

3. UNCERTAINTIES IN EVACUATION DECISIONS

In this section we review the various uncertainties that can affect evacuation decision making. This is done from both a general perspective and an event-specific perspective. This provides information on how evacuation decisions are made, the problems that exist in making such decisions, and how "poor" decisions can be and have been reached. Prior to the review, methods of collecting and organizing data are discussed.

3.1 METHODS

Using the four-category scheme of uncertainties presented in the introduction, we hypothesized 21 specific uncertainties thought to operate in evacuation decision making. We then identified the available reports and studies on evacuation. Table 2 lists these evacuations used to construct the data base and the reference numbers for the associated literature. We analyzed the content of these reports using the matrix in Appendix A. These data were reviewed and all cases of uncertainty were identified and each coded as to which category it represented, who experienced the uncertainty, and which stage of the decision was affected. A summary of the data included in this review is given in Appendix B.

After reviewing the data, we collapsed the original 21 categories into 19. These are presented in Table 3 along with a summary of the number of observations in each category.

Table 2. Evacuation included in the review

Hazard	Location	Event reference*
Dam failure	Baldwin Hill, CA	1
Flood	Rio Grande River	2
Dam failure	Port Jarvis, NY	3
Flood	Denver, CO	4, 5
Dam failure	Buffalo Creek, WV	6
Dam failure	Lawn Lake, CO	7
Flood	Big Thompson Canyon, CO	8
Flood	Louisville, KY	9
Flood	Washington State	11, 12
Flood	Tucson, AZ	14
Flood	Johnstown, PA	16
Tornado	Topeka, KS	17
Tornado	Worcester, MA	18
Tornado	Red River, AR	19
Volcano	Mt. St. Helens, WA	20, 21, 22, 24
Volcano	Kilauea, HI	23
Tsunami	Crescent City, CA	25
Tsunami	Hilo, HI	26
Nuclear accident	Three Mile Island, PA	27
Hurricane (Iwa)	Oahu, HI	28
Hurricane (Carla)	Gulf Coast	29, 30
Hurricane (Alicia)	Texas	31
Hurricane/flood	Gulf Coast and Eastern US	32
Chemical spill	Mississauga, Canada	33, 34, 35, 36
Chemical spill	Not available	34
Chemical fire	Taft, LA	37
Mud slide	Port Alice, Canada	38
Firework explosion	Houston, TX	41
Tsunami	Alaska	42
Hurricane	Gulf Coast, Eastern US	43
Tsunami	Crescent City, CA	44
Hurricane	Gulf Coast	46
Nuclear accident	Three Mile Island, PA	47
Hurricane	Coastal US	48
Flood	Big Thompson, CO	49
Hurricane	Coastal US	50
Hurricane	Texas	52
Various	Not specific	54
Hurricane	Gulf	55

*See Appendix B.

Table 3. Evacuation uncertainties

	Number of times uncertainties documented
<u>Interpretation</u>	
Recognition of event	21
Recognition of consequences/likelihood	16
Definition of magnitude	12
Self-definition of role	3
Recognition of relevant information	4
Definition of authority	13
<u>Communications</u>	
Who to notify	2
Ability to describe hazard	12
Physical ability to communicate	35
Conflicting information	10
<u>Perceived impacts of decision</u>	
Causing panic looting or other adverse responses	10
Loss of job/other personal consequences	4
Cost of evacuation or economic loss	5
Liability	4
<u>Exogenous factors</u>	
Time availability	9
Feasibility of evacuation	4
Prior experience	9
Planning	5
Outside pressures/expectations	7

Caution should be used in interpreting this data. First, it must be recognized that the studies and reports examined have not systematically sought to research or report on uncertainties. Thus, the lack of a documented case does not prove a particular uncertainty did not exist, nor that it has not affected decisions. Rather, it means only that it has not been recorded in this historical record. Second, the frequency of an observation does not reflect the magnitude of the uncertainty. On one hand it may mean that it occurs more frequently. On the other, it may mean it is simply more easily observed.

In the following sections, we review each uncertainty in the four major categories and discuss an example of each.

3.2 INTERPRETATION OF HAZARD, INFORMATION AND ROLES

The degree to which information about an impending hazardous event successfully works its way through from event detection to a prudent public evacuation decision is subject to the range of interpretations that the people who process that information make as they receive the information, interpret it, and pass it along to others. These interpretations, which are relevant to more than just how hazard information is interpreted, can facilitate the evacuation process if they are made soundly; or they can raise uncertainties in the system and give rise to bad decisions. In this section, we discuss interpretation uncertainties listed in Table 3.

3.2.1 Recognition of Event

The ability to recognize the presence of an impending hazardous event is determined by the degree to which people can observe an indicator associated with a potential threat and conclude from it that a threat exists. For example, observation of a particular cloud formation may mean rain for some, tornado threat to a few, and merely indicate a cloudy day to others. Variation exists in the ability of people to recognize a potential threat, and this variation exists among those who are "trained observers" as well as among general members of the public as well. Variation in the ability of people to recognize an impending hazardous event has constrained some evacuations in the past by consuming time thereby reducing the time available to the public in which to respond.

For example, in several recent dam failures, the private company responsible for managing the reservoir failed to understand that the dams were unsafe. Furthermore, when the dams were about to fail after periods of heavy flooding, the inability to link runoff conditions with dam failure precluded an early warning. This was characteristic of both the Buffalo Creek flood¹ and the Lawn Lake Dam disaster.²

3.2.2 Recognition of Hazard

Variation in ability to define the level of threat, once the event has been recognized, is a second uncertainty which has constrained effective and timely hazard recognition. Once the physical properties of an impending event are recognized -- for example, that a flood will occur or

a hurricane will strike -- uncertainties can exist in reference to what that event will mean for the people that will be affected. For example, an impending flood could affect a large part of town or only a small segment of town; or a hurricane could produce hazardous winds for 30 miles inland or only 3 miles. Uncertainty in the ability of people to recognize the extent of a public hazard associated with a recognized impending hazardous event has been the cause of over- and under-estimating the seriousness of impending emergencies. This uncertainty has led, in some cases, to less effective and poorly timed evacuation decisions.

Although the evacuation of 225,000 people in Mississauga, Canada, following a train derailment was effective, it was initially hampered by the inability to define the potentially hazardous materials on the train. At first, the manifest could not be located by local officials and when it was, it was unclear whether or not it was accurate.³

3.2.3 Definition of Magnitude

It is often difficult to forecast accurately the precise magnitude of hazard of an impending threatening event. For example, the precise windspeed of hurricanes when landfall occurs is difficult to foretell. Consequently, the inexactness of the sciences which seek to predict magnitude create uncertainty, on occasion, in terms of the advisability of evacuation. There are magnitudes of event for which evacuation is advisable, and others for which it is not.

Instances in which the magnitude of an impending event does not clearly indicate a need for evacuation create uncertainty and can lead to what appears to be wrong evacuation decisions in hindsight after the hazard impacts the area at risk. At the same time, this problem can also delay evacuations. The Rapid City flood,⁴ for example, is a case in point. Heavy rains and rising water levels in the creek were both detected. However, the magnitude of the flood event was not accurately foreseen: the significant losses were associated with the breaking of a natural canyon dam not known to those estimating magnitude.

3.2.4 Self-definition of Role

People have sometimes experienced uncertainty in understanding, knowing, and effectively assuming the roles and obligations of participating in the communication process. This uncertainty has affected both those who initiate communication and those who receive it. People uncertain about their communication role do not always perform it. Consequently, role uncertainty by those who play key parts in the chain of communication in a warning system has slowed the evacuation by not conveying risk in a timely manner.

For example, the mining company responsible for creating the slag-heap reservoir on Buffalo Creek did not define their role as one of emergency responder. As a result, when the dam failed, no timely alert was given to public officials who could issue evacuation orders.¹

3.2.5 Sorting of Relevant Information

Sorting of relevant information occurs when there is either too much or irrelevant information facing the decision-maker. It is then necessary to determine which pieces of information should be used to make a decision, and which should be ignored. For example, a local sheriff who must decide whether to activate an evacuation alarm system in the vicinity of a nuclear power plant might be given recommendations from three different organizations, and in addition he is given meteorological data, information on plant conditions, source terms, projected dose rates, etc. The sheriff may well be overwhelmed by the information. Some information may be excluded and the decision made on the basis of only part of the information. Another possibility is that the information is ignored and the decision is made on the basis of some exogenous factor. This uncertainty in how information is sorted may be reflected in the quality of the evacuation decision.

For example, when Mt. St. Helens became active, emergency response organizations were given "raw" data on seismicity and plume activity. In the course of trying to understand and use this data, they tended to neglect some responsibilities such as providing warnings to the public.⁵

3.2.6 Definition of Authority

Definition of authority is how various actors perceive the responsibility and power of other actors to make decisions. These definitions create uncertainties in several ways. First, if more than one person or

agency assumes a leadership role, conflicts could occur. Second, if definitions of authority are wrongly perceived, information may not reach the right people. Third, if no one takes charge because they perceive it as someone else's responsibility, decisions could be delayed or overlooked.

This was problematic among agencies and with private corporations preceding the large eruption at Mt. St. Helens.⁵ In this situation, disagreement over evacuation authority arose between the U.S. Forest Service and a lumbering company. The Forest Service wanted to evacuate lands that were being harvested. The conflict led to a series of revisions in evacuation policies with compromises on both sides. Fortunately the eruption occurred on a Sunday when no logging was taking place.

3.3 COMMUNICATION PROBLEMS

Public evacuation advisements are usually the result of long chains of communication between different people, with varied jobs and roles, in different organizations. Consequently, a key to understanding the evacuation decision-making process is to view it as a series of communications between both people and organizations. This process of communication, involving people and organizations and ultimately the public, has been a general category of uncertainties that have surfaced in past evacuations to constrain the evacuation process. These uncertainties fall into four categories, and a description of each follows.

3.3.1 Who to Notify

Uncertainty over whom to communicate hazard information, either in reference to other organizations or the identification of particular persons in other organizations, has constrained the communication process in some past evacuations and, subsequently, delayed public evacuations. Sound hazard recognition and accurate determination of threat can be less than fully useful when that information is not communicated to all those who could carry that information through to other organizations and then the public. The dissemination of threat information to communities about to experience a potential disaster can be constrained if those who possess the threat information do not know what local agencies and which people within them to notify about the threat. For example, at Mt. St. Helens, the dissemination of a warning concerning ashfall levels and consequences has been attributed to the lack of pre-disaster interactions between state and local emergency organizations and the knowledge of whom to tell when the volcano erupted.

3.3.2 Ability to Describe Hazard

Those engaged in the provision of hazard information to others have created uncertainties because of how threat descriptions were worded. Non-scientists, for example, rarely share a common understanding of probabilities; vagueness in the specification of the area-at-risk can lead to increased uncertainties for those confused over which people to warn; and technical descriptions of physical processes associated with a hazard

may mean little to those interested in only simple definitions. The inability of some scientists and technicians to describe hazard in clear and simple ways has, sometimes, created uncertainties for those who must use that information to make decisions about public response and give public warnings. It has also created uncertainties in the sequential process of communication leading up to evacuation advisements.

For example at an explosion at a chemical plant in Taft, Louisiana, the evacuation of the surrounding population was delayed by an inability to communicate information about the explosion and potential consequences.⁶ Company officials did not explain the accident in terms that local officials could readily use in making their decisions. Even when they recommended a five-mile evacuation, local officials did not understand why it should be that distance.

3.3.3 Physical Ability to Communicate

The physical ability to communicate notifications, alerts and warnings has been a source of uncertainty in some prior evacuations. Loss of the technical capacity to communicate can retard communications to both the public and to other organizations. Some reasons include, for example, the non-match of radio frequencies, the lack of dedicated phone lines when regular lines are overloaded, and the lack of back-up communications systems when planned or routine systems fail. A good example of a physical communication failure is provided by the 1977 Johnstown flood. The loss of the phone system hampered efforts of the Corps of

Engineers weather observer to determine rainfall and also for the NWS to subsequently alert local officials.⁷

3.3.4 Conflicting Information

Conflicting information is the presence of either data or recommendations which lead to different conclusions about whether to evacuate. In this situation, the decision-maker must decide which information is valid. For example, if a local official in charge of evacuation receives information from one source that a dam has overtopped and from another that it is sound, a decision to evacuate may be confused or delayed. If the erroneous information is acted upon, a bad decision may result.

This type of situation was encountered in the 1983 Hurricane Alicia. Local officials relied on official forecast information from the National Hurricane Center (NHC) and the Galveston National Weather Service Office. The local weather service was warning officials that the hurricane could take a northerly turn and hit Galveston. The NHC was concentrating on warning of a more southerly landfall. Galveston officials played down the potential of being affected and when the storm turned, it was too late to evacuate.⁹

3.4 PERCEIVED IMPACTS OF DECISIONS

Uncertainties also exist in the evacuation process because of a range of perceptions that people in decision-making roles hold regarding the potential negative impacts of making wrong decisions. Some of these

perceived impacts have no basis in reality and are part of a general myth-structure about public emergency response. Other perceived negative impacts are potentially real. Four types of impact perceptions were identified, and these follow.

3.4.1 Perceptions of Panic and Looting or Other Adverse Consequences

Evacuation decisions can be influenced by a decision-maker's perception of adverse public consequences of ordering an evacuation. Typical concerns may be that people will panic and be hurt or killed, or that homes will be looted while residents are away. While these situations may arise in some very rare circumstances, such beliefs are largely unfounded given previous experiences. Despite elaborate research evidence to the contrary, these beliefs still persist. In addition, decision-makers may also believe that a false warning may hinder future evacuation needs (the cry-wolf syndrome). There is, again, little research evidence that this is the case.

For example in Hurricane Carla, it was documented that the state government decided against a general evacuation order for fear of panic and unnecessary movement. Instead they let local governments make decisions.⁹ In Hurricane Alicia several local governments, having evacuated unnecessarily for Hurricane Allen, decided not to evacuate for fear of being wrong again.⁸

3.4.2 Personal Consequences

Uncertainty has led to apprehensiveness in communicating and notifying other organizations and the public about an impending threat; often this results in downplaying the potential threat when it is communicated. Persons have feared personal negative consequences of transmitting risk information that may befall themselves with the non-occurrence of the hazard. Concern over personal consequences has centered on loss of reputation or image, loss of votes in a future election, and the like. For example, in a 1965 tsunami threat situation in Crescent City, California, local officials feared public sanctions if they called for another evacuation and no tsunami occurred.¹⁰

3.4.3 Perceptions of Cost or Losses from the Evacuation

Evacuation decision-makers can be influenced by their perceptions of the dollars costs or losses that may stem from an evacuation, particularly when it is precautionary. Cost may include transportation and sheltering of the public, as well as costs borne for emergency personnel. Losses can include revenues lost from employment or sales, or damages incurred from injury during evacuation, or the shutdown of productive sectors in an economy. A city, for example, which has exhausted its emergency funds for police overtime, may be reluctant to order an evacuation for which it cannot easily pay. For example, perceived economic losses played a significant role in determining evacuation zones at Mt. St. Helens. Evacuation boundaries were shifted in order to split

cost of manning roadblocks between two counties and to allow access to economic enterprises in the area.⁵

3.4.4 Perceptions of Liability

How agencies or actors within them define liability questions can also influence evacuation decisions. This can occur in several ways. First, and most likely, liability for public safety is a frequently raised issue for public agencies. The major concern is over responsibility for damages if a hazard occurs and actions are not taken to protect the public. This perception tends to cause officials to err on the side of caution in some situations. On the other hand, decision-makers may perceive liability for ordering an unneeded evacuation which leads to unnecessary costs and possible evacuation-associated damages.

Although the issue of liability as an influence on decision making is noted theoretically and is discussed in pre-emergency planning, it does not appear to be a major influence on actual decision making based on the data reviewed in this investigation.

3.5 EXOGENOUS INFLUENCES ON THE DECISION

Other uncertainties have surfaced to constrain good evacuation decisions and outcomes that are somewhat outside the domain of the evacuation decision-making process. These sources of uncertainty, here labeled as exogenous influences, are discussed in the sections which follow.

3.5.1 Time Availability

Time availability refers to the length of time between the detection of a hazard and the manifestation of impacts or effects. Judgments that a lengthy time exists may delay decisions. Judgments of short time may rush decisions. Furthermore, short response times may influence decisions to not evacuate for fear of people being exposed to damage while they are engaged in evacuating. Concern over adequate lead time to conduct an evacuation may lead to decisions to evacuate before sufficient information about the hazard may be collected. An example is a decision to evacuate a beach community or barrier island before the path or magnitude of a hurricane is known.

Such was the case in 1980 when Hurricane Allen threatened the Texas shoreline. Decisions to evacuate had to be made while the path was still subject to a wide prediction error. As a result, the NWS advised the evacuation of Galveston, only to have the storm veer to the south.

3.5.2 Evacuation Feasibility

Evacuation feasibility refers to the perceived success of an evacuation in protecting the public. Feasibility perceptions can be influenced by factors such as the severity of the hazard, geography, safety of evacuation routes and so forth. Misperceptions of feasibility could lead to poor decisions concerning evacuation or influence the timing of evacuation decisions. For example, the fear of a radioactive release during a fast-moving accident at a nuclear plant, in conjunction

with poor weather, could lead to an evacuation decision prior to development of plant conditions that would normally suggest that an evacuation is in order.

3.5.3. Experience

Prior experiences with other evacuations and emergencies can influence decision-maker judgments and raise uncertainties in the evacuation decision-making process. Occasionally, people can imagine that impending hazardous event will materialize in a way much like those which have already been experienced, even though this image may be inconsistent with current information about the impending event. On the other hand, the lack of experience with a particular hazard can, for some, raise uncertainty in imagining what an impending event may be like. Experience, and the uncertainties it can raise, can lead to either premature or tardy communications and evacuations.

This accident situation was experienced at Crescent City, California, during 1964. The warning of a potential tsunami which proved to be a false alarm played a role in delaying law enforcement officers' decisions to evacuate people in a subsequent warning situation.¹⁰

3.5.4 Prior Planning

The presence, absence or extent of in-place evacuation plans can greatly influence evacuation decisions. Experience shows that the lack of a plan can delay or confuse decisions to evacuate. Theoretically,

possession of an evacuation plan could increase the likelihood of having an evacuation merely because it has been planned for. Additionally, emergency plans which are too rigid and too inflexible can themselves frustrate timely emergency response and, subsequently, evacuations.

An example of the former is the accident at TMI. The lack of a plan definitely contributed to confusion over evacuation decisions.¹¹ Likewise, the absence of plans for special facilities like hospitals in the vicinity of TMI may have contributed to decisions to allow hospital employees to evacuate without consideration of the consequences.

3.5.5 Outside Pressures or Expectations

Evacuation decisions can be influenced by expectation or demands of persons outside the evacuation-decision environment. For example, a public official may perceive that, given a certain situation, an evacuation is expected by the public. In addition, a decision-maker may feel pressure from another level of government or some other agency when deciding whether or not to conduct an evacuation. At times the pressure may be counterproductive when the responsible official overacts to the pressure and follows the opposite course of action.

At TMI, the Governor's decision to recommend a selective evacuation was, in part, a response to outside demands and pressures to demonstrate control and leadership.¹¹

During the approach of Hurricane Alicia, communication from the Governor to the Mayor of Galveston regarding evacuation may have played a role in the decision to not evacuate.⁸ In this case the Mayor may have

reacted negatively against the state's position rather than make a decision independent of the state.

This section has provided a general overview of many uncertainties in evacuation decision making and has provided examples of each. The presence and absence of these factors or the response of a decision-maker to them help shape the potential liability of public officials and agencies for their decisions to evacuate. The list herein provided may not be exhaustive, and it is possible that other factors could also create uncertainties as well. Nevertheless it provides insights into the potentials for liability and allows us to draw some observations concerning Federal assumption of evacuation liabilities under the Price-Anderson Act.