36	Overtopping from flood	2,209
Walnut Grove Dam, AZ	1890	2	Overtopping from flood	70 to 100
Austin Dam, PA	1911	2	Weakness in foundation	78
Lower Otay Dam, CA	1916	19	Overtopping from flood	30
St. Francis Dam, CA	1928	2	Dam sliding	420
Buffalo Creek Coal Waste Dam, WV	1972	0	Slump of dam face during 2-year rain event	125
Canyon Lake Dam, SD	1972	39	Overtopping from flood	uncertain
Teton Dam, ID	1976	0	Piping during first filling	11
Laurel Run Dam, PA	1977	63	Overtopping from flood	40
Kelly Barnes Dam, GA	1977	78	Heavy rains saturated embankment leading to downstream slope failure	39

Emergency action plans with descriptions of the threatened area were not available for Teton Dam or for the four dam failures that caused significant life loss during the 1970's.

At Buffalo Creek Coal Waste Dam, a breakdown in communications and failure to recognize the severity of the threat contributed to the large loss of life. About 90 minutes before the failure, two Logan County sheriff deputies met with a Buffalo Mining Company foreman in a community about 3 miles downstream from the dam and were told by the foreman, "We've ditched that thing up there, and you boys can go home" (Charleston Gazette, April 27, 1972). While informal warnings were issued to some people hours before the failure, there was no concerted effort to issue dam failure warnings in all impacted communities before dam failure.

Canyon Lake Dam is located on the western edge of Rapid City, South Dakota. The 10 p.m. television news wrap-up from a Rapid City station indicated that the seriousness of the flood was not realized at that time. At 10:30 p.m., in a simultaneous TV and radio broadcast, the Rapid City mayor urged people in "low lying" areas to evacuate. No mention was made of potential dam failure. Canyon Lake Dam failed sometime between 10:45 p.m. and 11:30 p.m. There were 165 fatalities on Rapid Creek downstream from Canyon Lake Dam. Many people would have died even if the dam had not failed.

An emergency action plan and dam failure inundation map were not available for Teton Dam when it failed at about noon on a bright and sunny spring day during its initial filling. Between 10:30 a.m. and 10:45 a.m. Reclamation's Project Construction Engineer

notified sheriff's offices in the two nearest downstream counties advising them to alert citizens of potential flooding and to be prepared to evacuate the area downstream from the dam. The owner of a Rexburg commercial radio station was notified by the sheriff's office and then traveled by vehicle to the dam. He began broadcasting live at about 11:35 a.m. from a site overlooking the dam and soon saw the whole downstream face of the north side of the dam crumble. He began broadcasting continually from that point on – **“People downstream, evacuate quickly! Hurry! Hurry!”** The flood resulted in the inundation of 185 square miles, destroyed 771 homes and damaged 3,002 others. The loss of life was low due to the timely warning that was issued by the radio broadcaster and public safety officials, daylight, clear weather, and the sparsely populated dam failure flood path for several miles downstream from the dam.

Laurel Run Dam failed at about 2:35 a.m. from overtopping caused by a flash flood. The National Weather Service did not issue any flash flood watches or warnings until 2:40 a.m. No one was at the dam to monitor its condition and no formal or informal warnings were issued to people at risk.

Kelly Barnes Dam failed at about 1:30 a.m. Two volunteer firemen examined the dam shortly after midnight and did not see anything amiss. Continuing rain prompted the firemen to warn some residents below the dam of potential trouble. Dam failure warnings were not issued.

Changes in Practice

The dam failures in the 1970's resulted in the recognition that improvement was needed in plans and procedures used to warn people in the event of a dam failure.

In 1970, the United States Committee on Large Dams published a Model Law for State Supervision of Safety of Dams and Reservoirs. The model law suggested that the state agency responsible for dam safety “shall be responsible for determining that an emergency exists and warning the public through normal disaster communication channels.”

In June 1977 the General Accounting Office (GAO), after reviewing procedures and practices used by the Bureau of Reclamation in constructing Teton Dam, prepared a report listing actions needed to increase the safety of dams built by the Bureau of Reclamation and the Corps of Engineers. The report noted that there were no effective means to alert people in the canyon downstream from the dam. The report also stated that a sheriff in one of the impacted counties did not immediately notify residents after receiving a call from the Project Construction Engineer at Teton Dam because he did not understand that the situation was urgent. The report recommended that the Corps of Engineers and Bureau of Reclamation revise guidelines and procedures to establish a stronger emergency preparedness program. The report also recommended that emergency preparedness plans be prepared. The plans should:

- Be developed and discussed with local community leaders

- Include a definition of emergency situations requiring notification of community officials
- Include names and phone numbers of project and community officials
- Include maps showing areas that would be flooded by dam failure.

The Federal Guidelines for Dam Safety, originally issued in June 1979 and reprinted in April 2004 as FEMA 93, suggested that an emergency action plan (EAP) be formulated for each federal dam. “Emergency Action Planning Guidelines for Dams,” FEMA 64, was issued in February 1985. “Emergency Action Planning for Dam Owners, also tagged as FEMA 64, was issued in October 1998 and reprinted in April 2004. FEMA 64 provides the 6 basic elements of an EAP:

- Notification flowchart – Who is to be notified, by whom, and when
- Emergency detection, evaluation, and classification – To timely classify an emergency
- Responsibilities – Defines what is done by dam owner and state/local emergency management officials
- Preparedness – Actions to take before an emergency
- Inundation maps – To facilitate notification and evacuation of impacted areas
- Appendices

Status of Emergency Action Plans

While most Federally owned or regulated high-hazard potential dams have EAP’s, approximately 40 percent of the Nation’s state-regulated high-hazard potential dams did not have an EAP as of October 2006 (FEMA 608).

Bad Things Can Happen Even with EAP’s

Emergency action plans do not guarantee that warnings will be issued and warnings do not guarantee that people will move out of harms way.

An EAP was available for Taum Sauk Dam when it failed during pre-dawn hours on December 14, 2005. Before the EAP was implemented, and before any dam failure warnings were issued, the flood destroyed a house occupied by a family of five and swept the occupants into the frigid water. Through luck and good fortune, all survived although one of the three children was hospitalized for 2 weeks while recuperating from burns caused by warming packs used by rescue workers.

The vulnerability of New Orleans to massive destruction during a direct hit from a large hurricane had been well publicized in the local and national media. Thirteen months before Hurricane Katrina caused massive property damage and loss of life in the New Orleans area, emergency officials from 50 parish, state, federal, and volunteer organizations participated in a five-day “Hurricane Pam” planning exercise. The exercise helped officials develop joint response plans for a catastrophic hurricane in Louisiana.

New Orleans Mayor Ray Nagin called for the first ever mandatory evacuation of New Orleans at about 9:30 a.m. on Sunday, August 28, 2005 as Hurricane Katrina approached the city. The hurricane eye passed over the Gulf shoreline, 70 miles from New Orleans, at about 6:30 a.m. on Monday and flooding quickly ensued. Approximately 20 percent of New Orleans residents did not evacuate prior to the flooding with some remaining in their homes and others relocating to shelters of last resort such as the Superdome. The Louisiana Katrina death toll, including storm related out-of-state deaths was 1,577 in May 2006.

Approximately 6,000 people died when a hurricane devastated Galveston Island, Texas in 1900. With that history and the vulnerability of a barrier island, you would think people would be ready to evacuate as a major hurricane approaches – not so. As Hurricane Ike approached the island, Galveston Mayor Lyda Ann Thomas called for a mandatory evacuation on Thursday, September 11, 2008. That evening, the National Weather Service issued a very strong warning stating, “Persons not heeding evacuation orders in single family one or two story homes will face certain death.” Despite the strong warning and mandatory evacuation, 40 percent of residents decided not to evacuate. Why did so many people risk their lives by not heeding the warning and order to evacuate?

Reasons Why People Don’t Evacuate During an Impending Disaster

An evacuation during an impending disaster can range from moving to an upper story of a multiple story building for a few hours, to walking a few hundred feet away from a creek and staying there for an hour or so, to traveling tens of miles to reach a safe area and then remaining there for several days. While it may be physically and emotionally easy to move a few hundred feet out of harms way, it may be much more difficult if the threat requires an evacuation of many miles and/or many days.

The reasons why people may not evacuate, or delay the initial departure or mobilization, are generally related to the warning message, people’s experience with previous events, their general beliefs or situational handicaps, and the logistics of traveling to a safe area. Reasons why people may not evacuate include the following:

Evacuation Response Influenced by the Warnings Issued:

- Warning and dam surveillance monitoring systems malfunction (or not exist).
- Emergency Action Plans (EAP’s) do not exist or are poorly executed.
- No warning is issued.
- Warning is issued but the message is poorly worded, i.e., the message is not specific, consistent, accurate, certain and clear, as to the location of the risk areas, what the public should do, character of the hazard and time till impact.
- Warnings were not issued repeatedly or using every available means.
- Warning is issued in a language not understood by some people at risk.
- Warning is issued using jargon or technical terms not understood by some people at risk.
- Warning is issued but doesn’t reach all at-risk areas.

- Remote areas may not have cell phone or adequate radio/television coverage.
- Warning is issued but doesn't reach the hearing impaired or people who are socially isolated from other people.
- Warning is issued but did not mention or order that evacuation take place.
- Warning is issued but evacuation is "recommended" rather than "mandatory."
- Warning is issued but other warnings or information provide conflicting information regarding the need to evacuate.

Evacuation Response Influenced by the Interpretation of the Warning Message or the Personal Characteristics and Beliefs of those Receiving the Warning:

- Environmental cues (or lack of) cast doubt on the validity of the warning message.
- Neighbors were not evacuating.
- Similar warnings had been issued in the past and nothing bad happened.
- Remained in harms way in earlier storms without any problems.
- Evacuated in the past, nothing bad happened, don't want to repeat mistake.
- Watching television reporters broadcasting live from at-risk areas make people think, "If they can be there, why not me?"
- Warning is heard but is believed to be an exaggeration or not true.
- Warning is heard but is believed that the danger is not as bad as the warnings imply.
- Warning is not heard because people are asleep.
- Warning is received but falls on non-attentive ears.
- A belief that the warning is directed to other areas, "It can't happen to me!"
- Perceive that no real danger exists.
- The belief that they are safer in their home than elsewhere.
- Carry an anti-authority attitude, "No one tells me what to do."
- Don't want to disrupt every-day life and uproot family unnecessarily.
- Need to get all family members together before evacuating.
- Need to pack up and transport personal papers and possessions, causing delay in departing.
- Expect others to provide for their care and well-being.
- People are handicapped or physically disabled.
- Stubborn.
- Obstinate.
- Have pets and they aren't allowed at destination lodging or shelter.
- Need to care for pets.
- Livestock need care and attention.
- Fear of looters.
- Need to remain at house or business to protect it from environmental threat.
- Couldn't leave job.
- Don't want to leave everything familiar.
- Just don't want to leave.
- Don't want to leave a place with deep emotional attachment.

- Home or apartment is seen as safe, secure and comfortable.
- “Elderly Syndrome,” i.e., feel safest or most comfortable in own home.
- Don’t want to leave comfort of vehicle or home.
- Fatalistic – need to take part in the hurricane or other disaster party.

Evacuation Response Influenced by the Difficulty or Inconvenience of Reaching a Safe Destination:

- The safe area is unpleasant (hillside on a dark, stormy and rainy night; or the floor of a school gymnasium).
- Believe that evacuation process may be dangerous.
- No where to go – no friends or relatives in destination area (this may be especially true for long-distance evacuations associated with hurricane evacuation).
- Didn’t have financial means to go – no automobile and/or money for gas, food and lodging.
- Don’t own a vehicle and alternate transportation not available or sought out.
- Escape roads, routes and avenues do not have the capacity to convey the number of evacuees in the time available before onset.
- Tried to evacuate, got stuck in traffic, returned home.
- Major traffic problems or a chaotic evacuation are anticipated so no attempt is made to evacuate.
- Evacuation routes unavailable at threat onset (World Trade Center stairways above impact level and a flooded Johnstown prior to South Fork Dam failure).
- Waited too long (perhaps packing possessions or making residence storm ready) and then evacuation routes were cut off.
- Evacuated and then returned to retrieve pets or other possessions.

Even when a warning message is understood to be valid and is socially confirmed, there may still be a reluctance to leave. Given a choice, people would prefer to stay put rather than to evacuate. Individuals under stress typically attempt to consider the least disruptive option in the stressful situation. Some protective action other than evacuation is likely if there is only moderate rather than strong belief in the threat. Even when people feel endangered, they try to maintain their normal routines. Leaving a residence or other familiar place, in the face of danger, is not an everyday occurrence. (Quarantelli, 1990: 7)

Enhancing Warning and Evacuation Effectiveness

There is a common feature in the U.S. dam failures that caused large numbers of fatalities – either no warning was issued prior to dam failure or strong and forceful warnings were not widely and repeatedly issued to those at risk.

Issue Dam Failure Warnings!

An integral step in minimizing loss of life from future dam failures is to issue warnings before dam failure. Warnings must be issued before dam failure to assure that people in close proximity to the dam have sufficient time to get out of harm’s way. To assure that warnings are issued the following is needed:

- Dam monitoring, on-site surveillance, and instrumentation
- Functional emergency action plans and notification plans
- Dam officials having the **authority and courage** to notify downstream emergency management organizations of the need to evacuate
- Dam officials having the **courage** to issue strong, urgent and accurate accounts of the danger posed by dam failure when such messages are appropriate. The tone and content of the message originating from dam officials sets the tone for the urgency (or lack of) evacuating people occupying the dam failure flood path.

Dam owners are handicapped in issuing warning and evacuation messages to the public because this responsibility rests with local and state public safety officials. Information regarding the dam's condition, however, starts with the dam owner. When truly catastrophic flooding is about to occur, it is imperative that the dam owner not mince words, but instead convey information and messages that create a perception of the threat as being certain to occur and having severe consequences for those at risk. The media and public safety officials are likely to pass the tone and content of the message on to those at risk.

It appears that accurate and forceful warnings would be issued when dam owner representatives, public safety officials and broadcast media are in view of the dam site so that they can observe the situation first hand. As the condition of Teton Dam rapidly deteriorated on the morning of June 5, 1976, on-site Reclamation personnel contacted local law enforcement officials. The best warnings originated from a commercial radio station owner broadcasting live from the dam and county officials who had the opportunity to fly in a fixed wing plane observing the approaching dam failure flood wave.

“Seeing is Believing” leads to “Let’s Get Out of Here!”

There is a saying, “A picture is worth a thousand words.” I’ll create my own saying, “Seeing something live is worth a thousand pictures.” People spend lots of money, time and effort to attend live sporting events or concerts when much of what is seen or heard is available, at minimal cost, on television or digital media.

This desire to see something with your own eyes, in person, manifested itself during the Teton Dam failure. In the aftermath of the failure of Teton Dam failure, various groups and organizations obtained oral history interviews of people impacted in some way by the dam failure. Literally hundreds of transcripts were prepared, some are on the web and some are in libraries in Idaho. Valuable information can be extracted from this rich data base.

A theme that arises from these first-hand accounts is that people are hesitant to take action before they can “see something with their own eyes.” As Teton Dam deteriorated

on Saturday morning, Reclamation staff traveled to the dam, partly to see what was happening. Later in the morning, Don Ellis, owner of a Rexburg radio station learned about the possible failure from the Madison County sheriff's office and thought, "Well, maybe I'd better go up and see what was going on." He traveled to the dam, observed it crumbling, and broadcast excellent life-saving warnings/messages from a promontory overlooking the dam. (He received a recognition plaque from Idaho Governor Andrus recognizing him for his work in warning people). After the dam failed, Madison County emergency management officials from Rexburg flew in a small private plane from the Rexburg airport toward the advancing floodwater because as the Civil Defense Director stated, "We wanted to see what we actually had, we needed that type of information." A resident near the mouth of Teton Canyon, about 5 miles downstream from the dam, upon hearing about the failure stated, "I made a suggestion that we get in our pickup and go on up and see what was going on." These types of reactions in response to the initial Teton Dam information received were repeated throughout the day. Many people threatened by the Teton Dam failure were warned several times. Many evacuated from harm's way only upon seeing the approaching flood water "with their own eyes."

Earlier, I listed more than 50 reasons why people don't evacuate during an impending disaster. Combined, these reasons act as a giant anchor, keeping some people from taking any life-saving action. Perhaps, if we are able to help feed the human appetite of seeing something live and in-person, we will have more positive outcomes from future dam failures. Procedures and actions that might achieve this would include: 1) Having dam owner representatives, public safety officials, and the news media convene at the dam in a location that would not be impacted by dam failure. This allows representatives from these organizations to "see with their own eyes" and eliminates any time delay associated with confirming the danger. 2) If safe, get public safety officials and news media in helicopters or airplanes to observe flooding and to embellish warning and evacuation efforts. 3) Welcome news media to the site or to the skyways above the site; have public affairs people feed them information, and encourage live broadcasts. These live broadcasts may serve as a surrogate to people "seeing something live and in person." Images shown on television of water surging out of a dam would likely provide clear and undisputable evidence that the danger is real and evacuation is necessary.

Dam Failure Warning Message Content and Delivery

Dam owners, responsible for the losses caused by dam failure, have a very real interest in how warning messages are delivered to people at risk. If the warning is deficient in any way, and the flooding caused by dam failure is catastrophic, additional people will perish. Dam owners hope that public safety officials orchestrate a perfect warning and evacuation.

Dam failure warning messages should be:

- Labeled as coming from a panel of officials, scientists and experts
- Clear regarding message content
- Consistent in message content

- Certain that the event will occur (or is occurring) and is not a rumor
- Precise in message content
 - Provide the location of areas that will be flooded
 - Provide information on when communities will be impacted
 - Provide information on flood magnitude such as flood depths or a comparison to previous floods
 - Provide a description of the likely flood impact - if the flood is going to be 40 feet deep and sweep all houses away in a certain area: **Include it in your message!**
 - Provide guidance on protective action to take (what should people do?)
 - State that the flooding is from dam failure (if true)

Dam failure inundation maps are commonly included in an Emergency Action Plan. The maps, however, do not always provide sufficient information to develop the content for the message described above. It may be advisable for people preparing dam failure inundation maps and studies to develop a description of the flooding (and impacts) that would result from failure. These dam failure modeling specialists may be in a better technical position to do this than the downstream community officials who may have little or no knowledge on how to interpret a dam failure inundation map. Messages that say “low lying areas” or “areas near the creek” need to evacuate would likely be deficient and not result in favorable outcomes.

To provide greater assurance that people will evacuate, strong, urgent and forceful warnings need to be issued using every means or technology available. This would include:

- National Weather Service
- Television, both local channels and cable
 - Discontinue routine broadcasting, otherwise people will discount the urgency of the situation
- Radio, both AM and FM stations
 - Discontinue routine broadcasting
- Internet
- Sirens, both tone and preferably voice
- Police
- Fire personnel
- Reverse 911 (community notification system) with voice messages to landline phones
- Reverse 911 (community notification system) with voice and text messages to cell phones
- Technology of the day

People potentially threatened will receive messages from the above sources and then discuss the need to evacuate with family members, friends, neighbors or relatives (who likely also received information from one or more of the warning technologies described above. It is important to continually repeat the warnings because very few people will

respond/evacuate based on the first message received. For many, seeing the approaching floodwater is the key piece of information that prompts protection action being taken.

Conclusion

The single most important factor that influences public response to warnings is confirming risk information through interacting with others and searching for additional confirmatory information (Mileti, 1995). People will adjust the rapidity of their evacuation behavior based on the severity and timing of the impending threat (Sorensen and Mileti, 1988). Let's do our best in future dam failures to assure that dam failure messages are timely and incessantly repeated and that we attempt to let people "see with their own eyes" using the best technologies available at the time. With the most destructive dam failure floods, let's make sure that people Get out, Get OUT, GET OUT of harms way!

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