NATURAL DISASTERS AS THE CAUSE OF TECHNOLOGICAL EMERGENCIES: A REVIEW OF THE DECADE 1980-1989

Pamela Sands Showalter
and
Mary Fran Myers

Natural Hazards Research and
Applications Information Center
University of Colorado, Boulder

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PREFACE

This paper is one of a series on research in progress in the field of human adjustments to natural hazards. The series is intended to aid the rapid distribution of research findings and information; it was started in 1968 by Gilbert White, Robert Kates, and Ian Burton with National Science Foundation funds.

Publication in the Natural Hazards Working Paper Series is open to all hazards researchers wishing quick dissemination of their work and does not preclude more formal publication. Indeed, reader response to a publication in this series can be used to improve papers for submission to journal or book publishers.

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The Natural Hazards Research and Applications
Information Center
Institute of Behavioral Science #6
Campus Box 482
University of Colorado
Boulder, Colorado 80309-0482

SUMMARY

Historically, natural and technological disasters have been treated separately in hazards research and literature. This report is an effort to determine how commonly these two types of disaster interacted in the United States from 1980 to 1989. Data was collected by performing a literature review, contacting organizations and individuals active in hazards research and mitigation, and through a questionnaire sent to the emergency management agencies of all 50 states. The general consensus derived from the data is that the number of incidents where natural and technological disasters interact is rising while preparations, which recognize the complications inherent in such combined events, remain cursory. There is a pressing need for states to record, and make available to managers, information regarding the number of combined natural/ technological events affecting their areas. Only when such data is available will it be possible to make appropriate decisions regarding the best way to reduce the effects of a natural disaster causing a catastrophic release of hazardous materials.

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From legislation establishing the United States Decade for
Natural Disaster Reduction 100th Congress, 2nd Session

Generally, the average citizen within the U.S. classifies natural disasters and technological hazards as two separate entities. This perception can be partially attributable to the fact that an oil spill, nuclear plant core melt-down, or chemical release can occur on a calm, beautiful day, while a flood, tornado, or hurricane is associated with the proverbial "dark and stormy night."

In contrast to the public's segregated classification, hazards researchers are aware that natural and technological hazards are not mutually exclusive. The dynamic processes that take place during a natural disaster can often act as a catalyst for the creation of a hazardous material (hazmat) release. And, although there is no precedent for a hazmat release creating an *immediate* natural disaster (in contrast to the theory that synthetically produced chemical byproducts are altering natural systems on a global scale), such a release could be followed by a natural event which could in turn spread the effects of any accidentally released materials.

This report is the result of a project suggested by the Environmental Protection Agency (EPA) to investigate how frequently technical hazards are produced by natural hazards because:

> Rational decisions about catastrophe require an inventory of its sources, probabilities, geographic distribution, and trends. An inventory might help to clarify the social costs of disaster including those of prevention, reconstruction, as well as the less easily calculable social-psychological costs. (Orr, 1979, p. 47)

Two avenues were used to explore this issue and are reflected in the chapters that follow. The first three chapters discuss the findings of a literature search that revealed a number of natural incidents involving hazmat releases, thereby justifying concern with the problem of interacting natural/technological events. The fourth chapter describes a survey which was sent to the emergency management agencies of all states to elicit their response to the issue, contains a detailed discussion of the survey results, and includes recommendations from respondents regarding how to better prepare for the possibility of such events. The final two chapters discuss the survey's findings in terms of implicit and explicit state-level concerns, and reveals that interacting natural/technological events are an as yet little-studied problem, which could bear closer scrutiny at local, state, and federal levels.

A LESSON FROM CANADA

The U.S. has yet to be the victim of a natural disaster creating a catastrophic technological calamity (hereafter referred to as a "na-tech" event--pronounced "nay-tek"), however, low-impact episodes are not uncommon. Household propane tanks become floating mines during heavy flooding, leaking fuel from earthquake-ruptured gasoline lines can ignite, hurricanes cause electrical outages which can affect the stability of chemicals which must be kept agitated or refrigerated, and tornados tear hazmat storage containers apart. While the public focuses on loss of life and primary structural damage, hazards researchers and emergency practitioners realize that "almost every natural disaster is accompanied by some sort of technological disaster (e.g., hazardous material spills, fuel ruptures, or electrical exposure)" (Colorado Department of Public Safety, 1991, p. 34) capable of radically aggravating any situation. An example of the vulnerability of our "built environment" to the vagaries of a natural disaster is well illustrated by a tornado which struck Edmonton, Alberta (Canada), in July 1987. This tornado (Figure 1) remained in contact with the ground for 64 minutes killing 27 people, injuring several hundred more, and causing more than $500 million worth of damage. As the tornado moved through an industrial area, it scooped up hundreds of cars, trucks, and storage tanks, frequently smashing them into stationary structures. As reported by the Alberta Public Safety Services (no date), Holmes and McCulloch (no date), and Holmes (1991, personal communication), roads were nearly impassable due to flooding and debris and first responders were greeted by many large storage tanks, containers, and road vehicles overturned, punctured, and releasing dangerous goods (such as sulfuric acid) onto the ground or into the atmosphere (Figures 2-4). Utility poles and wires were down over the entire area. Natural gas lines were ruptured, propane tanks punctured, and fuel was leaking from damaged vehicles. According to reports, the air was "ripe"

Figure 1. The Edmonton Tornado.

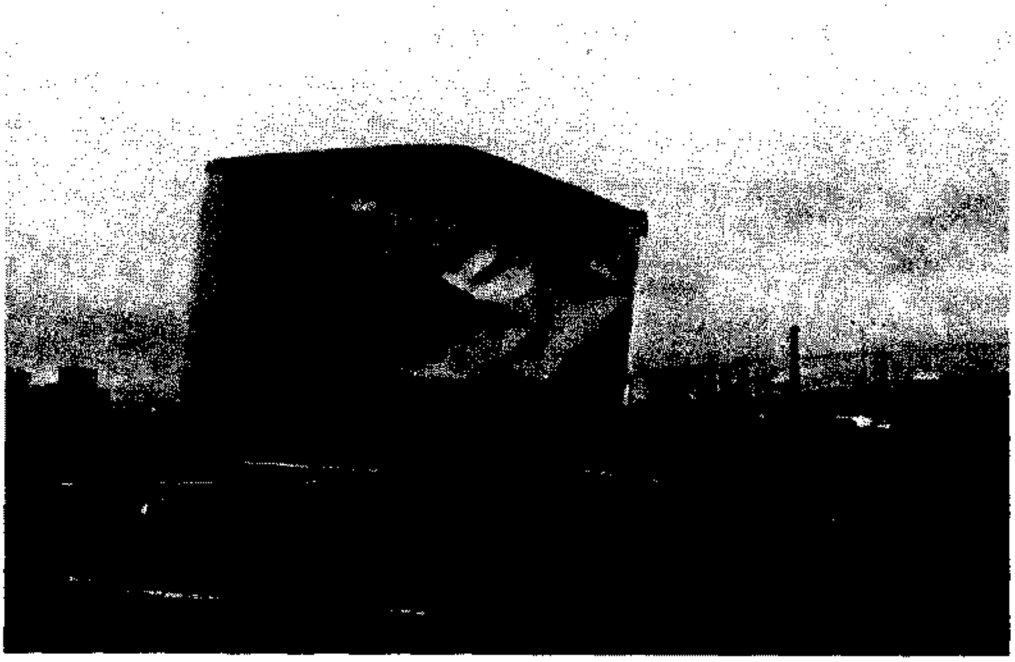


Figure 2. Storage Tank Overturned and Damaged by the Edmonton Tornado.

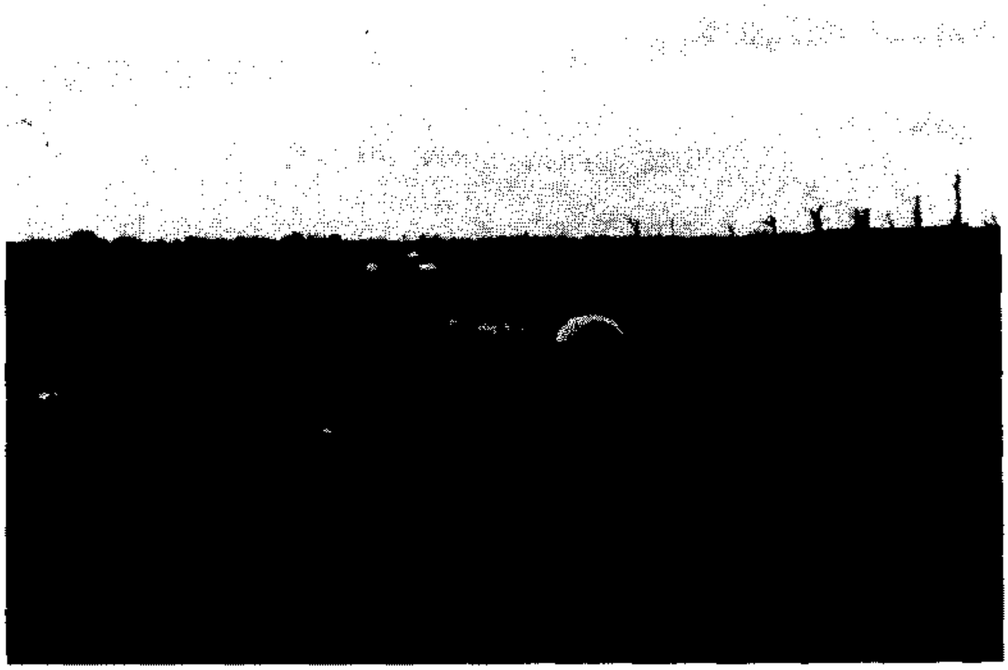


Figure 3. Leaking Containment Vessel Damaged by the Edmonton Tornado.

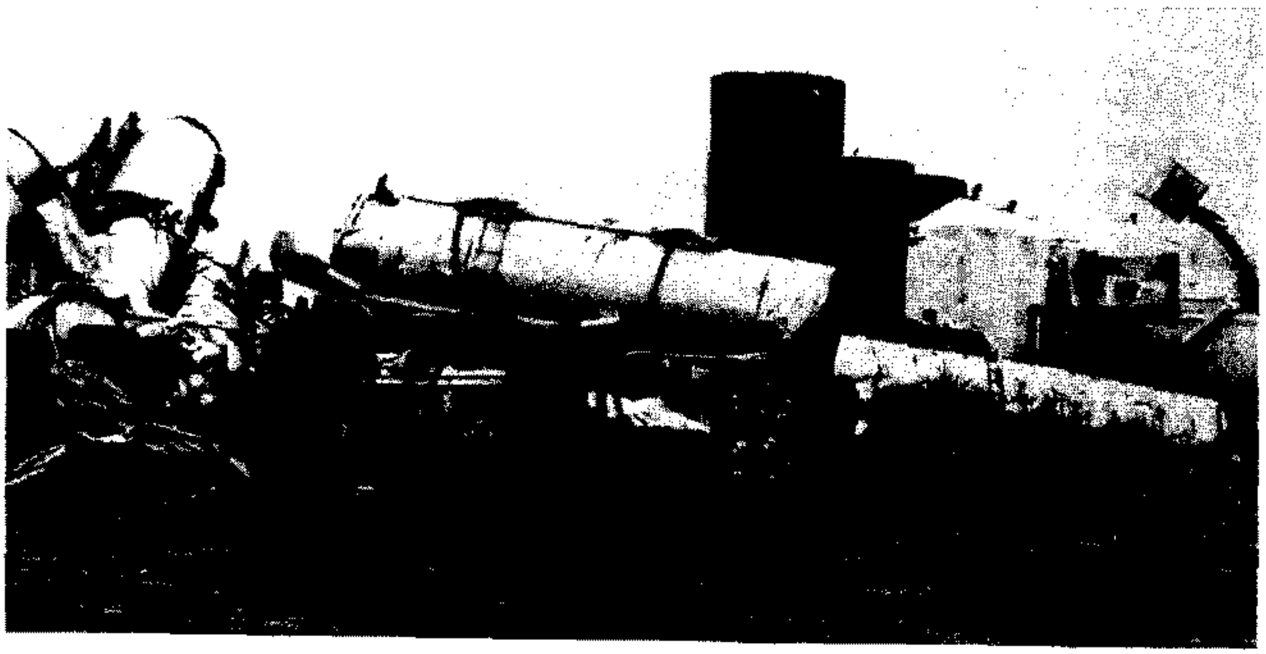


Figure 4. Railway Tank Cars Damaged by the Edmonton Tornado.

with the smell of released hydrocarbons. Many storage tanks and containers had or were in the process of releasing their contents, some of which included liquid oxygen and other cryogenic products; diesel fuel (40,000 lbs); liquid asphalt; herbicides such as 2,4-D (20 drums); anhydrous ammonia; bulk gaseous oxygen; and acetylene. Besides the bulk containers, thousands of small containers of dangerous goods were damaged or carried away from their original locations by the storm. These involved all classes of dangerous goods, including infectious substances and radioactive materials. Three polychlorinated biphenyl (PCB)-filled scrap electrical transformers were damaged, with a loss of 280 gallons of oil containing 365,000 parts per million (ppm) of PCB (in the U.S., spills with concentrations greater than 50 ppm must be reported). The PCB subsequently contaminated a 384 x 164 foot zone which alone cost more than $1 million to clean up. In addition to the damage to the industrial park, a nearby train was derailed and rolled onto its side. This train included a number of tank cars, some of which contained chlorine, anhydrous ammonia, and flammable liquids. Fortunately, there were only minor leaks from these cars. Also fortuitously, the tornado passed between four large oil refineries causing only slight damage to some of their storage tanks. These refineries were designed to withstand maximum wind speeds of 240 km/hour, but the tornado generated winds in excess of 400 km/hour. A propane loading terminal was damaged, but site emergency crews quickly brought leaks under control. The tornado also passed within 1,500 meters of three world-scale chemical plants but inflicted only minor damage. Hazardous material releases contaminating the ground and water necessitated clean-up by containment, vacuum trucks, and soil removal.

The Edmonton tornado, one of Canada's worst natural disasters, is an example of a na-tech event which could easily have become even more devastating. In light of this tornado, Tierney's observation that U.S. disaster literature or emergency preparedness policy rarely acknowledges "the role of earthquakes and other natural disasters as [originating] agents in hazardous materials emergencies [although] it is obvious that facilities that produce, store, and transport chemicals are vulnerable to such agents," (1988, p. 248) seems especially relevant.

CHAPTER II
ELEMENTS THAT INCREASE VULNERABILITY

MATERIALS

The U.S. is greatly dependent on the production and use of materials which are potentially, or purposefully, dangerous to biological organisms. Every day, chemical and petroleum industries manufacture approximately 275 million gallons of gasoline and 2.5 million pounds of herbicides (Tierney, 1988). The production of synthetic organic chemicals has increased ten-fold over the last 45 years, with annual production totalling about 270 billion pounds in 1990 (reflecting an increase of about 3 billion pounds between 1989 and 1990), and annually, 700 to 1,000 new chemical compounds are introduced for agricultural, medical, and industrial commercial applications (N.A., 1991c; Pennsylvania Department of Community Affairs, 1988). Some of these chemicals, in addition to their inherent toxicity, have the potential to react violently on contact with moisture, water, or air causing explosions, igniting fires, or creating harmful fumes or gases, thereby presenting a hazard to society and to the environment. Hazardous wastes are also an increasing concern with, in 1985, an estimated 275 million metric tons generated by over 200,000 facilities across the U.S. with "small quantity generators" (facilities which produce less than 2,200 pounds of hazardous waste per month), probably accounting for a significant proportion of the output (U.S. General Accounting Office, 1991b, pp. 13-14).

Local government officials should be aware that while steps are being taken at the federal and state level to regulate distributors, manufacturers, and commercial/ industrial users of dangerous chemicals, little else is being done at these levels "to regulate the design and construction of such facilities located in areas vulnerable to natural hazards such as flooding" with the exception of "hazardous waste facilities, nuclear power plants and storage tanks regulated by the State Fire Marshal" (Pennsylvania Department of Community Affairs, 1988, p. 1).

Chemicals, gases, petroleum products, and radioactive materials must be manufactured, transported, stored, and distributed in our highly technological society. As a result, hazardous materials can be found in numerous settings and locations. The more obvious examples include: manufacturing facilities that utilize such chemicals, chemical production plants, transshipment sites, railways, and various pipelines (Eguchi, Tierney, and Antonoplis, 1988). Railways generally have a good safety record, but the number of rail accidents increased from less than 8% to 11% between 1976 and 1982, and it has been estimated that 35% of all freight trains carry hazardous materials (Kasperson and Pijawka, 1985).

Lifelines in urban areas which carry gas and liquid fuel are potential agents of hazardous material releases in the event of a natural disaster, with their vulnerability recently characterized as: high for earthquakes, moderate for tornados, and low for both hurricane and flood (National Institute of Building Sciences, 1989). Less conspicuous are those hazardous materials found on or in farms, hospitals, educational institutions, household basements, and retail store shelves. And, while there are an estimated 32,000 to 50,000 known hazardous waste dumps scattered throughout the U.S. (Zeigler, Johnson, and Brunn, 1983), it is unknown how much material has been illegally buried, stored, or dumped "by 'midnight haulers' or 'gypsy truckers'" (Zeigler, Johnson and Brunn, 1983, pp. 61-62). These unknown sites can pose unpleasant surprises, such as occurred on June 6, 1990, when a tornado in Limon, Colorado, damaged an abandoned grain elevator and disturbed "highly toxic and very dangerous chemicals" that had been left at the site (Colorado Department of Public Safety, 1991, p. 18).

Recognition of the dangers of "multihazard" or na-tech events is beginning to surface, but such references usually comprise only a very minor part of much larger documents (e.g., Federal Emergency Management Agency, 1990a, pp. 27, 30, 74; Huey, 1990, pp. 1J, 4K). In most cases, however, there is essentially no recognition of the likelihood of na-tech events. Unfortunately,

> The spreading potential for cataclysmic outcomes, and the difficulty of forecasting and avoiding their occurrence, creates the likelihood that modern societies will be faced with a series of disasters that will be costly in terms of capital and lives. The odds are complicated by the further possibility that cataclysm might occur as a spiral of interlocking events and processes, [unfortunately] our understanding of low probability/high consequence events . . . is highly conjectural and inconclusive. (Orr, 1979, p. 45)

DEMOGRAPHICS

While overall fatalities caused by natural disasters have decreased in the U.S., property losses are on the rise, largely due to population movement into hazard-prone areas. The public's perception that technology can eliminate the hazards of extreme natural events entices people into locales that would be better devoted to less intense use (Zeigler, Johnson, and Brunn, 1983). Along with population movement into risky areas, population growth itself has placed increased numbers of people at risk. When sites for facilities that manufacture, process, or store hazardous materials were originally chosen, proximity to transportation routes and markets were probably given precedence over vulnerability to natural disasters. With the passage of time, population trends encouraged development around facilities that originally had not been near residential areas (Tierney, 1989). Larger populations living and working in close proximity to hazmats are two factors that currently place a greater population at risk. Following a major natural disaster, this population may find an overburdened health care system unable to assist persons who have been exposed to hazardous materials and who typically need specialized medical services. Because of the increased likelihood of multiple releases following a natural disaster, vulnerable communities need to confront the possibilities of na-tech events now, for during a disaster it will be "virtually impossible to address these incidents and at the same time cope with other essential . . . tasks such as search and rescue operations and damage assessment" (Tierney, 1989, p. 34).

As greater numbers of people, businesses, plants, and storage facilities are exposed to natural events, the potential for a catastrophic na-tech disaster rises. Up to the present, local, state, and federal regulations have proven adequate to the task of containing such risks. It is important, however, that emergency managers recognize that what has served in the past may prove inadequate in years to come. One cannot calculate riskiness merely by adding up the types of threats that exist in, or which can impact, a particular area. Accuracy in estimating risks of disasters "decline as the complexity of the system and the magnitude of potential consequences rise" and "estimates of risk which focus on the event itself without consideration of the ripple effects in space and time tend to underestimate substantially the ramifications of high-consequence events" (Orr, 1979, pp. 46, 48). For instance, the long-term environmental impacts of na-tech incidents could include contaminated soil and ground water, as well as uninhabitable buildings (Tierney, 1989), leading to population displacement and additional burdens on government resources.

THE NATURAL-TECHNOLOGICAL INTERFACE

There are many differences between natural and technological hazards regarding how they are perceived by, and how they effect, populations. Table 1 illustrates some of these major differences. Despite the contrasts illustrated in Table 1, natural and technological hazards can also be dynamically intertwined. A list of similarities which blur distinctions between the two types of disaster are displayed in Table 2.

Tables 1 and 2 help to illustrate that any disaster which evolves into a na-tech event complicates mitigation efforts and attempting to prepare for such an event is a complex process. True "integrated planning" must take into consideration technical, technological, physical, economic, social, psychological, organizational, and institutional factors. The logistical problem of addressing such a large number of variables may raise the question of how feasible it is to attempt the complicated process necessary in planning for a na-tech disaster. The stance of this document is that since "certain steps are important to planning for both types of disaster" (Towfighi, 1991, p. 107), it makes sense to confront the issue before a significant na-tech event takes place.

CHAPTER III
CASE STUDIES

Emergency managers need firm data in order to determine whether the risk of a catastrophic na-tech event is enough of a threat to warrant heightened concern. Our literature review revealed that na-tech events may be more common than generally believed. The following case studies illustrate the types of events to which the nation may be becoming increasingly vulnerable.

Table 1. List of Differences Between Natural and Technological Disasters

Natural Disasters	Technological Disasters
Are an expected aspect of the physical environment	Are created by human development and use of hazardous materials and are usually caused by human error
Are considered uncontrollable	Are considered controllable
Issues of control appear to produce more psychopathology in affected citizens	Issues of control appear to produce lower psychopathology than natural disasters
Humans are not held responsible	Responsibility is perceived as lying with a human or group of humans who calculate an event's predictability
Onset often allows warning/evacuation	Characteristically occur rapidly and without warning
Reluctance to evacuate until the threat is seen as extreme and impending	A large portion of the population will evacuate without formal instructions to do so
Usually have a clear beginning and end via obvious destruction	Although the onset may be clear (e.g., warning sirens signalling a release), its "end" may be less apparent
The event and its effects on people and the environment are generally visible	The event and its effects on people and the environment are generally invisible
Recovery is generally visible (e.g., removal of debris)	Recovery is generally invisible (i.e., "removal" of radiation cannot be seen)
Individuals can personally observe the effects of a natural disaster	Because effects are often invisible, individuals are more dependent on authority figures and/or the media for facts
Private individuals, public agencies, and corporations become involved in the response	Corporations and governments respond while private citizens are relegated to roles as victims and/or must be separated from the event's aftermath to ensure their safety
Authority figures are seen as helpful	Authority figures are seen as evasive and unresponsive
Individuals tend to personalize event	Individuals tend to depersonalize event
Mitigation focuses on human adjustment to potential events or to hazardous areas	Mitigation tends to focus on the technical process
Response/relief efforts more common than mitigation because of perceived lack of control over the event	Because of perceived control, mitigation is more common than response/relief
Familiarity develops due to experience	Familiarity is lacking because of less experience
Accumulated experience guides mitigation, management and preparation decisions	Few accumulated experiences to guide mitigation, management, or preparation decisions
Following an event, community solidarity and consensus generally emerges	Following a technological event, a community may search for a "culprit," and conflict may emerge
No documented increases in naturally occurring hazardous events	A greater potential exists for hazardous technological events because: 1) a greater number of facilities use hazardous materials; 2) greater numbers and amounts of hazardous materials are in the marketplace; and 3) due to population growth and its spatial distribution

Table 2. Similarities Between Natural and Technological Hazards

Humans desire to reduce the consequences of hazardous events and therefore will work toward that end.

Mitigation efforts include solutions which are structural (technological/engineered solutions) and non-structural (land use regulations; economic incentives to encourage safe locational decisions; acknowledging the human component in engineered solutions and making efforts to reduce human failure during the building, use, and maintenance of facilities). There is a belief that mitigation efforts should often be able to bridge "natural" and "technological" boundaries.

It is difficult to achieve full implementation of mitigation measures because a multitude of interests interfere with finding an optimum balance between safety and autonomy. How does one encourage acceptance of regulations or determine the degree of permissible risk? Community sponsored mitigation is often equated by the public with a loss of individual autonomy and choice.

Vulnerability is increasing: populations are larger, exposing more people to danger; people are venturing into or living in, hazard-prone areas due to employment opportunities, recreational desires, or poverty.

Problems are shared in the area of risk communication, e.g., perception/interpretation; response to warnings/information; and how attitudes and beliefs shape behavior.

The immediacy of short-term economic concerns often overshadows fears regarding impending dangers.

The level of potential risk must be weighed against the costs and benefits of mitigation.

Once mitigation/prevention/response systems are created it becomes a human responsibility to control "system failures".

Affected citizens require external assistance.

Affected citizens may suffer from the effects of the event for years.

The ability to predict the onset of some natural events (e.g., hurricanes, volcanic eruptions, and tornados) makes them seem more "controllable" - therefore more similar to a technological risk. Also, some natural events such as earthquakes and landslides are characterized by "rapid onset" similar to technological events.

The spatial effects of natural or technological hazards can range from specific points on the ground such as a lightning strike or small oil leak, to extensive (and in some scenarios global) arenas such as Hurricane Hugo's impact on the Virgin Islands and the eastern coast of the U.S., to a nuclear holocaust.

Psychological problems, pathologies, or impairment suffered by disaster victims will rise in comparison to unaffected populations.

Every disaster situation involves threat detection, evaluation, and information dissemination.

GEOLOGIC EVENTS

Earthquakes

Loma Prieta: On October 17, 1989, at 5:04 p.m. (PST), a magnitude 7.1 earthquake shook approximately 400,000 square-miles of the west coast, from Los Angeles, California, to the border of Oregon, and into western Nevada. The quake killed 62 people, injured more than 3,750, and caused damage in excess of $6 billion (U.S. Army Corps of Engineers, 1990). Although public concern focused on visible structural wreckage such as a collapsed freeway, emergency responders had to deal with a variety of hazardous material releases caused by the earthquake.

Petroleum Spills: Damage occurred to many fuel storage tanks which were nearly full and located on soft-soil sites. One diesel tank developed a slow leak while one lube oil and three gasoline tanks suffered significant damage and leakage. Fifty thousand gallons of gasoline were restrained within containment dikes and removed to another refinery. Fortunately, no fires occurred. In addition, a large fuel spill occurred at the San Francisco airport and it was feared that one gas station's underground fuel tank had leaked (Benuska, 1990; Kay, 1989).

Chemical Releases/Emissions: A structural fire occurred at a lumberyard when pipes to a propane-fueled emergency generator ruptured, causing the discharging propane to ignite when the generator activated (Benuska, 1990). Between 5,000-20,000 lbs. of ammonia were released when a ceiling-mounted evaporator broke loose from its pipes in Watsonville, and formaldehyde was spilled at a Bay Area hospital. Containers of malathion and chlorine fell from shelves in a retail store, mixed, and the subsequent fumes necessitated the evacuation of the building. Sloshing of liquids stored in tanks that did not suffer direct damage resulted in the inadvertent mixing of incompatible chemicals on floors and the generation of toxic gases. At least 40 locales experienced this rarely reported type of hazmat release. And, although it is clear that a loss of electrical power can cause problems, so can power restoration--in one case a float valve in a tank of plating chemicals jammed after power was restored and the tank overflowed (Association of Bay Area Governments, 1990; 1991).

Cyanide and acid splashed on the floor of a plant in San Jose, creating hydrogen cyanide gas. Containment trenches caught the liquid and moved it to recovery areas where it was neutralized. Two buildings at Stanford University suffered releases of toxic gases: in one building a cylinder leaked hydrogen gas and in another, toxic gas leaked from a compressed-gas system. Fifty thousand gallons of highly acidic water escaped into a storm drain from a broken pipe in a semiconductor plant in Santa Clara (Kay, 1989). Grocery stores suffered spills of ammonia, while formaldehyde and other chemicals fell to the floors of university and high school science labs (Dickerson, 1989).

In total, the Association of Bay Area Governments (1990) reported that ruptured tanks and pipes, equipment leaks, and broken containers of hazardous liquids resulted in over 300 reportable or reactive spills in the San Francisco/Monterey Bay areas and chemical sloshing accounted for an additional 40 spills. Fortunately, little of the material from these spills reached storm drains or sewage lines. Additionally, at least 50 releases of hazardous gases (other than natural gas) occurred.

Asbestos: Bottome (1990) reports that in dozens of buildings in San Francisco, asbestos-containing fireproofing materials shook free of their structural skeletons, falling into tenant spaces from ceiling tiles, inside fan rooms, onto elevator cars, onto the floors of mechanical rooms, and on top of computer equipment, desks, and belongings. Where the asbestos fell onto drop ceiling tiles from structural decking, it was necessary to vacuum and encapsulate each tile before reactivating the building's ventilation system. Many buildings undergoing remedial asbestos work at the time of the earthquake "were unable to maintain negative air pressure differentials during the power outage that followed the tremblor. Some floors suffered the loss of isolation barriers when windows were blown out" and response teams had to scramble to reseal the windows. Aftershocks further frustrated recovery efforts by shaking loose additional material in some areas that had already been cleaned, and months after the quake a number of building owners "faced . . . the need to demolish damaged buildings in compliance with the Clean Air Act; yet [were] unable to enter the building[s] to remove the asbestos because the buildings [were] structurally unsound" (Bottome, 1990, p. 41).

Asbestos problems reportedly surfaced in over 80 buildings damaged by the earthquake. Such releases produce a trail of increasing costs to citizens and society. For instance, building occupants and clean-up/renovation crews have a higher chance of being exposed to the asbestos, hence claims for personal injury may increase.

Specialized, mandatory asbestos removal/reduction techniques can be very expensive and time-consuming, resulting in prolonged building vacancy. Or, if a building is to be demolished, asbestos may have to be removed before demolition is allowed (Association of Bay Area Governments, 1990).

According to Bay Area firefighters, there were three reasons why toxic damage from the Loma Prieta earthquake was limited: 1) stringent hazardous materials laws; 2) excellent industry controls and response teams; and, 3) luck (Kay, 1989).

Whittier: On October 1, 1987, the magnitude 5.9 Whittier Narrows earthquake in California displaced a one-ton chlorine tank that was being filled, resulting in the release of a half-ton toxic cloud. Power failure caused by the earthquake disabled the company's warning siren. And the telephones were not functioning so it was impossible to warn officials in neighboring jurisdictions of the threat (Association of Bay Area Governments, 1991; Tierney, 1988).

Unnamed: On January 2, 1991, a magnitude 4.8 earthquake occurred 60 kilometers from the Waste Isolation Pilot Plant in New Mexico which is to be a future storage site for nuclear waste (NA, 1992).

Potential Earthquakes: In addition the examples above, there are locales for which earthquake-precipitated na-tech events are a virtual certainty and whose occurrence could be devastating. For instance, the Los Angeles Standard Metropolitan Statistical area has the second-highest number and geographic concentration of chemical facilities in the U.S.--facilities which are also located close to the Newport-Inglewood, as well as other, faults (Tierney and Anderson, 1990). There, the probability of earthquake-generated hazardous materials releases has been estimated as 62% while the preparedness of handlers of hazardous materials is considered moderate or low. In coming decades, one or more damaging earthquakes are projected for the area. In order to "contain future losses and facilitate recovery, mitigation strategies and disaster preparedness efforts must address **both** types of hazards" (Tierney and Anderson, 1990, p. 12; bold theirs).

The West Coast is but one example of an area with a high concentration of facilities dealing with hazardous materials and susceptible to earthquakes. Only recently have seismic-hazard analysts begun to consider the possibility of surface faulting east of the Rockies. Such faulting "could seriously damage a nuclear power plant or pierce a hazardous-waste site, allowing dangerous chemicals to enter underground water systems" (Monastersky, 1991, p. 164). One area which is seismically active but often overlooked because of the rarity of large earthquakes is the New Madrid Seismic Zone (NMSZ) in the Central U.S. That region hosts "several communities with high concentrations of chemical plants" (Tierney, 1988, p. 249). A major city in the area, Memphis, Tennessee, has been called "America's Distribution Center" due to extensive air, rail, and water transportation facilities. Oil and gas pipelines also traverse the area from Louisiana and Texas. Unfortunately, the infrastructure within the locale is aging and is therefore susceptible to damage from a seismic event. Researchers have established that there is a 40-63% probability of a magnitude 6 or greater earthquake occurring somewhere in the NMSZ between 1985-2000, with that probability rising to 90% by the year 2040 (Johnston and Nava, 1985). When a large earthquake strikes there in the future, hazardous material releases are a virtual certainty. It is believed by emergency management personnel in Tennessee that if an earthquake impacted Memphis there would be major chemical releases (Suiter, 1991, personal communication).

Rock Slide

In Colorado, on September 30, 1991, a rock slide derailed a freight train which plunged the two lead locomotives down a 500-foot mountainside. Two crewmembers were killed and the diesel fuel that spilled into South Boulder Creek started a fire that burned most of the day (NA, 1991b).

Volcanic Eruption

Mount Redoubt, Alaska: Volcanic eruptions are highly localized events which in some cases have proven to be predictable. Nevertheless, volcanoes pose a multifaceted threat. Ash columns propelled several kilometers into the atmosphere can disrupt airline traffic and deposit material downwind effecting agriculture and clogging air intake valves on mechanical equipment. Ice-laden summits which are suddenly melted generate destructive floods and mudflows. Explosive eruptions (such as occurred at Mt. St. Helens) create pyroclastic flows of hot gases and debris that destroy everything in their paths. Lava flows and ash falls can cover buildings and access routes such as highways and bridges.

The recent phase of activity at Mt. Redoubt, which began on December 14, 1989, and continued well into 1990, was not widely reported in the popular press, yet ranks as the second most expensive volcanic eruption in the history of the U.S. Redoubt's activity generated destructive volcanic ash and pyroclastic flows composed of hot, rapidly moving clouds of gas, rock debris, and ash which bred massive debris flows carrying water, blocks of ice, vegetation and volcanic rock debris. On December 15, 1989, and on January 8, 1990, explosive events deposited ash on and around the cities of Kenai and Soldotna, causing power outages and school closings. Ice melted by explosive events caused avalanches, hot debris flows, and flooding (Brantley, 1990). At least four commercial aircraft have suffered abrasion from airborne ash necessitating the replacement of cockpit windows as well as repairs to the leading edges of wings.

On January 2, 1990, the largest floods generated by Redoubt carried trees with 0.8-meter diameters, and rocks and blocks of ice with 8-meter diameters, down to Cook Inlet. As the debris-laden waters travelled to the sea, they skimmed by diversion levees built at the Drift River Oil Terminal (DROT), damaging logistical support facilities (Alaska Volcano Observatory Staff, 1990). At DROT, oil is pumped through buried pipelines into the facility from 10 platforms in western Cook Inlet. Storage capacity at the terminal is 1.9 million barrels or 83.6 million gallons. Fortunately, none of the seven storage tanks containing over 830,000 barrels of oil were harmed. After this "near miss," more than $20 million was spent at the facility to mitigate against future volcanic activity (Brantley, 1990).

CLIMATIC EVENTS

Hurricane

Hurricane Hugo: In Puerto Rico, Hurricane Hugo's effects on the ability of people and supplies to travel into or out of the country were exacerbated when "asbestos-containing ceiling materials fell into the security area through which all passengers had to pass prior to boarding. No one could go through the security area--or get either on or off the island--until the asbestos was cleaned up" (Draper, 1990, p. 35). Asbestos tiles collapsed into a 30- by 80-foot government office which contained water resources documents (information on pump stations for water transport) critical to the region's reconstruction, then the storm winds blew additional asbestos onto the surrounding grounds. And, at three locations, a utility reported crumbling asbestos insulating materials as a result of the storm (Draper, 1990, p. 38).

In the Virgin Islands, at least two major oil spills were caused by Hurricane Hugo. At the Virgin Islands Water and Power Authority (VI WAPA) facility in Christiansted, St. Croix, No. 6 oil was stored in a 54,000 barrel (2,031,087 gallon) storage tank located approximately 250 feet from the shoreline. The hurricane's force destroyed the

> steel containment wall surrounding this storage tank and, in so doing, severed a discharge line near the bottom of the tank. This released No. 6 fuel oil at an estimated rate of 1750 barrels [65,771 gallons] per day, or about 50 gallons per minute . . . onto the facility grounds. (Bills and Whiting, 1990, p. 171)

At the Hess Oil Virgin Islands Corporation (HOVIC) refinery located on the south coast of St. Croix, the hurricane destroyed five large oil storage tanks and severely damaged several others (Figure 5), causing the release of 420,000 gallons of diesel oil (National Response Team, 1990). Although most of this oil was contained within earthen berms and only a small percentage flowed to the HOVIC tanker harbor (where natural wind and wave action kept it pressed against the shoreline (Bills and Whiting, 1990), Hugo's winds blew the oil contained in the retaining ponds about the island and onto roofs where rain washed the oil from the roofs into residential cisterns causing their contamination (Federal Emergency Management Agency video tape).

Previously on St. Croix, contingency planners had focused their response strategy around a worst case scenario involving a 1.5 million barrel catastrophic tanker grounding. Because of Hugo, "that scenario has been replaced by a 14 million barrel catastrophic destruction of the HOVIC tank farm . . . no one can view the destruction of the HOVIC tank fields wrought by the fury of Hurricane Hugo and fail to recognize the awesome potential for disaster" (Bills and Whiting, 1990, p. 182).

Hugo's wrath did not diminish as it travelled north. The Isle of Palms, a seven-mile-long, 1.5-mile-wide island off the coast of South Carolina suffered extensively. After

Figure 5. Damage Caused by Hurricane Hugo at the Hess Oil Refinery

the storm's passage, the police were the first to return, and according to their Chief,

> What I saw was an absolute nightmare! Pictures don't do it justice, . . . Most of the island had septic tanks. All the septic tanks, with very few exceptions, were above ground. There was raw sewage everywhere. Most homes had propane tanks, and the residents were cautious enough to cut the valves off before they left. The problem was, Hugo took all the propane tanks and ripped them up out of the people's yards, even the ones that were underground floated up away from the house. In one day, salt water will totally destroy the copper pop off valves on propane gas tanks, and we had an island full of propane gas! That's all you could smell. We had raw sewage mixed with propane gas. We didn't know what in the world we were going to do . . . If a resident came on to the Isle of Palms, and lit up a cigarette, or cranked up a chainsaw and a spark flew, chances are, the entire island could have exploded . . . the streets were gone. Most of the streets were impassable. There were 80-100 foot sections of roadway gone, with 40-50 foot deep holes, where the waters, as they were receding, just ate the concrete away. Should they cause a fire, no fire trucks to put it out, and if the fire trucks were there it didn't have any water, the water department was certainly down, they couldn't operate. (Iacovelli, 1991, pp. 10-11)

Hurricane Hugo's impact on response capabilities can also be illustrated by the experience of Lee county in South Carolina which had to wait three months for the state to respond to a "request for assistance to clean up over 25,000 gallons of spilled gasoline" (U.S. General Accounting Office, 1991a, p. 4).

Flooding

Chehalis River, Washington State: On November 24, 1986, the Chehalis River overran its banks, sweeping into the American Crossarm facility in the city of Chehalis. On facility grounds there were 10,000 gallons of a mixture of diesel oil and pentachlorophenol, commonly called Penta, stored in tanks and open sumps. Exposure to Penta can cause skin rashes, dizziness, headaches, and nausea. Polluted waters affected four city blocks, contaminating four businesses and 15 homes. To mitigate the effects of the oily toxic material, streets, sidewalks, and the interiors and exteriors of contaminated homes had to be cleaned; sod and topsoil removed, stored, and eventually incinerated; and housing assistance provided by the Federal Emergency Management Agency (FEMA) obtained. Ironically, only 20 days before the flood, the company had been ordered by the Washington Department of Ecology to dispose of the stored Penta within 90 days (D'Acci, nd). According to D'Acci, ". . . the Penta spill was clearly preventable; and . . . many floodplains have the potential for similar spills due to the nature of floodplain development" (nd, p. 8).

Skagit River, Washington State: Additional flooding in Washington State (during November 1990), breached a levee on the left bank of the North Fork of the Skagit River, flooding the entirety of Fir Island. Most of the 167 homes on the island were significantly damaged. Uncontrolled releases of oils, chemicals, pesticides, and manure affected many areas and complicated response efforts. Barrel drums, oil, and propane tanks distributed by the floods (Figures 6-9) still littered floodplain areas at the time the Interagency Hazard Mitigation Team's (IHMT) report was issued in January, 1991. Sewage treatment plants overtopped by floodwaters or suffering other damage also contaminated some areas. The report stated that interactive hazards such as flood-caused chemical spills were increasingly common problems:

Figure 6. Propane Tank Deposited Next to Road by Flood.

Figure 7. Propane Tank Deposited Next to Home by Flood.

Figure 8. Barrel of Hazardous Material Deposited in Tree by Flood.

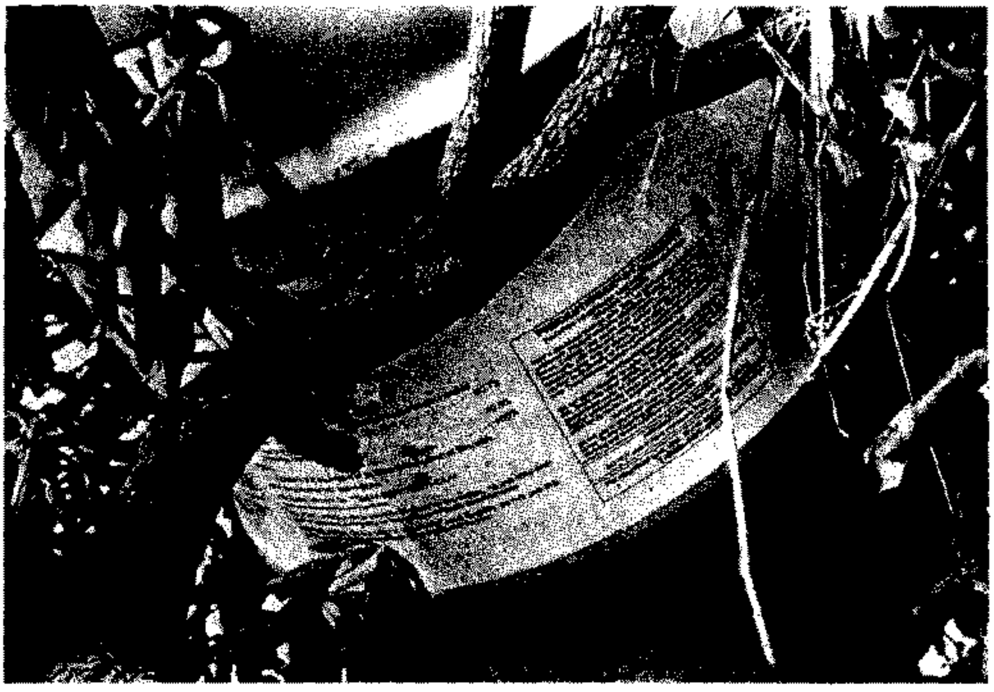


Figure 9. Close-up of Barrel of Hazardous Material.

> In agricultural areas, many farms have a variety of oils, chemicals and pesticides stored on site in unsecured, unanchored containers. These contaminants can have both acute and long term effects. Spill response personnel must be deployed during major floods, thus causing potential safety problems to first responders. (Federal Emergency Management Agency, 1991a, p. 44)

Little Calumet River, Indiana: From November 27-28, 1990, during a five-hour period, heavy rains fell in Lake County, Indiana. As a result, flooding occurred along the Little Calumet River and some of its tributaries and some structures experienced sewage backing up through drains and toilets. Petroleum products from a gas station and from above-ground home heating oil tanks contaminated the water and many homes (Federal Emergency Management Agency, 1990b). Approximately 14 counties impacted by the flooding reported floating or overturned tanks of materials such as LPG, fuel oil, kerosene, and farm chemicals. Because the tanks were not clearly labeled, emergency responders had to treat all dislodged tanks as hazardous material containers with the potential to behave like "torpedoes when the floodwater currents propel them into standing objects such as bridges, houses, or mobile homes" (Federal Emergency Management Agency, 1991b, p. 20).

Other Climatic Events

Climatic hazards affect land-based facilities and structures such as offshore oil rigs, which are a fairly recent innovation and are susceptible to weather extremes. Nuclear power plants are also vulnerable, despite extensive safety precautions: "On the 15th [June, 1991], a bolt [of lightning] hit a transformer at the Yankee Nuclear Power Plant in Massachusetts, shutting down the plant for a few hours" (NA, 1991a, p. 1). On May 16, 1991, National Public Radio reported that a tornado near Laverne, Oklahoma, had just missed striking a gas plant. To complicate matters further, today's scenarios for future hazmat releases must also take into consideration the consequences of possible climate change. Climate change could pose a threat to radioactive waste repositories currently located in arid areas if, for example, variations in El Niño patterns change rainfall characteristics, altering flood frequencies and locations (Geological Society of America, 1990).

It is clear from this literature review that a natural catastrophe creating, or coming dangerously close to creating, a na-tech event is not an unforeseeable situation facing emergency managers. However, it is difficult, if not impossible, to fashion constructive policy decisions in the absence of data. Traditional research questions (e.g., what is known or unknown about a particular problem, what efforts have been employed to address it, and how successful were those efforts), assist decision makers by providing a foundation of past experience and knowledge and by confronting ignorance by explicitly recognizing that a problem exists (Chelimsky, 1991, p. 226). In an effort to establish an historical perspective of na-tech events at the national level, state emergency management agencies were surveyed. The responses to the survey are described in the following chapter.

CHAPTER IV
THE NA-TECH SURVEY

The general perception of na-tech events is that up to the present they have been of minor impact and/or have been sufficiently mitigated at the local level. The lack of standardized record-keeping regarding such events, however, makes it difficult to accurately determine whether such incidents truly are common or rare. In order to "improve probabilistic perception of hazards, it is essential that complete historical records be kept, analyzed, and made available in understandable form to all resource managers" (Slovic, Kunreuther, and White, 1974, p. 200). In an effort to begin compiling records of past na-tech events, and how management is responding to their future eventuality, emergency management agencies were asked to respond to a survey (Table 3; unabridged answers to the survey can be found in Appendix A). The survey's goal was to:

- document the number of na-tech events experienced by each state over the decade (1980-1989) as well as the number of state and federally declared disasters;
- document whether codes or regulations exist that address the possibility of na-tech events;
- solicit intuitive rankings of susceptibility to, and satisfaction with steps taken to avoid, na-tech events;
- request comments regarding why na-tech events appear to be uncommon; and
- obtain suggestions to reduce the possibility of such events.

Budgetary restraints, limited staffs, and the difficulty of retrieving the requested

Table 3. Abbreviated Version of the Na-Tech Survey.

1) CHEMICAL EMERGENCIES CAUSED BY NATURAL DISASTERS

Please list for each year from 1980-1989, the number of chemical spills, releases, or emergencies in your state caused by specific types of natural disasters.

2) OIL/FUEL SPILLS CAUSED BY NATURAL DISASTERS

Please list for each year from 1980-1989, the number of oil spills, releases, or other fuel-related emergencies in your state caused by specific types of natural disasters.

3) RADIOLOGICAL EMERGENCIES CAUSED BY NATURAL DISASTERS

Please list for each year from 1980-1989, the number of radiological material releases, spills, or emergencies in your state caused by specific types of natural disasters.

4) DISASTER HISTORY

Please list by year the number of state and federally declared disasters and the reasons for the declaration (NOTE: Do not list disasters twice; if both state and federal declarations were made, list only as a federal disaster).

MITIGATION

5) States generally have codes or guidelines that regulate or guide the ways in which hazardous materials can be used, stored, or transported. Please indicate whether or not your codes or guidelines specifically address the natural hazards to which your state is susceptible and how (e.g., chemical storage facilities not allowed in floodplains or seismic zones, certain highways closed to hazardous material transport due to high avalanche or landslide potential. Also, please enclose a copy of your codes.)

6) In relation to hazardous material storage, transport, or use, are there communities within your state that have different or more restrictive codes (relating to natural hazards) than state guidelines? (If "yes", please provide us with some examples.) Yes___ No___

7) Does your state have a document which provides guidelines for mitigating the effects of technological emergencies caused by natural disasters? If so, please provide the year these guidelines were published.

Yes___ (Year______) No___

a) If "yes", can you provide us with a copy of those guidelines?

No___ Enclosed___ Under separate cover___

8) In the following two questions, please rank your state on a scale of 1-5 (1=low, 3=moderate, 5=high):

a) How susceptible do you feel your state is to a natural disaster causing a hazardous material release or other technological emergency?

(low) 1-------2-------3-------4-------5 (high)

b) Are you satisfied with the steps your state has taken to reduce the possibility of such an occurrence?

(low) 1-------2-------3-------4-------5 (high)

c) Regarding (b) - why, or why not?

9) It has been suggested that despite apparent tremendous potential for technological emergencies resulting from natural disasters, the actual number of such incidents is relatively low. Do you agree with this statement? Yes___ No___

Why do you believe this is the case?

10) If you wished to further reduce your state's susceptibility to a technological emergency as a result of a natural disaster, what would be your top three mitigation suggestions?

information for all ten questions on the survey proved a hindrance to receiving complete responses from all states, especially concerning the documentation of actual events (Appendix A, Questions 1-3). Thus, subsequent to the initial mailing of the survey, it was determined that limiting responses to a few critical questions would still provide valuable information while lessening the burden on those states with outstanding surveys. Using completely answered surveys that had been returned as guides it was determined that Questions 8-10 were providing interesting insights. Therefore, the following analysis employs 25 completely answered surveys, and 17 partially answered surveys, for a total of 42 responses (84%).

THE SCOPE OF THE PROBLEM AT THE LOCAL LEVEL

In an effort to understand the scope of the problem, or whether it exists at a magnitude that should be of concern to emergency management officials, Questions 1-3 asked respondents to list known na-tech events in their states involving the release of chemicals, oils, or radiological materials, while Question 4 requested official counts (e.g., presidential/state declarations) of natural and technological disasters. As was noted earlier, budgetary restraints, limited staffs, and difficulties retrieving such detailed information limited the number of states able to complete these questions. Data was available for 20 states, however, which was used to identify some trends. The largest proportion of na-tech incidents involve interaction with earthquakes, followed by climatic-related events such as hurricanes, floods, lightning, winds, and storms (Figure 10). This is an important finding since at the national level, floods are the most common natural disaster and they also cause the largest portion of annual damage (in terms of property loss). Therefore, there is no correlation between the frequency of occurrence or annual damage caused by a specific natural hazard and its ability to create a na-tech event. A low probability/high consequence earthquake appears far more likely to create a low probability/potentially high consequence na-tech event.

A clear trend toward increasing numbers of na-tech events is illustrated in Figure 11. Removing the large numbers of releases caused by Hurricane Hugo and the Loma Prieta earthquake from the 1989 data does not alter this trend. There are three possible explanations for the increase: improved reporting procedures, an increase in the number of natural disasters, or an actual increase in the number of na-tech events. Of the 16 states supplying answers to Questions 1-3 (data from the additional four states in the first paragraph of this section came from EPA reports, not from the states themselves),

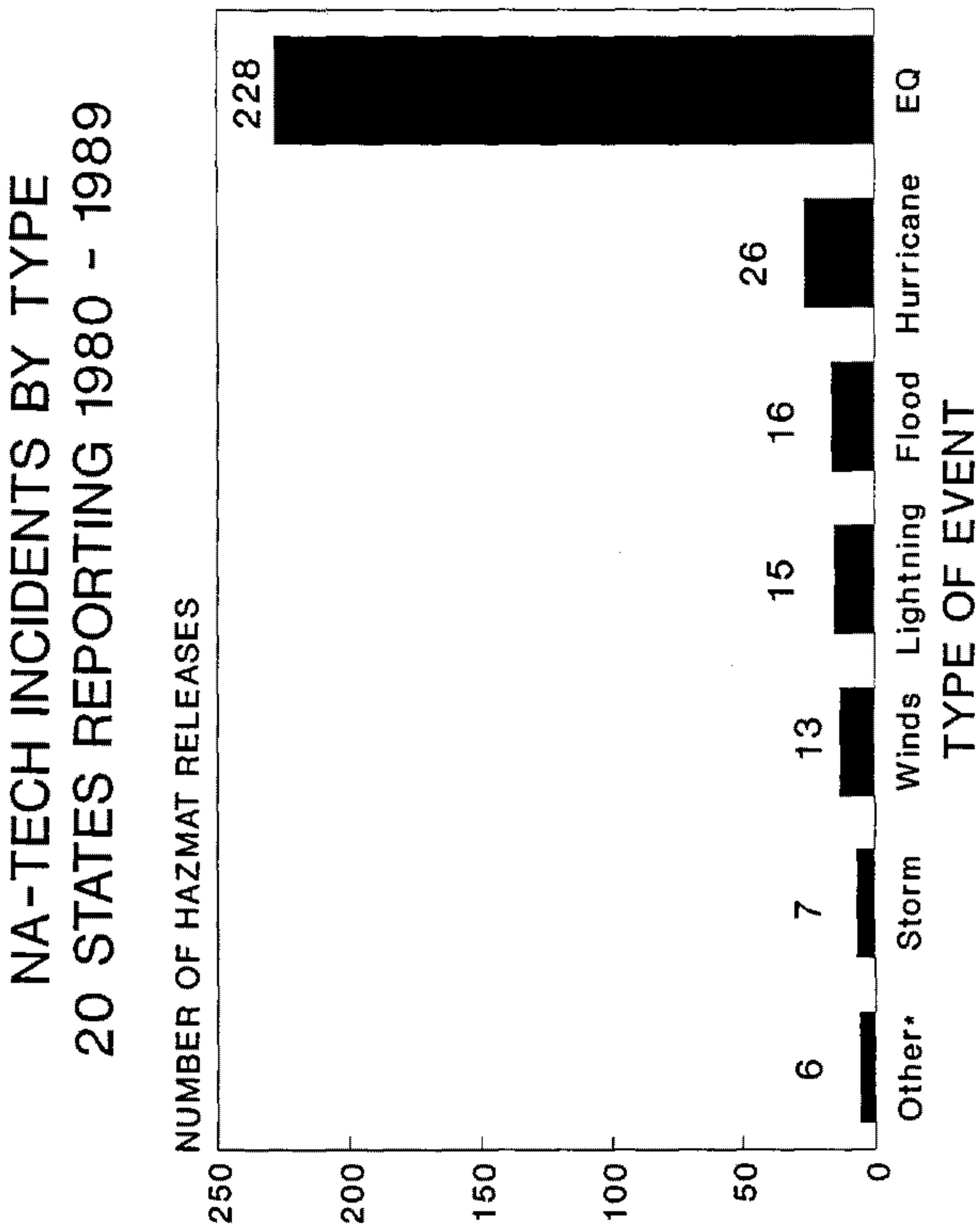


Figure 10. Natural Disasters Causing Na-Tech Events. (* Category "Other" is composed of dam breaks, fire, fog, ice storms, tornadoes, and land slides.)

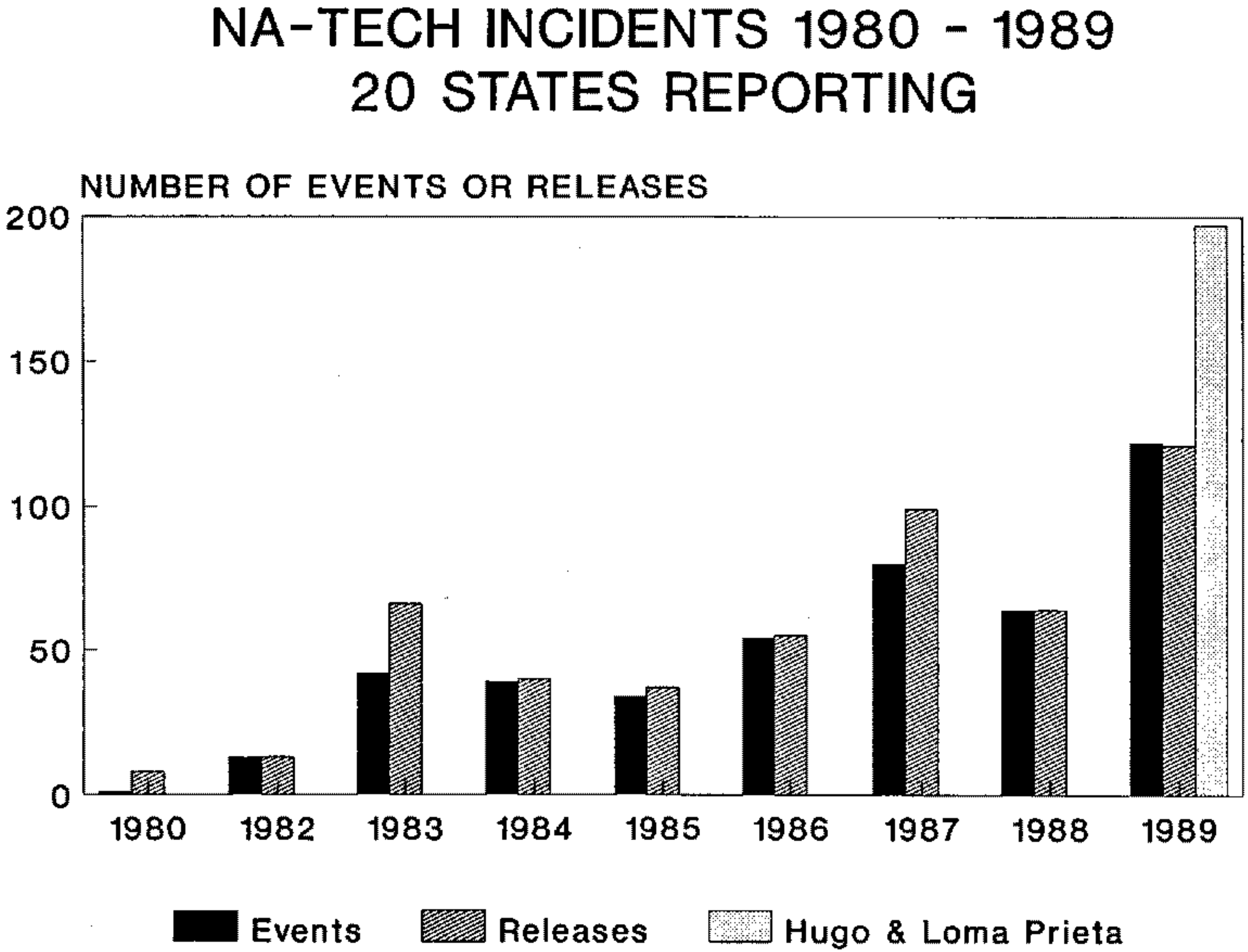


Figure 11. Na-Tech Events Occurring During the Decade 1980-1989.

none gave any indication that superior record-keeping was implemented toward the end of the decade. There is also no evidence indicating that the number of recorded natural disasters is increasing. Thus, it is concluded that the figures illustrate an increase in the actual number of na-tech events.

In the future, it is hoped that states will make an effort to track the occurrence of na-tech events. Up to the present, such record-keeping has been haphazard, or, even if it exists, difficult to retrieve. By identifying the fact that na-tech events exist as well as their most probable agents (i.e., earthquakes, then climatic events), emergency management agencies may become interested in tracking their occurrence. Up to this point, na-tech events were probably not recorded because the missing information simply was not "recognized as missing, so it was not sought" (Chelimsky, 1991, p. 227).

STATE AND FEDERAL HISTORICAL PERSPECTIVE

Question 4 was included in the survey in an effort to determine whether current record-keeping methods could help reveal what proportion of the country's natural disasters are producing na-tech events. Only after the survey had been distributed to all emergency management agencies was a listing of federal disaster declarations for each state acquired from FEMA. Comparing the FEMA numbers to those provided by the states (for federal disaster declarations) revealed some inconsistencies. Rather than assume that one set of records was superior to another, the FEMA documents were used to supplement the records provided by the states. FEMA records during the period 1980-1989 report 216 Presidential Disaster Declarations involving natural events (Table 4). Of these 216, 146 (68%), combined two types of natural hazard, and 30 (14%) were a combination of three or more natural hazards. The preponderance of combined events in Presidential declarations is probably due to the greater amount of destruction that they cause, and hence, the greater need for federal assistance. This hypothesis is borne out by the data provided by the respondents reporting in-state declarations where the number of single events outweighs the number of multiple events (Table 5). Flooding characterizes the largest number of disaster declarations in both national and state figures. Finally, the total number of state-declared single events would doubtless exceed the number of Presidential declarations during the decade, were such figures available from the 31 states unable to provide this information.

Table 4. Presidential Disaster Declarations Involving Natural Events: 1980-1989 (From FEMA Records)

SINGLE EVENTS		MULTIPLE EVENTS	
Type	Number	Type	Number
Coastal Storm	1	Coastal Storm/Flood	7
Earthquake	4	Coastal Storm/Flood/Mudslide/ Landslide	1
Fire	6	Dam or Levee Break/Flood	4
Flood	11	Hurricane/Flood	15
Hurricane	3	Hurricane/Tornado	1
Severe Storms	4	Severe Storm/Flood	92
Snow/Ice	4	Severe Storm/Flood/Coastal Storm	1
Tornado	5	Severe Storm/Flood/Mudslide/ Landslide	11
Volcano	2	Severe Storm/Flood/Mudslide/ Tornado	1
		Severe Storm/Flood/Tornado	16
		Severe Storm/Tornado	23
		Snow and Ice/Flood	2
		Tornado/Flood	2
TOTAL	40		176

Using the responses to Questions 1-4, an effort was made to estimate the number of hazmat releases that might be expected from a single natural event. The statistics are limited because only nine states were able to submit complete records regarding all three categories (na-tech events, state, and federal declarations). Table 6 indicates that 4 spills may be expected during a particular event, with that figure dropping to .36 spill if the two states with the most extreme figures (California and Texas) are removed from the calculations. These figures should be treated with utmost caution, however, because the data are incomplete due to a lack of reporting of such incidents (possibly because of routine handling at the local level). In retrospect, while the documentation provided by Question 4 was informative regarding a state's general susceptibility to natural disasters,

Table 5. State Disaster/Emergency Declarations Involving Natural Events: 1980-1989*

SINGLE EVENTS		MULTIPLE EVENTS	
Type	Number	Type	Number
Dam/Levee Break	3	Fire/Flooding/Mudslides/Thunderstorms	1
Drought	17	Fire/High wind	1
Earthquake	4	Fire/Wave action	1
Erosion	1	Flood/Hailstorm/High wind	1
Fire	37	Flood/Heavy rain	2
Flash flood	5	Flood/High tides/ Storm and wind-driven water	1
Flooding	50	Flood/High winds/Storms	1
Freeze	2	Flood/Ice jam	2
Heavy rain	4	Flood/Mudslides/Wildfire	1
High wind	1	Flood/Tornado	1
Hurricane	4	Hail damage/Tornado	1
Inclement weather	1	Heavy rain/High tides/High wind	1
Landslide/Mudslide	5	Heavy rain/Landslides	1
Severe Storm	1	Heavy wind/Torrential rain	3
Snow/Winter storm	14	High surf/High wind	1
Tornado	8	Severe storms/Tornados	1
Tropical storm	1		
Volcano	1		
TOTAL	159		20

* Figures do not represent all state declarations (e.g., "medfly infestation" is not included). Counts were only derived from state figures which were unambiguous, e.g., the number of events matched the number of "types" listed. Only 20 states were able to provide figures regarding in-state declarations.

Table 6. Reported Na-Tech Events Compared with State and Federal Disaster Figures*

State	No. Na-Tech Releases	No. State	No. Federal	Total State/ Federal	Approx. # Spills per Disaster
CA	228	21	19	40	5.7
FL	6	14	5	19	0.32
IL	17	11	8	19	0.89
MO	7	11	7	18	0.39
NV	2	1	1	2	1.0
PA	1	1	11	12	0.08
TX	389	1	20	21	18.52
VA	2	20	3	23	0.09
WI	2	4	6	10	0.20
Total	654	84	80	164	3.99
Total Excluding California and Texas:	37	62	41	103	0.36

* State and Federal figures do not include drought declarations. In addition, the figures in this table only represent those states that were able to clearly indicate the number of natural events responsible for na-tech events.

it was able to provide (in conjunction with Questions 1-3) little information regarding the interaction of natural and technological events.

EXISTING REGULATORY MEASURES

Survey Questions 5-7 attempted to discover the nature of existing laws, codes, regulations, or guidelines addressing possible interaction between natural and technological events. This information was sought for three reasons: 1) in order to determine whether the danger of na-tech events was being given explicit recognition through the development of codes; 2) to ascertain the levels at which codes were being enacted; and 3) in the belief that information regarding where codes exist could be a valuable resource for states which currently lack regulations, but may be considering their enactment in the future. Respondents offered the following observations.

Explicit Recognition: There was little indication of state legislation specifically designed to address the possibility of na-tech events. Frequently, general codes such as Article 80 of the Uniform Fire Code, guidelines contained within the National Flood Insurance Program (NFIP) (e.g., Statewide Building Codes [BOCA] and Floodplain Management Ordinances), the Uniform Building Code, and siting requirements described as following EPA rules were all that were provided as answers, imparting the impression that emergency managers find them useful in some capacity. Additional general responses to Question 5 included: 1) transportation codes used to restrict travel by transport vehicles on roadways during specified times (e.g., spring thaws), "safe haven" parking areas for trucks transporting hazardous materials, and codes following federal guidelines, such as the Department of Transportation's (DOT) Hazardous Material Transportation Regulations; and 2) codes for floodplains and wetlands restricting hazardous waste, fuel, and pesticide use, as well as the siting of treatment facilities and hazmat storage.

Level of Enactment: At the state level: 1) Delaware reported that its Department of Natural Resources does not issue permits in the 100-year floodplain; 2) the California Code of Regulations requires consideration of earthquakes when performing mitigation planning for facilities; 3) Oregon's OAR 340-120-015 governs the placement or storage of hazardous wastes in areas susceptible to hazards such as floods, landslides, and seismic activity while other comprehensive plans approved by their Land Conservation and Development Commission address hazardous wastes in those areas; 4) in Pennsylvania, efforts are underway which may result in stiffer restrictions on the location of above- and underground hazardous materials storage tanks; and 5) in Texas, companies must notify the Water Commission if they generate more than 100 kilograms of hazardous materials per month, while Senate Bill 1099 does not allow new sites in the 100-year floodplain or near a fault. At the local level: 1) Memphis-Shelby County in Tennessee reports that it is moving aggressively to incorporate seismic hazard risk data into land-use decisions relative to facilities that utilize hazardous materials; and 2) local jurisdictions reporting more restrictive codes than those provided at the state or federal level include: the Santa Clara County Toxic Gas Ordinance in California; Transportation Ordinances in Marion and Wayne counties, Indiana; floodplain management codes in

Clark County, Nevada; the counties of Beaufort, Aiken, and Lancaster in South Carolina; and the cities of Austin and Houston in Texas.

Existing Codes: Eight states indicated that they have documents that provide guidelines for mitigating the effects of technological emergencies caused by natural disasters. These states are: Georgia, Illinois, Missouri, Nevada, Oklahoma, Texas, Washington, and Wyoming. Most of these states were unable to provide the Natural Hazards Center with copies of the documentation because it was too extensive. Illinois and Washington, however, provided some documents with their surveys, and Oklahoma provided Annex P of their Emergency Operations Plan.

The uneven response to Questions 5-7 hinders the ability to draw any firm conclusions from the data, but may be of some use to states attempting to formulate their own codes. The responses that were received seem to indicate that, except in rare cases, the possibility of a na-tech event has yet to be addressed by legislative bodies. One reason for the absence may be the novelty of the concept and another may be that existing legislation is often interpreted as addressing na-tech hazards indirectly, through codes and laws enacted for other reasons.

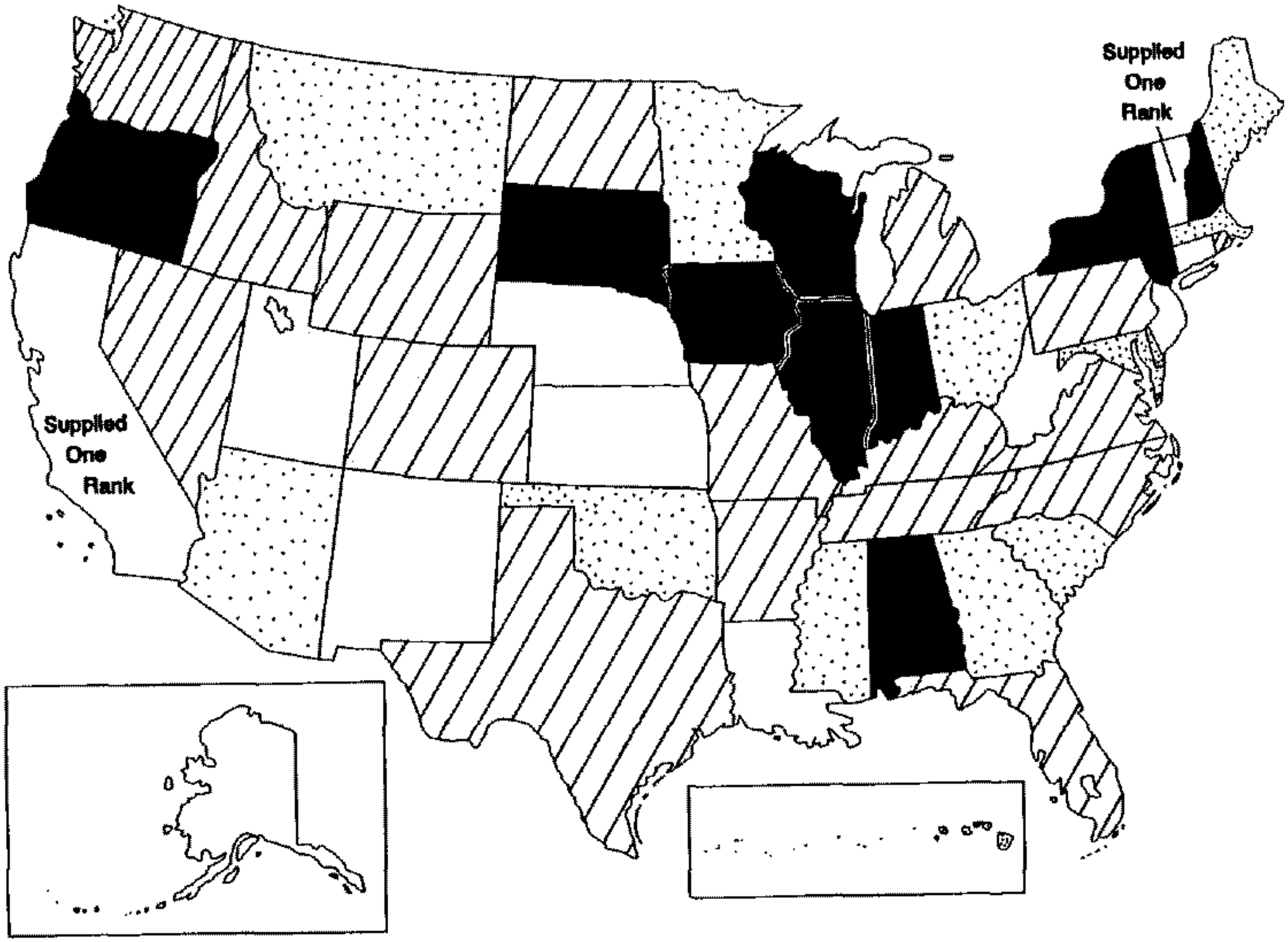
MEASURES OF NA-TECH SUSCEPTIBILITY AND SATISFACTION WITH MITIGATION

General Response

Question 8 asked respondents to rank on a scale of 1-5 (1=low, 5=high) two items: 1) the susceptibility of their state to a natural disaster causing a hazardous material release or other technological emergency, and 2) their satisfaction with the steps their state had taken to reduce the possibility of such an occurrence. Thirty-nine states supplied both rankings, two supplied one of the two rankings and two provided comments without rankings. The average ranking for susceptibility was 3.06 and for satisfaction was 2.88 (Table 7). A majority of states (17) ranked their susceptibility higher than their satisfaction, 13 states ranked their satisfaction higher than their susceptibility, and 9 states ranked their susceptibility and satisfaction equally (six choosing a rank of three, two choosing a rank of two, and one choosing a rank of four). Figure 12 illustrates the locations of these states. The hypothesis that those states indicating high susceptibility would have lower satisfaction rankings than those indicating

Table 7. Average Susceptibility/Satisfaction Rankings (1=low; 5=high)

State	Susceptibility Rank	Satisfaction Rank
AL	2	2
AR	5	2
AZ	2	4
CA	n/a	3.5
CO	4	1
DE	2	4
FL	4	3
GA	2	5
HI	2	3
IA	3	3
ID	4	2
IL	3	3
IN	3	3
KY	4	3
MA	2	3
MD	2	4
ME	1	2
MI	3	2
MN	1	4
MO	5	1
MS	3	4
MT	2	3
NC	4	2
ND	4	2
NH	2	2
NV	5	4
NY	4	4
OH	1	3
OK	3	3.5
OR	3	3
PA	5	3
RI	3	2
SC	2	3
SD	3	3
TN	3	2
TX	5	3
VA	4	3
VT	1	n/a
WA	4	2
WI	3	3
WY	4.5	3
Total	122.5	115
Average	3.06	2.88



Susceptibility ranked higher than Satisfaction = ▨
Satisfaction ranked higher than Susceptibility = ⊡
Susceptibility and Satisfaction ranked equally = ■
No Reply to the Questionnaire = □

Figure 12. Map Reflecting State Susceptibility/Satisfaction Levels.

low susceptibility was confirmed (Table 8). Comments accompanying the rankings, as provided by respondents, are enlightening. Those who ranked susceptibility higher than satisfaction voiced concerns over the following:

- That the possibility of na-tech disasters has not yet been seriously addressed. Although the potential of hazardous material releases accompanying natural disasters may be considerable, states that have not experienced such incidents may find it difficult to generate interest in taking steps to reduce their consequences. As a result, there is little preparedness, and mitigation is left to the response and recovery phase.
- There are unresolved growth management issues, such as when a state creates appropriate guidelines in good faith, only to have local governments undermine those guidelines by providing building variances allowing construction in hazard-prone areas. It can be difficult to accomplish needed goals under such circumstances.
- That resources or funding needed to mitigate a hazardous material release or to provide equipment and maintenance are lacking. It is felt that responsibility in this area should be shared at all levels of government, as well as with the private sector.
- The perception that the only localities with any regulations applying to a hazardous material release during a natural disaster are those participating in the National Floodplain Insurance Program, and that those floodplain ordinances only address hazardous materials as a secondary problem, e.g., storage of materials that may wash or float away. It seems frustrating that facilities utilizing hazardous materials and suffering less than 50% damage from a flood event may resume normal operations after recovery.
- That the amount of hazardous materials generated within and transported through the states continues to increase.
- That there needs to be additional emphasis on the management of hazardous materials use, storage, and manufacture in hazard-prone areas and there needs to be more "route control" of hazmat transportation.
- That even if a state is subject to significant threats from storms, flooding, tornados, and earthquakes it can be difficult to acquire the authority to require even the most basic preventative actions (such as spill prevention containment and countermeasures plans).

Respondents who ranked satisfaction higher than susceptibility generally felt that in their states:

- General highway programs combined with hazmat transportation requirements are sufficient to prevent most hazardous materials transportation risks arising from natural hazards.
- Suitable regulations are in place to mitigate such eventualities and mitigation and preparedness has been established and maintained.

Table 8. A Comparison of Satisfaction Rankings for Respondents Reporting High Susceptibility versus Respondents Reporting Low Susceptibility (1=low; 5=high)

High Susceptibility			Low Susceptibility		
State	Suscept. Rank	Satisf. Rank		Suscept. Rank	Satisf. Rank
AR	5	2	AZ	2	4
CO	4	1	DE	2	4
FL	4	3	GA	2	5
ID	4	2	HI	2	3
KY	4	3	MA	2	3
MI	3	2	MD	2	4
MO	5	1	ME	1	2
NC	4	2	MN	1	4
ND	4	2	MS	3	4
NV	5	4	MT	2	3
PA	5	3	OH	1	3
RI	3	2	OK	3	3.5
TN	3	2	SC	2	3
TX	5	3			
VA	4	3			
WA	4	2			
WY	4.5	3			
Total	70.5	40	Total	25	45.5
Average	4.15	2.35	Average	1.92	3.50

- Vulnerability to predictable (time, place, type) natural hazards is very low.
- Implementation of programs to replace hazardous chemicals with chemicals that pose little or no risk are reducing the number or amount of hazardous chemicals from commerce and therefore reducing the possibility of being impacted by natural hazards.
- It is difficult to achieve legislative consensus on such an issue.

Respondents who ranked their susceptibility and satisfaction equally noted that:

- Substantial measures are in place to satisfactorily handle any release of hazardous material resulting from natural causes, although some state and local building codes do not mandate substantially earthquake-proof construction.
- That, considering the availability of staff and financial resources, existing plans must suffice.
- And that, generally, hazardous materials are a local responsibility.

Finally, one respondent who gave a partial ranking commented that the question was too subjective to be meaningful. In that state, a significant portion of the population lives or works relatively close to facilities handling hazardous materials, yet little agreement could be found among colleagues regarding the state's susceptibility. The feeling was that the many steps taken to reduce the potential for damaging releases have safeguarded against major chemical or technological disasters caused by either human error or natural events.

Considering the comments in aggregate, it is clear that a basic difference of opinion exists. For those ranking susceptibility higher, current regulations are considered insufficient (for a variety of reasons) given the increasing number of hazardous materials being generated and transported. For those ranking satisfaction higher or ranking satisfaction and susceptibility evenly, current regulations are considered sufficient or that they must suffice given the low probability of a na-tech incident.

Comparison With Questions 1-3

Comparing states which were able to provide records of na-tech events (Questions 1-3) to states that did not have access to such records revealed that those reporting events felt much more susceptible (average ranking--3.6) and less satisfied (average ranking--2.72) than other states (average rankings 2.85 and 3.11, respectively; see Table 9). Access to records regarding specific in-state na-tech events clearly affected susceptibility/satisfaction rankings.

Table 9. A Comparison of Satisfaction Rankings of Respondents Reporting Na-Tech Events versus Respondents Not Reporting Na-Tech Events (1=low; 5=high)

Reported Na-Tech Events			No Reported Na-Tech Events		
State	Suscept. Rank	Satisf. Rank	State	Suscept. Rank	Satisf. Rank
CA	n/a	3.5	AL	2	2
CO	4	1	AR	5	2
FL	4	3	AZ	2	4
GA	2	5	DE	2	4
IL	3	3	HI	2	3
ME	1	2	IA	3	3
MO	5	1	ID	4	2
NC	4	2	IN	3	3
NV	5	4	KY	4	3
PA	5	3	MA	2	3
SC	2	3	MD	2	4
TN	3	2	MI	3	2
TX	5	3	MN	1	4
VA	4	3	MS	3	4
WA	4	2	MT	2	3
WI	3	3	ND	4	2
			NH	2	2
			NY	4	4
			OH	1	3
			OK	3	3.5
			OR	3	3
			RI	3	2
			SD	3	3
			VT	1	n/a
			WY	4.5	3
Total	54	43.5	Total	68.5	71.5
Average	3.6	2.72	Average	2.85	3.11

Comparison With Question 4

Comparing susceptibility and satisfaction levels with the in-state and federal disaster declarations requested in Question 4, it was hypothesized that, similar to the results in Table 9, respondents able to supply both state and federal figures would report higher susceptibility and lower satisfaction rankings by virtue of their better understanding of their state's overall vulnerability to natural disasters as a whole. Interestingly, this hypothesis was not confirmed. While states submitting in-state and federal figures ranked themselves as more susceptible (average ranking--3.3) than those states submitting incomplete figures (average ranking--2.45), they also were more satisfied (average ranking--3.07) than their counterparts for whom complete figures were unavailable (average satisfaction ranking--2.8) (Table 10). Therefore, impressions of high susceptibility did not directly correlate with low satisfaction, as in the previous table.

Separating and comparing the nine states reporting na-tech, state, and federal declarations against the 13 states with no information in any of these categories (Table 11), the susceptibility level for the nine states with complete information jumps from 3.3 in Table 10 to 4.25, while susceptibility for those states unable to access any information only rises from 2.45 to 2.8. A slight decrease in satisfaction is evident for states with complete information, falling from 3.07 to 2.9, while there is no change in satisfaction for states with no information.

Tables 8, 9, and 10 indicate that access to information increases impressions of susceptibility and as information becomes more detailed, susceptibility rankings rise accordingly. The slightly lower satisfaction rankings reported by those who did not have access to state and federal information may reflect dissatisfaction with record-keeping methods. The availability of accurate records appears to be directly related to respondent impressions of susceptibility, as well as with the satisfaction emergency preparedness officials hold regarding their state's levels of preparedness regarding na-tech events.

IMPRESSIONS OF NA-TECH PROBABILITY

Question 9 stated, "It has been suggested that despite apparent tremendous potential for technological emergencies resulting from natural disasters, the actual number of such incidents is relatively low. Do you agree with this statement? Why do

Table 10. A Comparison of Susceptibility and Satisfaction Rankings of Respondents Submitting both State and Federal Declarations versus Respondents Submitting Incomplete Declarations* (1=low; 5=high)

	Submitting State and Federal				No Submitted State and Federal				
St.	No. St.	No. Fed.	Suscept. Rank	Satisf. Rank	St.	No. St.	No. Fed.	Suscept. Rank	Satisf. Rank
AZ	56	4	2	4	GA	-	16	2	5
CA	31	19	-	3.5	IN	-	2	3	3
DE	0	0	2	4	KY	-	6	4	3
FL	18	5	4	3	ME	-	2	1	2
HI	11	11	2	3	MN	-	2	1	4
ID	33	3	4	2	NC	-	7	4	2
IL	12	8	3	3	NH	-	3	2	2
MD	1	2	2	4	SC	-	2	2	3
MI	1	5	3	2	TN	-	3	3	2
MO	14	7	5	1	VT	-	2	1	-
MS	55	8	3	4	WA	-	8	4	2
NV	2	1	5	4					
NY	3	4	4	4					
OH	25	7	1	3					
OR	29	0	3	3					
PA	2	11	5	3					
RI	1	1	3	2					
SD	5	7	3	3					
TX	1	20	5	3					
VA	20	3	4	3					
WI	4	6	3	3					
Tot.	324	132	66	64.5	Tot.	n/a	53.0	27.0	28.0
Ave.	15.4	6.3	3.3	3.07	Ave.	n/a	4.80	2.45	2.80

* States were not included in the "Incomplete Declarations" list if they were unable to supply the records personally.

Table 11. A Comparison of Susceptibility/Satisfaction Rankings for Respondents Able to Report Na-Tech, State, and Federal information versus Respondents Unable to Provide Information in Any of Those Categories (1=low; 5=high)

	Na-Tech, State, and Federal		No Information Available		
State	Suscept. Rank	Satisf. Rank		Suscept. Rank	Satisf. Rank
CA	-	3.5	AL	2	2
FL	4	3	AR	5	2
IL	3	3	IA	3	3
MO	5	1	IN	3	3
NV	5	4	KY	4	3
PA	5	3	MA	2	3
TX	5	3	MN	1	4
VA	4	3	MT	2	3
WI	3	3	ND	4	2
			NH	2	2
			OK	3	3.5
			VT	1	-
			WY	4.5	3
Total	34.0	26.5	Total	36.5	33.5
Average	4.25	2.90	Average	2.80	2.80

you believe this is the case?" Thirty five respondents (83%) agreed with the statement, four (10%) disagreed, and three (7%) were uncommitted. The reasons respondents agreed with the statement broke down into the following categories: good response team reactions; inadequate reporting procedures not reflecting reality; luck; effective regulations; effective planning; increased training and awareness; and, the most popular answer, the low probability that a na-tech event will occur. A breakdown of the number of times each category was chosen is presented in Figure 13. The data indicates that while the majority of respondents agree that the potential for a na-tech incident is high, most of them also conclude that the present lack of reported episodes is due to the low probability of such an occurrence. The belief in low probability does not, however, mean that those managers are satisfied with their state's level of preparedness for such an event. Table 12 compares those states who chose only "low probability" as an explanation against those who indicated that the few numbers of reported incidents are due to what could be termed "adequate mitigation measures" (i.e., they chose response, regulations, planning, and/or training/awareness). Although the low probability group feels somewhat less susceptible (2.75) than the mitigation group (2.88), they also are much less satisfied than the mitigation group (an average of 2.81 versus 3.50).

The lack of satisfaction exhibited by the low probability group may reflect an underlying concern that if their perception of low probability is shared by regulators, it may encourage regulatory complacency.

CHAPTER V
MITIGATION RECOMMENDATIONS

According to Quarantelli (1990), disaster planning has historically tended to be "agent-specific" with separate, distinctive plans organized around specific disaster agents such as hazmat releases, hurricanes, nuclear plants, floods, and earthquakes. We believe, however, that mitigation efforts should attempt to bridge "natural" and "technological" boundaries. If "our ultimate objective is to minimize fatalities, injuries, and economic losses . . . we must . . . turn our attention to . . . new hazards . . . increasingly present in our communities" (Tierney, 1989, p. 36). Na-tech events represent one of these "new hazards".

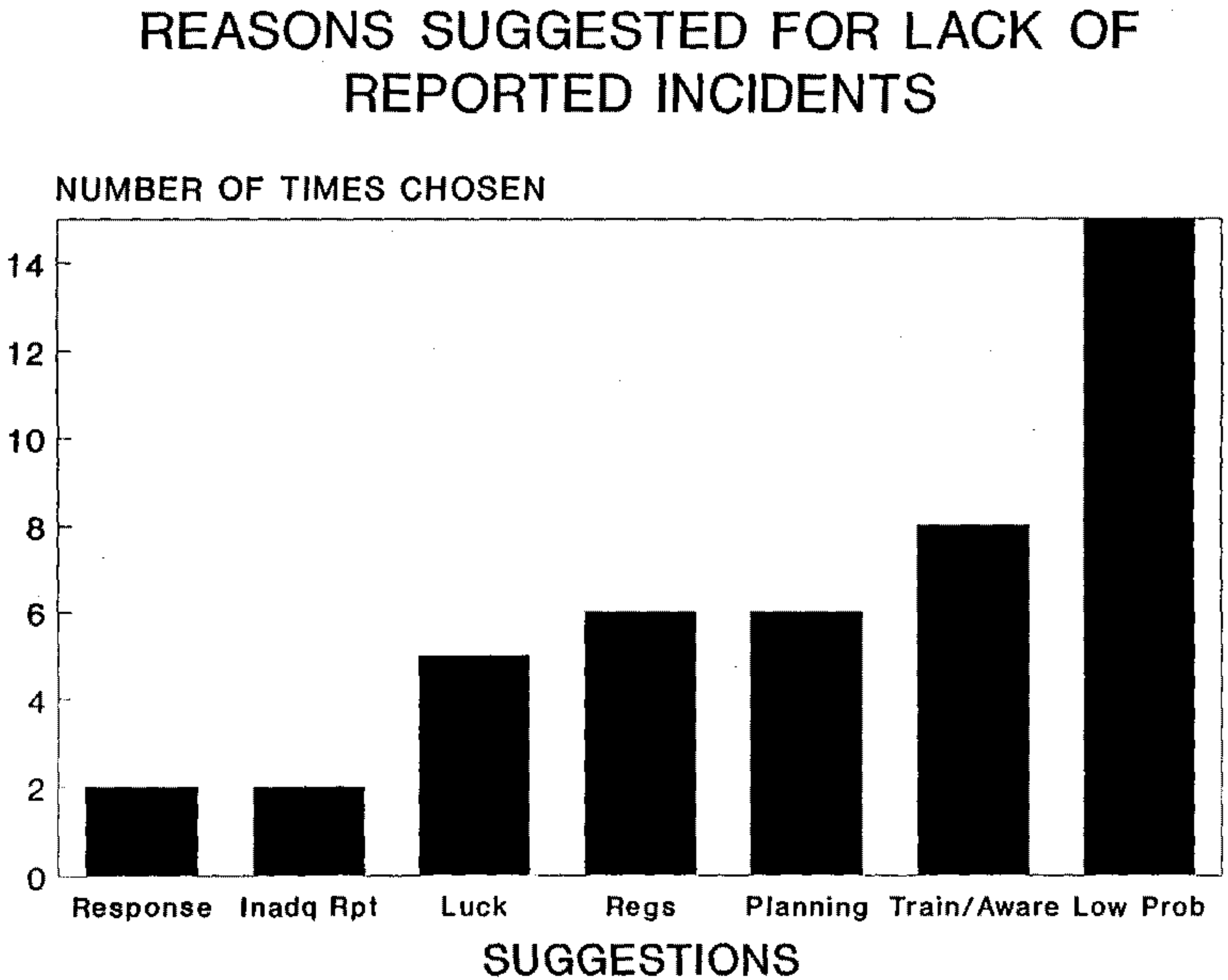


Figure 13. Why States Agreed Na-Tech Probability Low.

Table 12. Comparing Susceptibility/Satisfaction Rankings for Respondents Indicating Few Na-Tech Events are Due to Low Probability Versus Respondents Indicating Few Na-Tech Events are Due to Response, Regulations, Planning, and Training/Awareness (1=low; 5=high)

Low Probability			Response, Regulations, Planning, and Training/Awareness		
State	Suscept. Rank	Satisf. Rank	State	Suscept. Rank	Satisf. Rank
AL	2	2	AZ	2	4
FL	4	3	GA	2	5
HI	2	3	IL	3	3
IN	3	3	KY	4	3
MN	1	4	MD	2	4
MO	5	1	PA	5	3
MT	2	1	SC	2	3
NY	4	4	WI	3	3
OH	1	3			
TN	3	2			
TX	5	3			
VT	1	n/a			
Total	33	31	Total	23	28
Average	2.75	2.81	Average	2.88	3.50

Links between interactive hazards must be identified before disasters occur because "once the Flood's at the door, there's too little time and too much to do to allow for planning or cogent thought" (D'Acci, nd, p. 5). The problem of preparing for a na-tech event is, however, complicated by a number of factors including: the increasing volume and variety of hazardous materials stored and transported; the number of, and changes in, tenants handling such materials; the introduction of new materials and combinations of materials; and the wide range of involved agencies, organizations, and individuals whose interorganizational and jurisdictional complexities (including different, but over-lapping, roles) complicate efforts to develop mitigation and preparedness strategies (National Institute of Building Sciences, 1989; Tierney and Anderson, 1990). Attempting to surmount such problems during the heady days that follow a na-tech event could lead to short-term, politically expedient, and possibly maladaptive solutions. In an effort to assist managers who have yet to experience a na-tech event, the following recommendations have been compiled from observations gleaned from the literature, from those responding to hazmat releases following natural disasters, as well as from the respondents to our survey who were asked in Question 10, "If you wished to further reduce your state's susceptibility to a technological emergency as a result of a natural disaster, what would be your top **three** mitigation suggestions?"

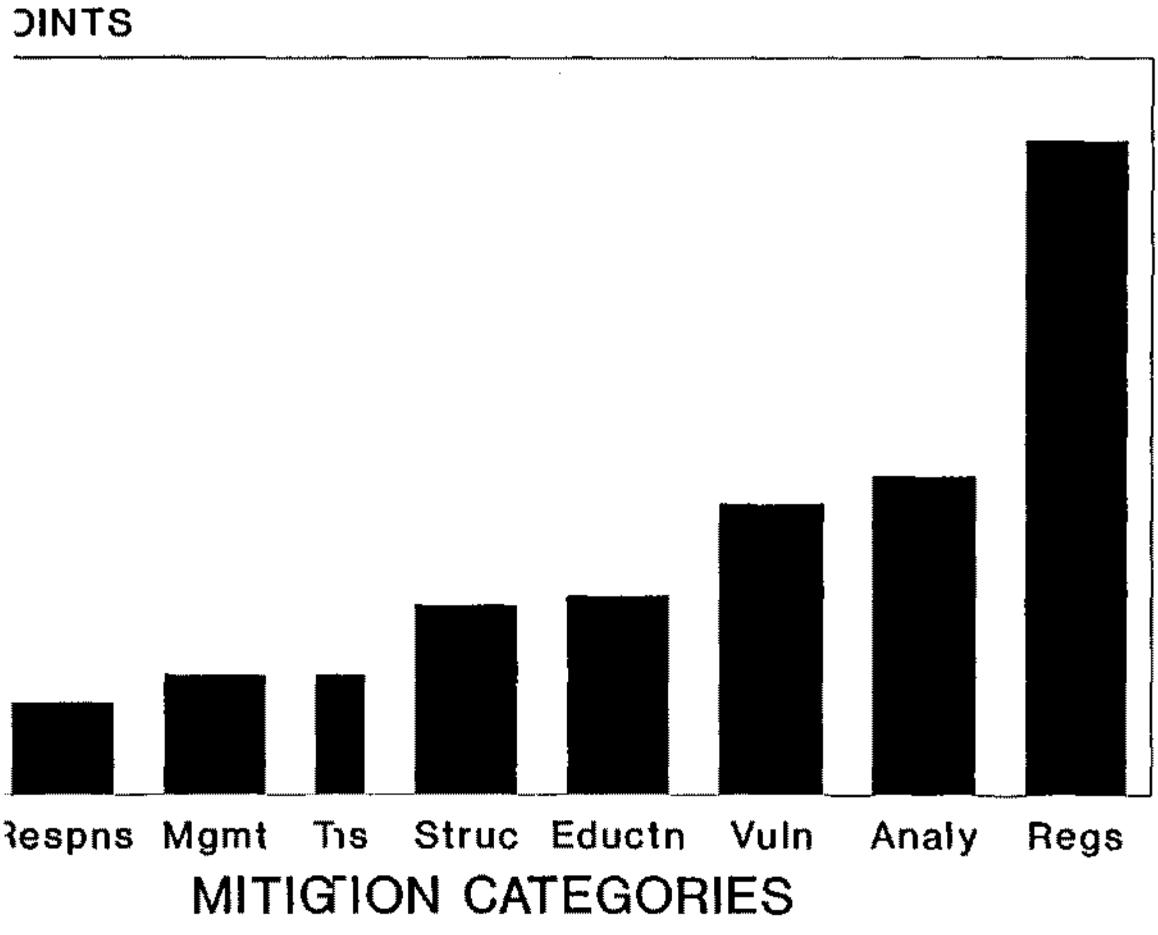
The three mitigation suggestions provided by the survey respondents generally fell into one of the following categories: develop and/or enforce appropriate regulatory measures; analyze, develop, and implement mitigation programs, projects and plans; perform a vulnerability analysis; increase training and awareness of officials and the public; develop and/or enforce appropriate transportation regulations; develop and/or enforce structural measures; improve land management of hazard-prone areas; improve response capabilities; and improve or add warning systems. These responses were weighted according to their selection as first, second, or third choices by giving a value of 5 to first choices, 3 to second choices, and 1 to third choices. Totalling each category provided a measure of its popularity which is reflected in Figure 14, and Figure 15 presents a breakdown of the suggestions as first, second, or third choices. A discussion of the mitigation suggestions is provided below.

PRE-EVENT RECOMMENDATIONS

Regulatory Measures

The most popular mitigation suggestion appearing on the survey was a call for regulatory measures. Suggestions from respondents as well as from the literature search reveal a wide range of actions that could be taken, for instance, requiring U.S. DOT and EPA regulations to consider natural disaster risks in the planning process and developing completed regulations to support the 1990 Federal Clean Air and Hazardous Materials Transportation Uniform Safety Acts. Another popular choice was enforcing and/or developing siting restrictions or guidelines for building or storing hazmat in hazardous areas (e.g., floodplains, waterways, "tornado alleys," falling rock zones, fault

IGATION SUGGESTIONS
WEIGHTED TOTALS



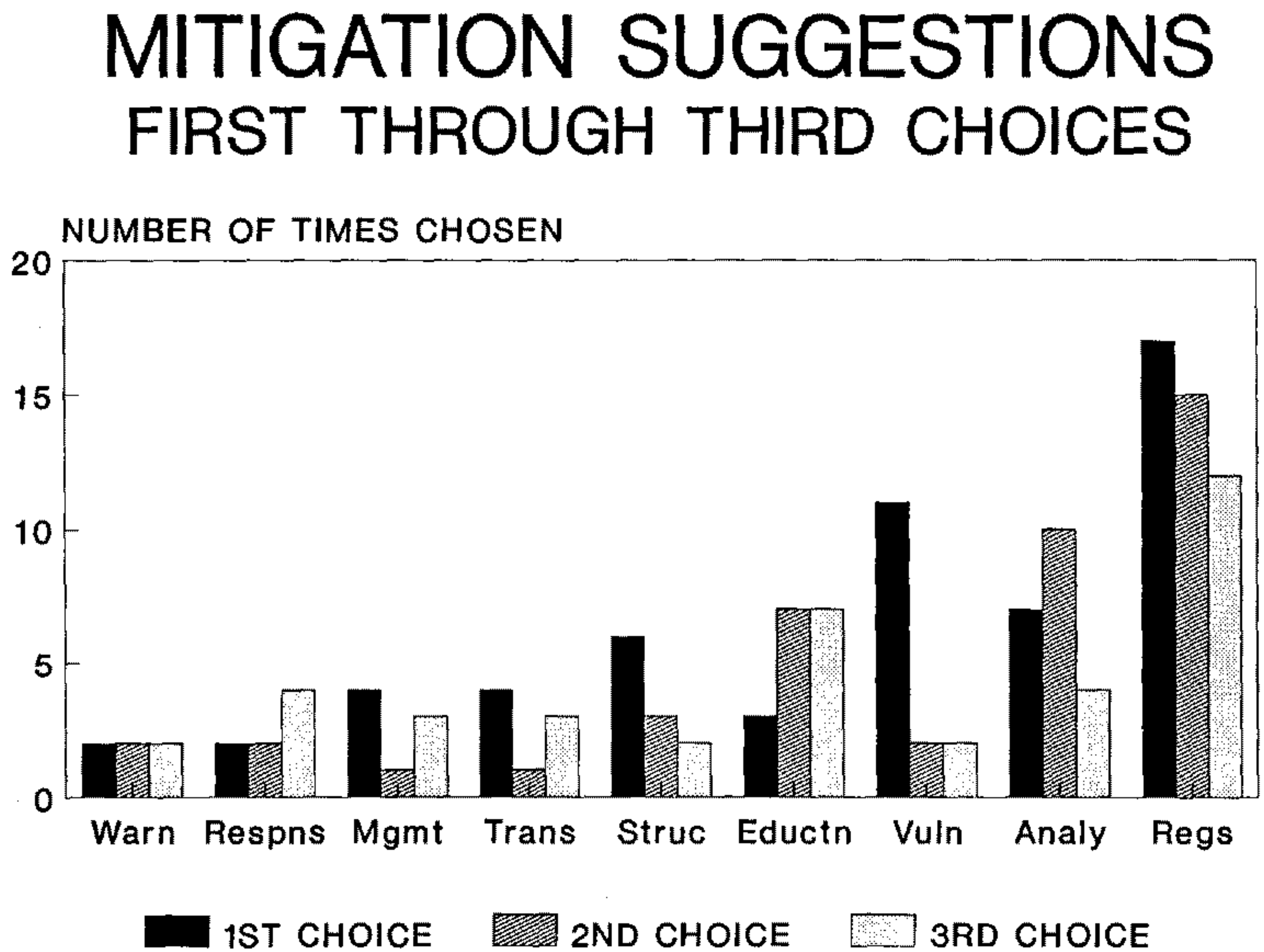


Figure 15. Number of Times Mitigation Suggestion Chosen.

zones) through the use of zoning, laws, permitting processes, and ordinances. For instance, written approval could be required from a state's fire marshal for the installation, replacement, or relocation in hazard zones of tanks, pumps, or drawing-off devices used with flammable or combustible liquids. Another frequent suggestion was instituting and enforcing tie-down requirements of hazmat storage containers to prevent movement if submerged in flood waters. It was felt that facilities utilizing or storing hazardous materials in a floodplain should be required to comply with National Flood Insurance Program, state, and local standards related to the 100-year base flood zone (or, preferably, to be able to withstand a flood of record exceeding the 100-year flood level). New hazardous waste facilities should be prevented from locating in floodplains and expansion or improvement of existing facilities should be tightly controlled. To fund the regulations, a fee system for those who manufacture, use, store, or transport hazardous materials could be implemented to provide planning, inspection, and enforcement funds.

It was felt that more definitive guidelines for state-wide mitigation actions were needed and that existing guidelines, such as Office of Safety and Health Administration (OSHA) standards for workplace safety, worker protection, training, and equipping, need to be more strictly enforced. Additional laws could limit facility storage of hazmats commensurate with toxicity effects on an exposed population in the event of a release; require businesses and persons who transport or use hazardous materials to have contingency plans in the event of a release; produce stricter land use controls, retrofitting of existing structures, and labeling of tanks to properly identify contents; and require operating instructions or procedures to be followed in the event of an emergency to be readily available, with personnel trained in emergency procedures kept informed of tank and emergency equipment location(s), and valve operation(s).

A final suggestion was to engage the insurance industry as an ally via a long-term program to adjust industry insurance rates to reflect the adoption of mitigation measures that minimize the potential for disaster generated damages, economic losses, and injuries.

The desire for regulatory measures is understandable since they: 1) document the seriousness with which various levels of government view the problem; 2) provide rigorous guidelines regarding acceptable activity; and 3) (if accompanied by funds) empower the emergency manager with the ability to monitor compliance. Since current data on na-tech events is still sketchy, however, it is recommended that any new regulatory policies that may be stimulated by this report "be cautious and flexible (maybe even reversible)," and that programs flowing from such policies may be most useful if they are initially small-scale (Chelimsky, 1991, p. 226-227).

Analyze, Develop, and Implement Mitigation Programs, Projects, and Plans

This category represents the second most popular mitigation suggestion received on the survey. Respondents and other sources suggested determining structural and non-structural mitigation measures that could reduce the threat or consequences of na-tech events. For instance, establishing in-state hazardous waste landfills and disposal sites which would include industrial and community household hazardous waste disposal. It was felt that public involvement would encourage proper handling and disposal of common hazardous wastes and would thus protect both urban and rural environments.

Additional research funds were advocated to more adequately determine what actions, rules, or laws currently address the possibility of na-tech events and what further actions may be necessary to improve preparedness. Research would help ensure that the possibility of na-tech events are incorporated into hazard analysis and local emergency operations plans, which assign responsibilities and duties in order to provide a successful response minimizing health, property, and environmental damage. Consideration of facility-specific or area-specific natural disasters as part of accident scenarios could be included in programs such as the Federal Superfund Amendments and Reauthorization Act (SARA) of 1986, Title III, the Clean Air Act of 1990, and the Hazardous Materials Transportation Uniform Safety Act of 1990.

Closer coordination among federal, state, and local agencies which have responsibilities dealing with hazardous materials releases or natural disasters should be established. Through the combined efforts of such agencies it might be possible to fund additional emergency operations centers and justify compiling, storing, and regularly updating at a single location information regarding industrial sites (e.g., who owns the property, what dangerous goods are stored on-site, what are the container/storage types and transport methods, who is the contact should a release occur). Such a central depository could house a geographic information system (GIS) capable of plotting known hazardous materials locations and their relationships to geographic features (e.g., floodplains, coastlines, buried or surface faults), thus helping site locations to be ranked in order of their susceptibility to natural forces. Specific information regarding hazmat sites could include: soil conditions/type, water table, saturation characteristics, susceptibility to liquefaction, drainage and vegetation characteristics, transportation routes and bridges, public utilities (water, power, waste), critical facilities (schools, hospitals, police/fire stations), and population density and distribution near the sites (from the census). With identification of types, amounts, and locations of hazardous materials, emergency preparedness exercises could incorporate releases of varying quantities of materials representing different levels of hazardousness to a community. Based on the experiences of the contingency planners at St. Croix, where "nature served warning . . . that worst case scenarios may be exceeded by unimaginable catastrophic events" (Bills and Whiting, 1990, p. 182), it is recommended that the largest hazmat release possible for an area be used for such exercises. Exercises help identify potential failure modes; calculate failure probabilities under different conditions; determine the amount of area effected by different materials under different conditions; estimate health effects on workers, community residents, and the environment (both immediate and long-term); and help identify where responsibility and costs for clean-up, medical care, and economic recovery will fall.

Vulnerability Analysis

This category represents the third most popular mitigation suggestion, one that most would consider the initial step for developing possible response measures for na-tech events. Suggestions advocated funding additional research into the problem of na-tech events, including obtaining and publicizing substantive data on types of hazmat releases that have occurred to-date as a result of natural disasters in order to quantify the extent of the problem. Only by doing so can states develop specific criteria against which to evaluate their vulnerability. Such data may also encourage counties to assess their vulnerability which could lead to the systematic incorporation of hazard and risk assessments into county and municipality land use plans.

Hazardous material sites in susceptible areas, such as chemical facilities in vulnerable coastal areas and inland flood zones, need to be identified. The vulnerability of coastal areas and earthquake risk areas also need to be studied to "factor in" the risks of large hazmat storage tanks.

Training and Awareness

As the fourth most popular mitigation suggestion, respondents advocated continuing training of public and private responders at all levels as one of the keys to successful response. Toward this end, the association of safety officials in a state could disseminate hazard mitigation tools, techniques, and strategies that can be integrated with existing safety programs to begin to minimize risk. Providing safe haven information to businesses and industries based on their plant floor plans and emergency operations plan (EOP) updates and exercises is one avenue that should be explored. It should also be possible to ensure that facility owners can handle worst case scenarios for their geographic area. Regulatory agencies should periodically inspect facilities, encourage training with facility personnel and local fire fighters, and increase the number (and publicize the results) of exercises in order to enhance public awareness and education. It is considered important to develop a more coordinated approach to general public awareness and education regarding chemicals, their uses, and the threats associated with hazardous materials. Education of the regulated community, the general public, and county officials may help produce a society that recognizes the need to properly manage such materials. An intensive education program could be initiated at the primary and secondary school levels to increase the awareness of hazardous materials found in everyday situations such as the home and school.

Three other suggestions round out our respondents' emphasis on pre-event mitigation measures:

Structural regulations could be used to require appropriate design and construction requirements for facilities using, producing, or storing hazardous substances keyed to mapped hazards zones (e.g., seismic-risk mapping or floodplains). Pipelines and storage facilities that contain hazardous materials should be required to be appropriately braced against various hazards (e.g., flood, high wind), and tanks located in floodplains should be protected, tethered, or otherwise secured to prevent free-floating in the event of a flood.

Transportation regulations could create or designate safe parking places or regional "safe havens" for vehicles transporting very hazardous materials or explosives through areas with a history of natural disasters. Such parking areas would be designed to protect the public and the environment in the event of a containment failure. Funding for creating the parking could be accomplished by charging a fee through SARA Title III-related state legislation for the transportation of hazardous materials and the fees could be used not only for safe havens but for equipment needed for responding to and handling hazardous materials incidents. Similar to the parking concept, specific routes should be developed for vehicles transporting very hazardous materials through states. Route selection would take into account factors such as natural disaster history and the potential for environmental damage along possible routes. In addition, state codes could be developed and enforced for transporting hazmats during periods of imminent natural disaster (e.g., during periods of potential or actual severe weather such as tornadoes, high winds, ice storms, flooding and other hazards), and to intensify cargo truck inspections.

Finally, **land management of hazardous areas** could be improved to: eliminate and prohibit chemical, fuel, or hazmat storage in the 100-year floodplain and/or to expand attention to facilities already located there to include design requirements and reporting procedures; require hazardous waste and material storage sites to be located away from Category 1 storm surge impact areas and the floodway as defined on FEMA flood maps; ensure proper siting of facilities and equipment with respect to their exposure to hazards and in accordance with considerations for susceptible populations; and to ensure that hazardous materials are stored in safe locations away from population centers.

POST-EVENT RECOMMENDATIONS

Suggestions that addressed the possibility of na-tech events after their occurrence were least frequently received and usually fell within the confines of response measures and warning systems. Our literature search also produced a recommendation regarding communications.

Response could be enhanced by placing appropriate resources (such as containment and handling equipment) in strategic locations state-wide so that local jurisdictions can reach them quickly to counteract hazmat spills. Response teams should be provided not only with equipment but with additional training and medical monitoring. Too often emergency responders are not safeguarded because funds are not available to provide adequate training. Improved response capabilities are needed because, as Cutter and Tiefenbacher note in the case of chemical releases, "despite federally mandated emergency response planning, the level of emergency preparedness . . . is still highly variable in this country" (1991, p. 419).

Additional **warning systems** were also advocated, along with the development of community-specific warning and evacuation plans for each high-risk situation.

For first responders, the ability to **communicate** using on-site radio telephones and a centralized use of a command center to locate and marshall resources can be critical. Response teams searching on foot will perform more efficiently if they have hand-held radios which eliminate the need to return to a vehicle in order to report their findings. Although cellular phones have sometimes been advocated for use during emergencies, their usefulness can be short-lived. The problem is that such phones access the nearest available tower, and, given the numbers of persons typically converging on a disaster scene (including the media and private citizens), overloading becomes almost inevitable. Cellular phones have jammed during at least two major incidents in the United Kingdom, and during a tire fire in Canada where the area around the site was labeled by the media as the "dead zone" because of phone problems (Scanlon, 1992, p. 38; Scanlon and Prawzick, 1991, p. 197).

It should be expected that a natural disaster will dismantle normal telephone and electrical service, therefore alternative means of communication are essential. Plants with hazardous materials should have radio communications adequate to receive natural disaster warnings where applicable (e.g., flood warnings), and to communicate with municipal and county emergency management agencies and officials as well as with any of their remote facilities. In addition, it is suggested that emergency managers take into consideration that a natural disaster violent enough to cause a hazmat release will also probably create difficulties gaining access to the site due to disrupted transportation routes. It will then follow that there will be problems with resource availability (material and human), leading to a reorganization of priorities due to excessive demands on the emergency response system, and that at the same time communications are sporadic or nonexistent and power and water services have been disrupted, the public still needs to be warned and/or evacuated (Tierney and Anderson, 1990).

Finally, we would like to note that although the majority of recorded na-tech events are, to date, associated with earthquakes (see Figure 10), recommendations received on the surveys were primarily concerned with activities associated with mitigating flood hazards. This concern probably reflects the fact that more states are susceptible to floods than earthquakes, however, we feel that such concern is justified considering the pervasive flood hazard in this country and the ease with which examples of na-tech events associated with flooding were found during our literature search.

CHAPTER VI
DISCUSSION OF SURVEY RESULTS

Survey results document an increase in na-tech events which do not correlate with the annual amount of damage or frequency with which a specific type of disaster occurs. Thus, the evidence indicates that low probability events such as earthquakes are the most frequent causes of na-tech events, which are themselves considered to be of low probability. The data would appear to support this impression with a best-case ratio of hazmat releases to natural disasters being approximately 1:3. Such odds, however, also confirm that na-tech events are not uncommon, even when calculating their frequency with figures believed to be artificially low due to non-reporting and local handling of incidents.

The majority of respondents believe that new regulations and/or enforcement/ expansion of old regulations could help mitigate the possibility of na-tech events. The preponderance of mitigation suggestions focusing on regulatory measures could be, in part, the residual effect from an earlier question respondents addressed in the survey regarding the existence of current codes and regulations. Recognizing that legislative bodies have yet to address na-tech events leads logically to the conclusion that such measures would be a good starting point. In reality, however, the starting point would ideally be in performing vulnerability analyses. But such analyses, in turn, are not possible without accurate, retrievable records that link natural disasters to hazmat releases.

The importance of accurate records was illustrated by the survey's measures of susceptibility and satisfaction. Although most states ranked their susceptibility higher than their satisfaction, the measures of susceptibility rose dramatically for those reporting the most complete information regarding in-state na-tech events, and disaster declarations at the state and federal levels. Satisfaction rankings for states reporting complete information were also higher, possibly because they are capable of explicitly recognizing na-tech occurrences and are therefore in a better position to mitigate their effects. The inability to locate records of na-tech events may lull officials to conclude that the na-tech problem simply does not exist.

Survey data revealed that respondents who felt that the present lack of reported na-tech episodes was due to their low probability also reported being less satisfied with their state's mitigation efforts. This underlying lack of satisfaction may be beneficial in the long run because normally, when the probability of a hazard is considered to be very low, people tend to behave as though it were zero because there are many common risks which must be addressed on a daily basis (Palm, 1981). It is difficult for individuals to conceptualize new threats that have yet to occur (Orr, 1979) because people are "strongly conditioned by their immediate past and limit their extrapolation to simplified constructs, seeing the future as a mirror of the past" (Kates, 1962, p. 88). The case studies presented in Chapter III may help dispel the notion that the possibility of a na-tech incident is so low that it can be ignored. This could be critical because "the less a situation is expected, the less likely relevant organizations will prepare and train for them" (Quarantelli, 1990, p. 12). Documentation of na-tech events may serve to adjust perceived notions of invulnerability, enabling emergency managers to be better equipped to face future emergencies. Even an event considered to have a *zero* probability of taking place cannot be interpreted as having a *zero possibility* of taking place. Such reasoning compels airline pilots to spend long hours in flight simulators while Machiavellian instructors introduce into their flights highly improbable sequences of events, such as hydraulic failure, wind shear, engine fires, and birds being sucked into air intakes. Emergency responders need to be equally prepared to react to low probability/

high consequence na-tech events. As Huff maintains, managers must "plan for three distinct types of crises . . .

- Events that are likely to occur
- Events that are unlikely, but nonetheless possible

[and]

- Events that seem virtually impossible" (1991, p. 6)

Ultimately, it appears that states need to: 1) develop methods to track na-tech events; 2) based on the new na-tech records, perform vulnerability analyses to assess the needs of specific counties; 3) following the vulnerability analyses, analyze and develop mitigation programs, projects, and plans including consideration for training and education; and 4) obtain the appropriate legislation that would enable implementation of these plans. Unfortunately, these steps require funding at a time of increased government cut-backs at the federal, state, and local level. Thus, it is probable that little will be done to curb the possibility of a catastrophic na-tech event until after such a disaster takes place. Historically, following disasters, lawmakers have quickly authorized funding for steps such as those outlined above. Those states willing and able to track na-tech events at this time will therefore be in an enviable position when funding for the other steps becomes available. By making such a preemptive effort it may be possible to avoid potentially maladaptive solutions to the problem that are sometimes characteristic of well-intentioned disaster-motivated legislation or reconstruction efforts.

CHAPTER VII
CONCLUSION

This study attempted to ascertain the nation's vulnerability to natural disasters causing hazardous materials releases, or "na-tech" events. A search of the literature and a survey of the nation's emergency management agencies revealed that na-tech events are more pervasive than commonly thought.

As was so dramatically revealed by the Edmonton tornado, hazards which co-exist can combine synergistically, thus, disaster response teams that specialize in either hazmat releases or natural disasters must create and maintain a dialogue in order to coordinate their efforts during na-tech events. The importance of taking such events into consideration is illustrated by the Chemical Manufacturers' Association's (CMA) "Community Awareness and Emergency Response" program which advises members that emergency plans should anticipate difficulties with organizational relationships when technological disasters occur during or in the aftermath of a natural disaster (Bolton, 1986). The most important implication of the CMA report is the recognition that extreme events do not impact hazardous material facilities selectively. When communities and commercial facilities are simultaneously affected by a natural disaster, response agencies become involved with assisting citizenry, which leaves hazardous material facility emergency plans that depend on the full cooperation of fire, police, and other emergency response departments inherently unworkable. The few number of reported events to-date should not be allowed to engender complacency. A survey of 300 communities in 19 cities found those communities generally inadequately prepared for serious chemical emergencies (Kasperson and Pijawka, 1985), and this was without considering the possibility of a na-tech type of event.

The similarities between natural and technological hazards that were outlined in Table 2 will continue to cause difficulties because modern humans increasingly "perceive the natural world as . . . within the realm of their control" (Rochford and Blocker, 1991, p. 187). It follows that if humans can "control nature" and something goes awry causing a na-tech event, a search ensues for someone to blame. Thus, in a na-tech event, the emergency manager may face being directly or indirectly held at fault not only for the hazmat release but for the natural disaster as well. This situation could be compounded by the way affected populations react subsequent to a na-tech event. For instance, after the Times Beach, Missouri/dioxin flood event, individuals exposed to both the flooding and the dioxin displayed greater "levels of depression, somatization, and anxiety" than people only exposed to the flood and "sought help for mental health problems at *twice the rate* of victims of either the floods or dioxin alone . . . (Soloman, Regier, and Burke, 1989, pp. 385-387; emphasis added). Thus, the natural/technological interface produces increased demands not just in terms of preparation, response, and recovery but also during post-recovery phases--in other words, at all possible levels of agency infrastructure.

Currently, the thinking among emergency planners who were contacted in the course of this research is that na-tech events have not been factored into the decision process because: 1) despite the potential for such events they rarely occur; 2) when they occur they are easily mitigated, and in some cases are "self-cleaning" in that floodwaters or rains disperse and/or detoxify dangerous agents; 3) compliance with current federal laws (e.g., SARA Title III) is for the most part satisfactory; 4) preparing for more common causative agents such as human error takes precedence; and 5) that na-tech events are mitigated as a by-product of other planning efforts.

Along with the Edmonton tornado, the case studies described in the text reveal that while the potential for a hazardous material release caused by a natural disaster may be low in an absolute sense, the threat is real and should a large incident occur its consequences are likely to be quite serious (Tierney, 1989, p. 35). In an effort to assess the nation's vulnerability to na-tech events, the research in this report reveals the following trends:

- the number of na-tech incidents is increasing and this does not appear to be related to improved record-keeping;
- even using figures which are considered artificially low, at least one hazmat incident can be expected per every three natural disasters;
- few regulations exist which explicitly recognize the ability of a natural disaster to cause a hazmat release, which does not encourage preparation for such events;
- most states rank susceptibility to na-tech events high and satisfaction with state preparation for such events low, and;
- managers able to pin-point na-tech events within their state and who had access to state and federal disaster declarations ranked themselves as significantly more susceptible to na-tech events.

Although most managers advocate increasing regulations to mitigate na-tech events, such proposals cannot be justified without firm data regarding how, when, and why they occur. It is therefore critical for states to begin incorporating methods to track na-tech occurrences within their current record-keeping efforts. Unfortunately, experience reveals a tendency to focus efforts on responding to events after the damage has taken place since "nothing helps to update risk assessment, vulnerability analysis, and emergency plans as much as a recent disaster" (Colorado Department of Public Safety, 1991, p. 30). Too often vulnerability assessments and statistical probability analyses have been "filed away and forgotten rather than used to affect public policy decisions before a disaster occurred" (Natsios, 1991, p. 112). We hope that this document can avoid such a fate. In any event, the evidence presented here will make it more difficult for policymakers to claim ignorance in the future should a na-tech event catch them unprepared.

REFERENCES

NA

1991a "In a Flash!" *American Weather Observer* (8)7: 1, 7.

1991b "2 Dead After Train Plunges Down Colorado Mountain." *The Orlando Sentinel* October 1, 1991.

1991c Reducing Toxic Waste: Collaborative Workshops with Developing Nations. *Inform Reports* 11(2): 1-5.

1992 "Quake Shakes Nuclear-Waste Space." *Science News* 141: 44.

Alaska Volcano Observatory Staff

1990 "The 1989-1990 Eruption of Redoubt Volcano." *EOS* (71)7: 265, 272-3, 275.

Alberta Public Safety Services

nd *Tornado: A Report*. Edmonton and Strathcona County, July 31, 1987.

Association of Bay Area Governments

1990 *Hazardous Materials Problems in Earthquakes: A Guide to Their Cause and Mitigation*. Oakland, California.

1991 *Toxic Gas Releases in Earthquakes: Existing Programs, Sources, and Mitigation Strategies*. Oakland, California, November

Benuska, L. (editor)

1990 "Loma Prieta Earthquake Reconnaissance Report." *Earthquake Spectra* Supplement to Volume 6, May.

Bills, C.E., and D.C. Whiting

1990 "Major Oil Spills, St. Croix, U.S. Virgin Islands." In *Oil Spills: Management and Legislative Implications, Proceedings of the Conference, Newport, Rhode Island*, May 15-18, 1990. New York: American Society of Civil Engineers.

Bolton, P.A.

1986 "Natural Hazards and Industrial Crises: Emergency Management Considerations." Paper presented at Conference on Industrial Crisis Management, New York University, September 5-6, 1986.

Bottome, R.S.

1990 "San Francisco Earthquake." *Asbestos Issues* May: 41, 125.

Brantley, S.R. (editor)

1990 *The Eruption of Redoubt Volcano, Alaska, December 14, 1989-August 31, 1990*. U.S. Geological Survey Circular 1061. Washington, D.C.: U.S. Government Printing Office.

Chelimsky, E.
1991 "On the Social Science Contribution to Governmental Decision-Making." *Science* 254: 226-231.

Colorado Department of Public Safety
1991 *Lessons Learned from Limon: A Tornado After-Action Report.* Disaster Preparedness Improvement Grant Program, August. Golden, Colorado: Division of Disaster Emergency Services.

Cutter, S.L., and J. Tiefenbacher
1991 Chemical Hazards in Urban America. *Urban Geography* 12(5): 417-430.

D'Acci, T.
nd "Using the Hazard Mitigation Process to Identify Interactive Hazard Locations in Base Floodplains." Unpublished paper, Washington State Department of Ecology.

Dickerson, D.A.
1989 "Toxic Chemicals Overlooked In Preparing for Quake." *Woodland Hills Daily News*, December 8.

Draper, III, A.C.
1990 "Full-Force Hurricane." *Asbestos Issues* May: 35, 38.

Eguchi, R.T., K.J. Tierney, and R.A. Antonoplis
1988 "An Assessment of the Risk of Hazardous Materials Release During Earthquake--The Impact on Surrounding Communities." In *Proceedings of the Ninth World Conference on Earthquake Engineering*, Vol. VII: 545-550. August 2-9, Tokyo-Kyoto, Japan.

Federal Emergency Management Agency
1990a *Disaster Mitigation Guide for Business and Industry*. FEMA 190/February 1990. 1990-719-571/10908. Washington, D.C.: U.S. Government Printing Office.

1990b *Interagency Hazard Mitigation Report, December 17, 1990*. Region V, FEMA 885-DR-Indiana.

1991a *Hazard Mitigation Opportunities in the State of Washington, Report of the Interagency Hazard Mitigation Team, FEMA-883-DR-WA*. Region X, January 9, 1991.

1991b *Interagency Hazard Mitigation Report, January 29, 1991*. Region V, FEMA 891-DR-Indiana.

Federal Emergency Management Agency Videotape
c. 1990 Hurricane Hugo in the Virgin Islands: The Federal Response.

Geological Society of America
1990 *Underground Storage of Nuclear Wastes and Salt Dome Storage of Hydrocarbons Among Themes of Geologic Sessions*. News release, October 31, 1990.

Holmes, R., and N. McCulloch
nd *The Edmonton Tornado: Edmonton, Alberta, Canada: Friday - 31 July 1987: Marking System Used for Building Searching*. Edmonton, Canada: Alberta Public Safety Services.

Huey, L. (compiler)
1990 *Overview of Earthquake Hazard Reduction in the Central United States: A Reader on Earthquake Hazard Reduction in the Central United States to Accompany Training Courses*. Open-File Report 90-94. Reston, Virginia: U.S. Geological Survey.

Huff, A.J.
1991 "Beware of Disasters that Aren't." *BICEPP News*, Summer.

Iacovelli, D.
1991 "Hugo Revisited." *American Weather Observer* 8(7): 9-11.

Johnston, A.C., and S.J. Nava
1985 "Recurrence rates and probability estimates for the New Madrid Seismic Zone." *Journal of Geophysical Research* 9: 6737-6753.

Kasperson, R.E., and K.D. Pijawka
1985 "Societal Response to Hazards and Major Hazard Events: Comparing Natural and Technological Hazards." *Public Administration Review* 45: 7-18.

Kates, R.W.
1962 *Hazard and Choice Perception in Flood Plain Management*. Department of Geography, Research Paper No. 78. Chicago, Illinois: University of Chicago.

Kay, J.
1989 "Toxics Do Little Damage." *San Francisco Examiner*, October 22.

Monastersky, R.
1991 "Christmas Quake Presents Geologic Gift." *Science News* 139: 164.

National Institute of Building Sciences
1989 *Strategies and Approaches for Implementing a Comprehensive Program to Mitigate the Risk to Lifelines from Earthquakes and Other Natural Hazards*. A report to FEMA, prepared by the Ad Hoc Panel on Lifelines, June. Washington, D.C.: Federal Emergency Management Agency.

National Response Team
1990 *Oil Spill Contingency Planning - National Status: A Report to the President*. S.K. Skinner and W. K. Reilly, October, 1990. Washington, D.C.

Natsios, A.S.
1991 "Economic Incentives and Disaster Mitigation." In *Managing Natural Disasters and the Environment*, A. Kreimer and M. Munasinghe (editors), pp. 111-114. Washington, D.C.: Environmental Policy and Research Division, Environment Department, The World Bank.

Orr, D.W.
1979 "Catastrophe and Social Order." *Human Ecology* 7(1): 41-52.

Palm, R.I.
1981 "Public Response to Earthquake Hazard Information." *Annals of the Association of American Geographers* 71(3): 389-399.

Pennsylvania Department of Community Affairs
1988 *A Special Report: Dangerous Materials and Substances and Flood Plain Management Regulations*. Flood Plain Management Division Information Series, August.

Quarantelli, E.L.
1990 *Similarities and Differences in Institutional Responses to Natural and Technological Disasters*. Disaster Research Center, Preliminary Paper #147. Newark, New Jersey: University of Delaware.

Rochford, E.B., Jr., and T.J. Blocker
1991 "Coping with 'Natural' Hazards as Stressors: The Predictors of Activism in a Flood Disaster." *Environment and Behavior* 23(2): 171-194.

Scanlon, J.
1992 *Convergence Revisited: A New Perspective On A Little Studied Topic*. Working Paper #75. Boulder, Colorado: Natural Hazards Research and Applications Information Center.

Scanlon, J., and A. Prawzick
1991 "Not Just A Big Fire: Emergency Response to an Environmental Disaster." *Canadian Police College Journal* 15(3): 166-202.

Slovic, P., H. Kunreuther, and G.F. White
1974 "Decision Processes, Rationality, and Adjustment to Natural Hazards." In *Natural Hazards: Local, National, Global*, G.F. White, (editor), pp. 187-205. New York: Oxford University Press.

Soloman, S.D., D.A. Regier, and J.D. Burke
1989 "Role of Perceived Control in Coping with Disaster." *Journal of Social and Clinical Psychology* 8(4): 376-392.

Tierney, K.J.
1988 "Earthquake-Generated Hazardous Materials Releases: Research and Policy Issues," in *Proceedings of the 2nd Japan-United States Workshop on Urban Earthquake Hazards Reduction, Shimizu, Japan*, July 27-29, pp. 248-250. Japan: Institute of Social Safety Science; U.S.: Earthquake Engineering Research Institute.

1989 "Secondary Hazards Resulting from Earthquakes: Hazardous Materials Emergencies and High-Rise Fires." *Urban Resources* 5(4): 33-36.

Tierney, K.J., and R.C. Anderson
1990 *Risk of Hazardous Materials Release Following an Earthquake.* Preliminary Paper #152, Disaster Research Center. Newark, New Jersey: University of Delaware.

Towfighi, P.
1991 "Integrated Planning for Natural and Technological Disasters." In *Managing Natural Disasters and the Environment*, A. Kreimer and M. Munasinghe, editors, pp. 106-110. Washington, D.C.: Environmental Policy and Research Division, Environment Department, The World Bank.

U.S. Army Corps of Engineers
1990 *After Action Report - Corps of Engineers Response to the Loma Prieta Earthquake.* San Francisco, California: South Pacific Division, December.

U.S. General Accounting Office
1991a *Disaster Assistance: Supplemental Information on Hurricane Hugo in South Carolina.* GAO/RCED-91-150. Washington, D.C.: Resources, Community, and Economic Development Division.

1991b *Reports and Testimony: July 1991.* GAO/OPA-91-12. Washington, D.C.: Office of Public Affairs.

Zeigler, D.J., J.H. Johnson, Jr., and S.D. Brunn
1983 *Technological Hazards.* Resource Publications in Geography. Washington, D.C.: Association of American Geographers.

SOME ADDITIONAL REFERENCE MATERIALS

N/A
1992 *Community Safety Element of the San Francisco Master Plan Background Report 1: Review of Seismic Information*. February. San Francisco, California: Department of City Planning.

Association of State Floodplain Managers (ASFPM)
1990 "ASFPM Report: Results of Regulations Committee Survey." October 1, 1990. Madison, Wisconsin.

Bolton, P.A.
1987 "Hazard Mitigation Implementation for Natural and Technological Hazards." Paper presented at Natural Hazards, Technological Risks, and Society Workshop, Boulder, CO, August 14-16.

D'Acci, T.
1991 "A November to Remember." *Washington Coastal Currents* 15(8): 6-7).

Denning, E.J.
1992 "Hazardous Materials Hazards as Secondary Results of Flooding: A Case Study of Planning and Response." Quick Response Report No. 49. Boulder, Colorado: Natural Hazards Research and Applications Information Center.

Drabek, T.
1986 *Human Responses to Disaster*. New York: Springer-Verlag.

Goodman, P.G., and C.E. Vaughan
1988 "The Implications of Times Beach: A Post-Disaster Field Study in Eastern Missouri." *Journal of Environmental Health* 51(1): 19-21.

Hwang, H.H.M., and C-H.S. Chen
1990 "Seismic Hazard Along a Crude Oil Pipeline in the Event of an 1811-1812 Type New Madrid Earthquake." National Center for Earthquake Engineering Research Technical Report NCEER-90-0006. New York: State University of New York at Buffalo.

Jackson-Russel, L., J.B. Perkins, and G.S. Silverman
1986 "Special Problems Posed by Hazardous Materials in Earthquakes." Workshop Curriculum Material. Oakland, California: BAREPP, May.

Jovanovic, P.
1988 "Modelling of Relationships Between Natural and Man-Made Hazards. In, *Natural and Man-Made Hazards*, M.I. El-Sabh and T.S. Murty, editors, pp. 9-17. Dordrecht, Holland: D. Reidel Publishing Co.

Kiremidjian, A.S., K. Ortiz, R. Neilsen, and B. Safavi
1983 *Seismic Risk to Major Industrial Facilities*. Report to the National Science Foundation, Grant No. CEE-8116997.

Kuroiwa, J.
1988 "Physical Planning for Multi-Hazard Mitigation." In, *Natural and Man-Made Hazards*, M.I. El-Sabh and T.S. Murty, editors, pp. 805-816. Dordrecht, Holland: D. Reidel Publishing Co.

Lafornara, J.P., H.J. Lamp'l, T. Massey, and R. Lorenzetti
1978 "Hazardous Materials Removal During 1977 Johnstown, Pennsylvania, Flood Emergency." *Information Transfer*: 156-160.

Reitherman, R.K.
1982 "Earthquake Caused Material Releases." In *1982 Hazardous Material Spills Conference Proceedings*, pp. 170-177. Rockville, Maryland: Government Institutes, Inc.

Seligson, H.A., and R.T. Eguchi
1990 "Societal Risk Associated with Crude Oil Transmission Systems in Areas of Seismic Risk: A Survey of Earthquake Performance of Liquid Fuel Pipelines and Facilities." Draft report prepared for the National Center for Earthquake Engineering Research. Los Angeles, California: Dames and Moore.

Tierney, K.J., and R.T. Eguchi
1989 "A Methodology for Estimating the Risk of Post-Earthquake Hazardous Materials Releases." Paper presented at the Association of Bay Area Governments annual Hazardous Materials Conference and Exhibition, San Jose, April 19.

Tierney, K.J., H.A. Seligson, and R.T. Eguchi
1990 "Chemical Hazards, Mitigation, and Preparedness in Areas of High Seismic Risk: A Methodology for Estimating the Risk of Post-Earthquake Hazardous Materials Releases." Draft report prepared for the National Science Foundation and the National Center for Earthquake Engineering Research. Dames and Moore, Los Angeles.

Trumbull, T.
1989 "Earthquakes and Hazardous Substances." *Refuse News*, December.

Wright, S.K.
1986 *A Users Manual for Flood Evacuation Planning of Water and Wastewater Treatment Plants*. Publication No. 87. Harrisburg, Pennsylvania: Susquehanna River Basin Commission.

APPENDIX A

UNABRIDGED ANSWERS TO THE NA-TECH SURVEY

QUESTION 1

CHEMICAL EMERGENCIES CAUSED BY NATURAL DISASTERS

STATE	YEAR	CAUSE	EVENT DESCRIPTION AND ITS IMPACT
AK	No reply to questionnaire		
AL	Accurate information not currently available		
AR	Information not available		
AZ	No records available		
CA	The responder provided an attachment from which all following information regarding earthquake-related releases was derived. In addition the responder noted, "We have no comparable record for other natural disasters. However, the lack of anecdotal accounts suggests that these events are rare."		
	1980	Earthquake	Livermore - approximately 8 chemical releases from various locations.
	1983	Earthquake	Coalinga - approximately 15 chemical releases from various locations.
	1987	Earthquake	Whittier Narrows - approximately 20 chemical releases from various locations.
	1989	Earthquake	Loma Prieta - approximately 163 chemical releases from various locations.
CO	1980s	Floods	Flooding along the Rio Grande where a railroad bridge was washed out and two box car loads of fertilizer was dumped in the river. Early 1980s.
	1982	Flood	Flooding along the upper reaches of the Arkansas in Chaffee County which went into old mines and brought out heavy metals into the stream. Same thing along Clear Creek and the Schwartzwalder Mine. Around 1982.
	1984	Floods	Flooding in both Grand Junction and Durango which affected the tailing ponds in these areas carrying the tailings down stream.
CT	No reply to questionnaire		
DC	No reply to questionnaire		
DE	None		

FL	1985	Northeastern (Winter Storm)	- salt spray from wind caused some power transformers to explode, spilling PCB Oil on the ground. (Jacksonville)
		Hurricane Kate	- a boat sank off the east point of Florida, nine (9) fifty-five (55) gallon drums containing acetone washed on shore.
GA	No record of chemical incidents caused by natural disasters prior to 1990.		
	<u>1990</u>	Flood	Richmond County, Georgia - 22 chlorine tanks weighing 240 lbs. each were washed away during flood. One tank damaged to the point of leaking. Seventeen tanks have not been recovered.
HI	None		
IA	Information not available		
ID	None		
IL	1987	Wind, Lightning	- on five separate occasions, lightning struck transformers associated with telephone lines causing the release of Polychlorinated Biphenyl (PCB). Minor ground contamination occurred but there was no serious threat to either the environment or the local population. - on two separate occasions, high winds associated with thunderstorm activity overturned transformers releasing Polychlorinated Biphenyl (PCB). Minor ground contamination occurred but there was no serious threat to either the environment or the local population.
	1988	Wind, Lightning	On two separate occasions lightning stuck a transformer and on four separate occasions high winds associated with thunderstorms overturned transformers causing the release of PCB in each instance. Minor ground contamination occurred but there was no serious threat to either the environment or the local population.
	1989	Wind, Lightning	- a 125,000 gallon capacity above ground tank was ruptured by high winds during a thunderstorm causing the release of an unknown quantity of a 28% nitrogen solution. Minor ground contamination occurred but there was no serious threat to either the environment or the local population. - on one separate occasion high winds overturned a transformer and on three separate occasions

lightning struck a transformer causing a release of PCB in each instance. Minor ground contamination occurred but there was no serious threat to either the environment or the local population.

Additional Note from IL:

* Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) mandated businesses to file hazardous substance release notifications with the State Emergency Response Commission (SERC). Although some business officials filed hazardous substance release notifications with this agency at their discretion prior to 1986, it was not until this agency's appointment as Illinois SERC in 1987 that it became a requirement. Therefore, our records of hazardous substance spill or release reports cover the year 1987 to the present. Our records before 1987 show no reported hazardous material related incidents resulting from natural causes.

IN No technological emergencies caused by natural disasters 1980-1989.

KS No reply to questionnaire

KY Unable to categorize incidents in this fashion; reporting system categorizes incidents by major hazard only; note records and survey of staff indicate no significant hazardous materials have resulted from natural calamities. Note however that KY has experienced occasion problems in re fuel tanks (LPG, heating oil, etc.) floating as a result of floods, resulting in obstructions at bridges, potential risk of explosion.

LA Per telephone conversation--unable to locate anyone with recorded information regarding natural/technological hazards. No written material forthcoming.

MA Information not available

MD None. Note: Record management procedures require record disposition after two years. No records available to response to questions 1-3. There were no known occasions where a natural event triggered a technological event (at least not since '84 and not involving floods!)

ME 1987 Flood During flood incident, stocks of TRIS, the flame retardant used in children's clothing, were dumped into flood-swollen river to eliminate costs of hazardous waste disposal. Attorney General successfully prosecuted. Water intake for Indian Island, Old Town, had to be shut down several days. No known health effects.

MI N/A

MN It would be difficult, if not impossible, to review 10 years of calls/reports of chemical spills, oil spills, and radiological incidents to determine if any were caused by natural hazards. (Our data simply do not indicate this type of connection.) However, in reviewing this matter with other staff, no one can recall any significant chemical spill, oil/fuel spill, or radiological emergency that occurred as a direct result of any type of natural hazard.

MO	1982	Flood	The problem with dioxin contamination at Times Beach was further complicated by Meramec River flooding.
	1984	Flood	Drums of chemicals were washed downstream in flooding near Valley Park, MO and elsewhere.

Additional Note from MO:

In addition to these incidents "caused" by natural disasters, natural phenomena often contribute to accidents involving hazardous chemicals. Fog, snowy and icy roads result in increased highway accidents, including motor vehicles transporting chemicals; high water flow makes it harder to control barges at certain critical points on the Mississippi River--accidents with barges increase at these times. There have been cases of floods, storms, and high winds causing dispersal of hazardous chemicals. Our current information management system doesn't allow MONR [Missouri Department of Natural Resources] to track and correlate these events. We hope to improve on this system in the near future.

MS	1990	Flood	Flooding caused displacement and rupture of high pressure natural gas line crossing the Old Tambigbee River Channel, northwest of Amory. Pipeline provided primary gas service for the City of Tupelo (population 23,905). 12,000 users were without service for three days during Christmas weekend with temperature below freezing.
MT	Information not available		
NC	1989	Hurricane	Loss of electric power caused by high winds destroying distribution system caused sewage plant pumps to fail allowing raw sewage to flow down city streets (Gaston County).
	1990	Ice storm	Contributed to tractor trailer accident spilling a "Poison B" placarded substance (Rowan County).
ND	Information not available		
NE	No reply to questionnaire		
NH	None reported.		
NJ	Our record keeping does not relate hazardous materials incidents with natural disasters.		
NM	No reply to questionnaire		
NV	None		

NY	We have no record of such occurrences. While I would expect to know about major spills triggered by natural disasters, smaller hazardous materials incidents would likely have to be dealt with by local responders and, in the midst of a major natural disaster, would not likely be reported to emergency management officials.		
OH	There are no specific records that identify a natural disaster causing a chemical [oil, or radiological] incident in list-form. To check this out EPA said it would entail reviewing approximately 72,000 reports (incident reports) to see if it had happened. My contacts couldn't remember any specific cases of a hazard incident being "caused" by a natural hazard. Our records here in my files show causes such as human error, mechanical problems, stress breakdown of equipment, transportation wrecks but none specifically stating this occurred because of hail, wind, flood, etc.		
OK	Information not available		
OR	Although numerous, small, transportation related chemical spills, releases or emergencies have occurred, there have been no major incidents.		
PA	1989	Heavy Rains	Washed out section of track between West Newton and Reduction, Westmoreland County, Pennsylvania. Caused two CSX trains traveling in opposite directions to collide. Dumped 20,000 gallons of cetyl dimethyl betaine (foaming agent used in making detergents) into the Youghiogheny River. Killed over 9,000 fish and required shutting down McKeesport water treatment facility for over eight hours. 31,000 people were affected. Cleanup required almost three weeks.
RI	None		
SC	1989	Hurricane	Category IV Hurricane (Hugo) blew down large oak tree. Tree fell on pipe rack to bulk aboveground storage tank. 3000 gal. of Isopropyl alcohol were lost. No surface water affected.
SD	No known incidents caused by a natural disaster.		
TN	1985	Floods	Waste treatment facility in Jackson, TN was flooded; creosote was released; clean-up was impeded by flood conditions; 400 gallons washed away.
	1990	Fog	Severe fog conditions led to 99 car/truck pile-up on I-75. Truck carrying oxidizer was in wreck; material was contained; rescue efforts were temporarily jeopardized.

TX	1982	U/K*	Two chemical spills due to "acts of God."
	1983	U/K	Twenty two chemical spills due to "acts of God."
	1984	U/K	Seventeen chemical spills due to "acts of God."
	1985	U/K	Fourteen chemical spills due to "acts of God."
	1986	U/K	Fourteen chemical spills due to "acts of God."
	1987	U/K	Twenty four chemical spills due to "acts of God."
	1988	U/K	Twenty four chemical spills due to "acts of God."
	1989	U/K	Fifty one chemical spills due to "acts of God."

Additional Note from TX:

*** Data taken from computer printouts which identify spills due to "acts of God" which includes any atmospheric or geological phenomena such as hail, windstorm, flood, landslide, earthquake, hurricane, tornado, volcanic eruption, frost, lightning strikes, or the like, which causes a spill or release to occur. Unfortunately, the Spill Incident Information System does not accommodate a sort of data by a specific phenomenon. However, all data is available as public information at the Texas Water Commission for individuals interested in further researching the causes of the spills.**

UT	No reply to questionnaire		
VA	1985	Flood	During the period November 3-7, 1985, heavy rains caused by a lingering storm and remnants of Hurricane Juan, occurred in the central and western part of the State. These rains caused record-breaking flooding in the headwaters of the Roanoke, James, and Potomac River Basins. Storage yards containing 55 gal drums of paints, solvents, and other hazardous material were flooded resulting in 1200-1500 drums being carried away into the river basins. These drums are still being found along the rivers today.
VT	None		
WA	1986	Flood	Excessive rainfall caused the Chehalis River to overflow, flooding downtown Chehalis. The flood waters entered an abandoned underground tank containing Pentachlorophenol, a wood preservative, which floated on top of the water. The Pentachlorophenol floated around the city hall, the Darigold Plant, other businesses and residences in a four block area. The area was evacuated resulting in some businesses being closed and approximately 90 persons being out of their homes for an extended time period (5 days to 1 month).
WI	1984	Tornado	In general terms, we can say that hazardous materials, particularly oils and fuels, posed a problem in the 1984 Barneveld tornado. This was a level V or VI tornado which literally flattened the)

village of Barneveld; population approximately 600. Immediately after the storm, the village was evacuated for fear of fire or explosion from ruptured gas lines, ruptured propane tanks, etc. Disposal of hazardous wastes and debris contaminated by hazardous materials also was an issue. The State Department of Natural Resources worked with Barneveld in addressing this problem. A permit was granted to open a special disposal site, with very specific restrictions and instructions on its operation and long-term maintenance. Separate records are kept for natural disasters and hazardous materials incidents. It is difficult, therefore, to go back and correlate the two and to cite specific types of spills resulting from a given tornado or flood.

WV No reply to questionnaire

WY Unable to retrieve detailed information requested due to limited resources.

QUESTION 2

<u>OIL/FUEL SPILLS CAUSED BY NATURAL DISASTERS</u>

STATE	YEAR	CAUSE	EVENT DESCRIPTION AND ITS IMPACT
AK	No reply to questionnaire		
AL	Accurate information not currently available		
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AZ	No records available		
CA	The responder provided an attachment from which all following information regarding earthquake-related releases was derived. In addition the responder noted, "We have no comparable record for other natural disasters. However, the lack of anecdotal accounts suggests that these events are rare."		
	1983	Earthquake	Coalinga - approximately 10 spills in various locations.
	1989	Earthquake	Loma Prieta - approximately 12 spills in various locations.
CO	Accurate information not currently available		

CT	No reply to questionnaire		
DC	No reply to questionnaire		
DE	None		
FL	1984	Northeastern (Mideast Storm)	Heavy seas from a "no name" storm caused a ship to run aground in West Palm Beach. Minor fuel spill.
	1987	Fog, Heavy Seas	Ship hit the jetties at the entrance to the St. John's River. Major oil spill followed.
GA	1982	Ice	Lumpkin County - Ice Storm caused propane tanker truck to overturn in Dahlonega, Georgia. The area (one mile) was evacuated until truck removed.
	1990	Flood	Richmond County - Flooding at waste oil recycling site resulted in the raised water table pushing gasoline and oil to the surface. Residents complained of headaches and odor. EPA cleaned up the area in approximately three weeks.
	1991	Flood	Laurens County - Water entered a 4,000 gallon underground diesel storage tank and displaced the fuel. Fuel ran through a mobile home complex and into a creek.
		Wind/Rain	Haralson County - Wind blew several mobile homes off their foundations. Gas leaks resulted from broken gas lines. Area evacuated until shut off completed.
HI	None		
IA	Information not available from respondent		
	1989	Storms	From EPA Incident Report form via James MacDonald. 1) "Pole blew down, broke busing on transformer. Oil leaked into unmown ditch." 2) "Storm blew down pole, oil leaked onto road, no rain after this." 3) "Lightning struck a transformer." 4) "Transformers knocked over into feed storage building and contaminated sacks of feed." 5) "Pole with transformer was knocked down." 6) "Transformer was hit by lightning."
ID	None		
IL	1989	Lightning	Lightning is attributed to a ruptured pipeline that was transmitting natural gas. The release occurred

			in the form of a vapor cloud that inflamed suddenly. Because of its location, this release did not present a threat to the general public. There were no injuries and evacuation from the vicinity of the fire was not required. Fire fighters and natural gas company crews extinguished the blaze and mended the ruptured pipe.
		Flood	Flash flooding caused a 10,000 gallon gasoline tank to become dislodged from its base anchors. The tank was ruptured while floating freely in the high flood waters causing the release of an undetermined quantity of unleaded gasoline. The tank was repaired when flood waters subsided. The tank was less than half full when the release occurred. The rupture was small and damage was caused solely by the release was not determined. No one was injured during this ordeal.

Additional Note from IL:

* Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) mandated businesses to file hazardous substance release notifications with the State Emergency Response Commission (SERC). Although some business officials filed hazardous substance release notifications with this agency at their discretion prior to 1986, it was not until this agency's appointment as Illinois SERC in 1987 that it became a requirement. Therefore, our records of hazardous substance spill or release reports cover the year 1987 to the present. Our records before 1987 show no reported hazardous material related incidents resulting from natural causes.

IN	None		
KS	1987	Storm?	From EPA Incident Report form via James MacDonald. "A 3 KVA pole blew over and transformer ruptured, spilled 6G mineral oil."
		?	From EPA Incident Report form via James MacDonald. "1906 oil well, unplugged and now in river bed as a result of river course change."
		High winds	From EPA Incident Report form via James MacDonald. "10 KVA power pole transformer blew off in heavy wind. 1 qt. spilled."
	1988	Storm?	From EPA Incident Report form via James MacDonald. "Wind blew pole down, transformer fell on roof of building."

KY Unable to categorize incidents in this fashion; reporting system categorizes incidents by major hazard only; note records and survey of staff indicate no significant hazardous materials have resulted from natural calamities. Note however that KY has experienced occasion problems in re fuel tanks (LPG, heating oil, etc.) floating as a result of floods, resulting in obstructions at bridges, potential risk of explosion.

LA Per telephone conversation--unable to locate anyone with recorded information regarding natural/technological hazards. No written material forthcoming.

MA Information not available

MD None. Note: Record management procedures require record disposition after two years. No records available to response to questions 1-3. There were no known occasions where a natural event triggered a technological event (at least not since '84 and not involving floods!)

ME	1987	Flood	Tanks containing approximately 6,000 gallons #6 Bunker Oil ruptured. Oil rose to top of water and coated everything it touched with thick, gummy oil. Several homes were affected inside and out. Guilford, ME.

MI I am not aware of any such documented incidents.

MN It would be difficult, if not impossible, to review 10 years of calls/reports of chemical spills, oil spills, and radiological incidents to determine if any were caused by natural hazards. (Our data simply do not indicate this type of connection.) However, in reviewing this matter with other staff, no one can recall any <u>significant</u> chemical spill, oil/fuel spill, or radiological emergency that occurred as a direct result of any type of natural hazard.

MO	1982	Flood	Meramec River flooding--fuel tanks were floated off foundations and propane tanks floated free downriver.
	1984	Flood	Rising water on Fish Pot Creek floated a tank of diesel fuel off its stand. At least two water supplies downstream on the Meramec River were threatened. The state of Missouri cleaned up the spill. Propane tanks and fuel tanks were also involved in flooding near Valley Park and elsewhere. Numerous propane tanks of various sizes were floating down the river.
	1987	High winds?	From EPA Incident Report form via James MacDonald. "Wind blew diesel storage tank over."
		Flood	During Missouri River flooding, numerous above ground storage tanks were floated off their foundations and underground tanks were floated out of the ground and propane tanks went floating free down the river.
	1988	Flood?	From EPA Incident Report form via James MacDonald. "Water floated oil out of tank."

Additional Note from MO:

In addition to these incidents "caused" by natural disasters, natural phenomena often contribute to accidents involving hazardous chemicals. Fog, snowy and icy roads result in increased highway accidents, including motor vehicles transporting chemicals; high water flow makes it harder to control barges at certain critical points on the Mississippi River--accidents with barges increase at these times. There have been cases of floods, storms, and high winds causing dispersal of hazardous chemicals. Our current information management system doesn't allow MONR [Missouri Department of Natural Resources] to track and correlate these events. We hope to improve on this system in the near future.

MS	None		
MT	Information not available		
NC	1984	Hurricane Diana	Caused numerous oil tainted with PCB's spills due to transformers falling from power poles.
	1989	Lightning	Lightning struck a 2 million gallon capacity above ground storage tank. Tank contained approximately 60,000 gallons of JPS. Fuel burned, blistering adjacent tanks. Location: Rac__ Island near Morehead City, N.C.
		Dam break	Heavy rains caused an earthen dam failure that flooded a pesticides storage lot and contaminated area in Fayettville, N.C.
		Hurricane Hugo	- 20,000 gallon petroleum tank washed into river. Tank empty but containing explosive vapors. No evacuation. Rockingham County. - entire inventory of natural gas company tanks washed down river posing explosive hazard. Watauga County. - numerous reports of natural gas line breaks due to uprooted trees severing underground lines. Mecklenburg, Gaston, and Catawba Counties.
	1990	Fog	Contributed greatly to 73 car accident on I-40 with numerous tractor/trailer saddle tank ruptures. Haywood County.
ND	Information not available		
NE	1988	Storm?	From EPA Incident Report form via James MacDonald. "Above ground tank activated. Possible magnetic relay activated by lightning."
	1989	Storm	From EPA Incident Report form via James MacDonald. "Damage to a pole mounted transformer because of a storm."
NH	None reported.		

NJ	Our record keeping does not relate hazardous materials incidents with natural disasters.		
NM	No reply to questionnaire		
NV	1986	Flood	Flood waters raised the Truckee River up until the natural gas line was taken out by debris. Natural gas was lost in three counties. Repairs were made 7 days later.
NY	We have no record of such occurrences. While I would expect to know about major spills triggered by natural disasters, smaller hazardous materials incidents would likely have to be dealt with by local responders and, in the midst of a major natural disaster, would not likely be reported to emergency management officials.		
OH	There are no specific records that identify a natural disaster causing a chemical [oil, or radiological] incident in list-form. To check this out EPA said it would entail reviewing approximately 72,000 reports (incident reports) to see if it had happened. My contacts couldn't remember any specific cases of a hazard incident being "caused" by a natural hazard. Our records here in my files show causes such as human error, mechanical problems, stress breakdown of equipment, transportation wrecks but none specifically stating this occurred because of hail, wind, flood, etc.		
OK	Information not available		
OR	As with question one ("Although numerous, small, transportation related chemical spills, releases or emergencies have occurred, there have been no major incidents."), no significant activity as a result of natural hazards.		
PA	1990	Landslide	Landslide ruptured a 10-inch pipeline, owned by Buckeye Pipeline Company, in South Buffalo Township near Freeport, Pennsylvania. Approximately 100,000 gallons of mixed petroleum products spilled with 1,800 barrels (about 99,000 gallons) entering the Allegheny River. Affected 14 water authorities, one public utility, and 66 municipalities. Three large corporations closed water intakes or went on restricted use. Many small businesses were forced to close due to water conservation measures. Sixty five water buffalos were employed and a pipeline was laid from Bull Creek to the community of Brackenridge. About 100 residents of a senior citizen high-rise in Freeport were evacuated when the fumes caused some to experience headaches and nausea.

RI	None		
SC	1989	Hurricane	The following petroleum spills were caused by Hurricane Hugo on September 21, 1989. This was a category IV hurricane, with sustained winds of 135 mph and gusts to 160 mph. Hurricane Hugo also produced a storm surge of 20.4 feet. Damage was usually caused by falling trees, flying objects, and the wall of water in the storm surge. Seven (7) gallons of mineral oil, Berkeley county; in Georgetown county, two incidents where 250 gallons of diesel fuel were released and two incidents where unknown quantities of diesel fuel and heating oil were released; 100 gallons of diesel fuel released in Horry county; 4 gallons of transformer oil in Kershaw county. 10,000 gallons of a mix of gas, diesel, and kerosene released from a bulk storage facility in Lee county. In this case, three aboveground tanks were blown over and lost all of their contents. There was no environmental impact on surface water in the area. Hugo's winds blew over aboveground storage tanks in Richland county (>1000 gallons of diesel fuel) and Charleston county (>1000 gallons of diesel and gasoline). In Georgetown county, two aboveground tanks located at marinas, one which released 1900 gallons of diesel fuel and the other >1000 gallons of the same, were blown over and pushed by the storm surge several miles into the marsh from their original locations.
SD	None		
TN	1990	Floods	Rail tank cars with LPG were swept into the river in Copperhill, TN, spilling contents. Cars retrieved, several hundred gallons of LPG were not contained due to conditions.
	1991	Tornado	Level IV tornado in Hardin County damaged 30,000 gallon LPG tank. Vapors leaked; evacuation conducted. Leak impeded evacuation/ medical treatment of tornado victims.
		Floods	Three 500 gallon LPG tanks were dislodged from foundation; floated down Tennessee River; spill was not contained due to weather conditions.
TX	1982	U/K*	Nine oil/fuel spills due to "acts of God."
	1983	U/K	Nineteen oil/fuel spills due to "acts of God."

	1984	U/K	Seventeen oil/fuel spills due to "acts of God."
	1985	U/K	Thirteen oil/fuel spills due to "acts of God."
	1986	U/K	Thirty eight oil/fuel spills due to "acts of God."
	1987	U/K	Forty oil/fuel spills due to "acts of God."
	1988	U/K	Thirty one oil/fuel spills due to "acts of God."
	1989	U/K	Fifty four oil/fuel spills due to "acts of God."

Additional Note from TX:

* Data were taken from computer printouts which identify spills due to "acts of God" which includes any atmospheric or geological phenomena such as hail, windstorm, flood, landslide, earthquake, hurricane, tornado, volcanic eruption, frost, lightning strikes, or the like, which causes a spill or release to occur. Unfortunately, the Spill Incident Information System does not accommodate a sort of data by a specific phenomenon. However, all data is available as public information at the Texas Water Commission for individuals interested in further researching the causes of the spills.

UT	No reply to questionnaire		
VA	1985	Flood	Heavy rains in the central and western part of the State caused record-breaking flooding in the headwaters of the Roanoke, James, and Potomac River Basins (same event as in Question #1). Several liquid propane bulk storage tanks were swept off their foundations and swept downstream, venting propane gas until the tanks were empty. One empty tank is still sitting on a river island. Many 100 lbs LPG tanks were also washed away. In Richmond, five fuel storage tanks in a tank farm were floated off their foundations, although they were contained within the farm, one was in danger of capsizing.
VT	None		
WA	1990	Flood	Record setting rains pushed the Skagit River to approximately 9 feet above its flood stage. This caused the levees to fail in several areas, flooding the farm land in a number of areas. The majority of these farms installed their own diesel tanks for their own farm machinery. Additionally, some also had propane tanks to heat their buildings. The excessively high flood waters floated the fuel out of the diesel tanks and loosened the propane tanks from their moorings. The result was a large amount of diesel fuel being distributed by the flood waters and propane tanks floating downstream.
WI	1984	Tornado	In general terms, we can say that hazardous materials, particularly oils and fuels, posed a

problem in the 1984 Barneveld tornado. This was a level V or VI tornado which literally flattened the village of Barneveld; population approximately 600. Immediately after the storm, the village was evacuated for fear of fire or explosion from ruptured gas lines, ruptured propane tanks, etc. Disposal of hazardous wastes and debris contaminated by hazardous materials also was an issue. The State Department of Natural Resources worked with Barneveld in addressing this problem. A permit was granted to open a special disposal site, with very specific restrictions and instructions on its operation and long-term maintenance.

Additional Note from WI:

Separate records are kept for natural disasters and hazardous materials incidents. It is difficult, therefore, to go back and correlate the two and to cite specific types of spills resulting from a given tornado or flood.

WV No reply to questionnaire

WY Unable to retrieve detailed information requested due to limited resources.

QUESTION 3

RADIOLOGICAL EMERGENCIES CAUSED BY NATURAL DISASTERS

STATE	YEAR	CAUSE	EVENT DESCRIPTION AND ITS IMPACT
AK	No reply to questionnaire		
AL	Accurate information not currently available		
AR	Information not available.		
AZ	No records available		
CA	None in California.		
CO	Accurate information not currently available		
CT	No reply to questionnaire		
DC	No reply to questionnaire		
DE	None		

FL	1985	Hurricane Elena	Storm stalled off the West Coast near Cedar Key, causing shutdown of Crystal River Nuclear Power Plant.
	1985	Wildfires	Fire burned power lines causing a loss of off-site power to Turkey Point Nuclear Power Plant.

GA Georgia has not experienced any radiological material releases, spills or emergencies caused by natural disasters.

HI None

IA Information not available.

ID None

IL None

IN None

KS No reply to questionnaire

KY Unable to categorize incidents in this fashion; reporting system categorizes incidents by major hazard only; note records and survey of staff indicate no significant hazardous materials have resulted from natural calamities. Note however that KY has experienced occasion problems in re fuel tanks (LPG, heating oil, etc.) floating as a result of floods, resulting in obstructions at bridges, potential risk of explosion.

LA Per telephone conversation--unable to locate anyone with recorded information regarding natural/technological hazards. No written material forthcoming.

MA Information not available.

MD None. Note: Record management procedures require record disposition after two years. No records available to response to questions 1-3. There were no known occasions where a natural event triggered a technological event (at least not since '84 and not involving floods!)

ME None known.

MI None by natural disasters.

MN It would be difficult, if not impossible, to review 10 years of calls/reports of chemical spills, oil spills, and radiological incidents to determine if any were caused by natural hazards. (Our data simply do not indicate this type of connection.) However, in reviewing this matter with other staff, no one can recall any significant chemical spill, oil/fuel spill, or radiological emergency that occurred as a direct result of any type of natural hazard.

MO None

Additional Note from MO:

In addition to these incidents "caused" by natural disasters [see Questions 1 and 2], natural phenomena often contribute to accidents involving hazardous chemicals. Fog, snowy and icy roads result in increased highway accidents, including motor vehicles transporting chemicals; high water flow makes it harder to control barges at certain critical points on the Mississippi River--accidents with barges increase at these times. There have been cases of floods, storms, and high winds causing dispersal of hazardous chemicals. Our current information management system doesn't allow MONR [Missouri Department of Natural Resources] to track and correlate these events. We hope to improve on this system in the near future.

MS None

MT Information not available.

NC	1984	Hurricane Diana	Caused operating difficulties at Brunswick Nuclear Power Plant forcing shutdown. Brunswick County.
	1985	Tunnel Collapse	Radioactive transport truck trapped in I-40 tunnel collapse. No leakage, no contamination. Haywood County.
	1989	Hurricane Hugo	Potential problem with McGuire Nuclear Power Plant having all means of warning and notification of public destroyed by high wind. Mecklenburg County.

ND Information not available

NE No reply to questionnaire

NH None reported.

NJ Our record keeping does not relate hazardous materials incidents with natural disasters.

NM No reply to questionnaire

NV	1986	Flood	Flood water damaged radiological detection instruments, instruments have radiological sources. The instruments were dug out of the mud and properly disposed of. Note some calibration instruments have a source of 500 Rad which is enough radiation to kill or cause serious health problems.

NY We have no record of such occurrences. While I would expect to know about major spills triggered by natural disasters, smaller hazardous materials incidents would likely have to be dealt with by local responders and, in the midst of a major natural disaster, would not likely be reported to emergency management officials.

OH There are no specific records that identify a natural disaster causing a chemical [oil, or radiological] incident in list-form. To check this out EPA said it would entail reviewing approximately 72,000 reports (incident reports) to see if it had happened. My contacts couldn't remember any specific cases of a hazard incident being "caused" by a natural hazard. Our records here in my files show causes such as human error, mechanical problems, stress breakdown of equipment, transportation wrecks but none specifically stating this occurred because of hail, wind, flood, etc.

OK Information not available

OR None

PA None to report.

RI None

SC No RAD emergencies caused by natural disasters.

SD No known radiological releases caused by a natural disaster.

TN No such emergencies.

TX None reported.

UT No reply to questionnaire

VA None

VT None

WA None

WI We haven no records indicating we've had this type of occurrence.

WV No reply to questionnaire

WY Unable to retrieve detailed information requested due to limited resources.

QUESTION 4

Note: an asterisk (*) indicates an incident added from FEMA records.

DISASTER HISTORY

STATE	YEAR	CATEGORY	NUMBER	TYPE OF DISASTER(S)
AK	1986	Federal	2	Coastal storm, high winds and waves*; severe storms and flooding*
	1988	Federal	1	Fire*
	1989	Federal	2	Severe freezing*; flooding*
AL	1980	Federal	1	Severe storms, tornadoes and flooding*
	1981	Federal	2	Severe storms, tornadoes and flooding*; severe storms and flooding*
	1983	Federal	1	Severe storms, flooding and tornadoes*
	1985	Federal	1	Hurricane Elena*
	1989	Federal	1	Severe storms and tornadoes*
AR	1980	Federal	1	Severe storms and tornadoes*
	1982	Federal	1	Severe storms flooding and tornadoes*
	1983	Federal	1	Severe storms, flooding*
	1987	Federal	2	Tornadoes*; severe storms and flooding*
	1988	Federal	1	Severe storms and tornadoes*
AZ	1980	State	11	Flood; fire (wildland)+; energy; infestation; SAR+; asbestos
		Federal	1	Flood
	1981	State	3	Hazmat++
	1982	State	4	Flood
	1983	State	7	Winter; rain; asbestos; civil disorder
		Federal	2	Flood
	1984	State	4	Flood
		Federal	1	Flood
	1985	State	5	Mudlift; agricultural loss
	1986	State	6	Flood; infestation; mass casualty
	1987	State	4	Drought
	1988	State	6	Flood; drought; winter
	1989	State	6	Flood; drought; infestation

+ Open Proclamation for each year 1980-1989
++ Open Proclamation for each year 1981-1989

STATE	YEAR	CATEGORY	NUMBER	TYPE OF DISASTER(S)
CA	1980	State	1	Series of earthquakes
		Federal	4	Rains, high tides, strong winds and flooding; rain, winds, mudslides and flooding; lower Jones Tract levee break; major brush fires and

				winds
	1981	State	2	Mediterranean fruit fly infestation; major brush fires
	1982	State	1	Early and unseasonable rains
		Federal	5	Heavy winds, rains, flooding and mudslides; strong winds and raging fire; McDonald Island levee failure; heavy rains and flooding; high winds and fires
	1983	State	3	High winds, storms and flooding; Mexican fruit fly; levee failure-Bradford.
		Federal	4	Heavy rains, high winds, tides and flooding; Coalinga earthquake; flooding along Colorado River; flash flooding*
	1984	State	4	High tides, flood, storm and wind-driven water; earthquake; fires, thunderstorms, flash flooding and mudslides; heavy rains
	1985	State	2	Fires; hydrilla proliferation
		Federal	1	Fires
	1986	State	2	Heavy rains; air disaster
		Federal	1	Heavy rains, high winds, flooding and mudslides
	1987	State	8	Del Monte forest fire; wildland fires (3); Medfly; earthquakes (2); wildfires, flooding, mudslides
		Federal	1	Earthquake
	1988	State	4	Fire and wave action; Medfly; wildland fires; fires/high winds
		Federal	2	Wind and rain storms, high tides, coastal flooding; wildland fires
	1989	State	4	Medfly (4)
		Federal	1	Earthquake
	1990	State	7	Rain and snow storms; earthquake; Med fruit fly; Mexican fruit fly; drought(2); wildland fires
		Federal	2	Wildland fires; extreme cold
CO	1982	Federal	1	Flash flood due to dam failure*
	1984	Federal	1	Severe storms, mudslides, landslides, and flooding*
CT	1982	Federal	1	Severe storms and flooding*
	1984	Federal	1	Severe storms, flooding*
	1985	Federal	1	Hurricane Gloria*
	1989	Federal	1	Severe storms, tornadoes*
DC	1989	Federal	1	Severe storms, high winds*
DE	No State or Federally declared in this period of time - only limited states of emergencies - 1980 to present			

FL	1980	State	3	Tropical storm; tornado; civil disturbance
	1981	State	2	Forest fires; severe freeze
	1982	State	1	Hurricane
		Federal	1	Severe storms, flooding*
	1983	State	4	Weather; truckers strike
	1984	State	1	Flood
		Federal	1	Freezing temperatures*
	1985	State	1	Fire
		Federal	3	Severe freeze*; Hurricane Elena*; Hurricane Kate*
	1986	State	1	Wildfires
	1987	State	2	Flooding; oil spill
	1988	State	2	Tornado; barge hit bridge
	1989	State	1	Wildfires
GA	1980	Federal	2	Heat, drought; pine bark beetle
	1981	Federal	1	Drought
	1982	Federal	4	Cold weather; crops (2); flooding
	1983	Federal	3	Cold weather, wind-hail; drought-heat; fire
	1984	Federal	1	Tornadoes, wind, rain, hail, flooding
	1985	Federal	1	Cold weather, drought, hurricane (??)
	1986	Federal	1	Drought
	1987	Federal	1	Drought
	1988	Federal	1	Drought
	1989	Federal	1	Tornado
HI	1980	State	2	High wind, high surf; heavy rains and flooding
	1981	State	4	Drought (2); flash flood; heavy rain; high wind
	1982	Federal	2	Hurricane Iwa; heavy rains, flooding*
	1983	State	2	Drought+
		Federal	1	Lava flow++
	1984	State	1	Drought
		Federal	1	Lava flow
	1985	State	1	Drought
		Federal	1	Lava flow
	1986	Federal	1	Lava flow
	1987	State	1	Heavy rains and flooding
		Federal	2	Lava flow; heavy rains and flooding
	1988	Federal	2	Lava flow; heavy rains and flooding
	1989	Federal	1	Lava flow

+ One drought disaster was 1983-1985.
++ Federal lava flow disaster declared in 1990, retroactive for 1983 and open-ended.

IA	1984	Federal	1	Severe storms, tornadoes, hail and floods*
	1987	Federal	1	Storms and flash flooding*
	1988	Federal	1	Rain, winds and tornadoes*

ID	1980	Federal	1	Mt. St. Helens eruption (volcanic ash)
	1981	State	2	Statewide forest fires; riot at State Correctional Facility
	1982	State	4	Flooding (3); dam failure
	1983	State	3	Flooding (2); landslides
		Federal	1	Earthquake - Borah Peak
	1984	State	5	Flooding (4); grasshoppers
		Federal	1	Flooding/ice jam
	1985	State	4	Flooding (1); grasshoppers (1); forest fires (2)
	1986	State	6	Flooding (3); land/mud slides (2); forest fire
	1987	State	2	Range fire; forest fire
	1988	State	2	Forest fires (2)
	1989	State	5	Winter storm (2); forest fires (3)
	1990	State	1	Dam failure
IL	1981	Federal	1	Flood and tornado combination (FEMA 643)
	1982	State	3	Torrential rains and heavy wind (2); tornado
		Federal	2	Tornado; tornado and flood combined (660.674)
	1983	State	3	Flash flooding (2); drought in all 102 counties
		Federal	1	Flood (FEMA 684)
	1984	State	1	Tornado (Fayette County)
	1985	State	1	Partial washout of Lake Charleston Spillway (Coles Co.)
		Federal	1	Flood (FEMA 735)
	1986	State	1	Flooding (Alexander, Pulaski and Union counties)
		Federal	1	Flood (FEMA 776)
	1987	Federal	1	Flood (FEMA 798)
	1988	State	2	Flooding and ice jams (Kane, LaSalle and Winnebago counties)
	1989	State	1	Thunderstorms and heavy winds (Alorton)
		Federal	1	Tornado (FEMA 819)
	1990	Federal	3	Ice storm (FEMA 860); tornadoes and floods combined (FEMA 871); tornado (FEMA 878)
IN	1982	Federal	1	Flood--Ft. Wayne, Executive Order 7-82 652-DR-IN
	1986	Federal	1	Tornado--Lynn, 767-DR-IN
KS	1981	Federal	1	Severe storms, flooding, tornadoes*
	1982	Federal	1	Severe storms, flooding*
	1984	Federal	1	Severe storms, flooding, tornadoes*
	1986	Federal	1	Severe storms, flooding*
KY	1981	Federal	1	Sewer explosion
	1982	Federal	1	Flash flood

	1984	Federal	1	Flood
	1989	Federal	3	Floods
LA	1980	Federal	2	Severe storms and flooding*
	1983	Federal	2	Severe storms and flooding*
	1984	Federal	1	Severe storms and flooding*
	1985	Federal	1	Hurricane Juan*
	1987	Federal	1	Tornadoes and flooding*
	1989	Federal	4	Severe storms and flooding*; severe storms and tornadoes*; Tropical Storm Allison*; heavy rains and flooding*
MA	1981	Federal	1	Urban fire*
	1985	Federal	1	Hurricane Gloria*
	1987	Federal	1	Severe storms, flooding*
MD	1985	State	1	Hurricane Gloria
	1986	Federal	1	Flood, Potomic River
	1989	Federal	1	Wind
ME	1987	Federal	1	Flooding
	1989	Federal	1	Flooding
MI	1980	Federal	2	Severe storms, tornadoes*; Severe storms, flooding*
	1982	Federal	1	Flooding*
	1985	Federal	1	Flooding
	1986	Federal	1	Flooding
	1989	State	1	Flooding
	1990	State	2	Tornado; forest fire
MN	1987	Federal	1	Flooding/tornado
	1989	Federal	1	Flooding+

+ These figures do not include small business declarations, agricultural disaster declarations, or county/city "declarations."

MO	1980	State	2	Drought; tornados
		Federal	1	Severe storms, tornadoes
	1981	State	1	Hyatt Regency skywalk collapse
	1982	State	2	Tornados; snow storms
		Federal	2	Flooding
	1983	State	2	Flooding; tornado/hail damage
	1984	State	2	Blizzard; tornados
		Federal	1	Flooding
	1985	State	2	Tornado/flooding; ice storm
	1986	Federal	1	Flooding
	1987	State	1	Ice storm

	1988	State	2	Flood; drought
		Federal	1	Tornado
	1989	Federal	1	(USDA) Ice storm--roofs collapsed on commercial poultry breeder houses killing 2,000,000 chickens and turkeys.
MS	1980	State	7	Tornado; flood
		Federal	1	Flood
	1982	State	8	Tornado; flood; winter storm
		Federal	1	Tornado
	1983	State	15	Tornado; flood; winter storm
		Federal	3	Floods
	1984	State	8	Tornado; flash flood
		Federal	1	Tornado
	1985	State	1	(???)> >Hurricane; winter storm
		Federal	1	Hurricane
	1986	State	1	Tornado
	1987	State	4	Tornado; drought; wildfire
		Federal	1	Tornado
	1988	State	5	Tornado; flood; hurricane; winter storm
	1989	State	6	Tornado; winter storm
MT	1981	Federal	1	Severe storms, flooding*
	1986	Federal	2	Heavy rains, landslides and flooding*; severe storms, flooding*
NC	1984	Federal	2	Tornado; Hurricane Diana
	1987	Federal	1	Red tide
	1988	Federal	1	Tornado
	1989	Federal	3	Tornado; hurricane; flooding
ND	1982	Federal	1	Flood*
	1989	Federal	1	Flood*
NE	1980	Federal	1	Severe storms, tornadoes*
	1984	Federal	2	Severe storms, tornadoes*
NH	1985	Federal	1	Flooding
	1986	Federal	1	Flooding*
	1987	Federal	1	Flooding
NJ	1984	Federal	1	Northeast storms and spring floods
	1985	Federal	1	Hurricane Gloria
NM	1983	Federal	1	Severe storms, flooding*
	1984	Federal	1	Severe storms, flooding*
	1985	Federal	1	Severe storms, flooding*

NV	1983	State	1	Flash flood, Slide Mountain, Washoe County
	1986	Federal	1	Flood - Clark, Douglas and Carson City
	1988	State	1	Pepcon explosion - rocket fuel
NY	1984	Federal	2	Flood
	1985	State	2	Flood
		Federal	1	Hurricane Gloria
	1987	State	1	Snowstorm
		Federal	1	Bridge collapse/flood
	1991	Federal	1	Ice storm
OH	1980	Federal	1	Flooding
	1981	Federal	1	Floods and tornadoes
	1982	Federal	1	Flooding
	1984	State	1	Severe winter storm
	1985	State	3	Water shortages
		Federal	1	Tornados and severe storms
	1986	State	4	Water shortage, water contamination
	1987	State	4	Severe winter storm, water shortage
		Federal	1	Flooding
	1988	State	8	Water shortage, water contamination
	1989	State	5	Water shortages, power outage
		Federal	2	Flooding
OK	1981	Federal	1	Severe storms and flooding*
	1982	Federal	1	Severe storms and flooding*
	1983	Federal	2	Severe storms and flooding (2)*
	1984	Federal	2	Severe storms and tornadoes*; Severe storms and flooding*
	1986	Federal	1	Severe storms and flooding*
	1987	Federal	1	Severe storms and flooding*
OR	1980	State	3	Severe snowstorm, Hood River and Multnomah Counties; crop damage due to eruption of Mt. St. Helens, Polk, Tillamook, and Yamhill Counties; flooding, Hood River County.
	1981	State	2	High winds, heavy rain, high tides, Lincoln and Tillamook Counties; forest industry crisis, Forest Products Industry
	1982	State	3	Flooding, Malheur County; land inundated by flood water - declaration ongoing through 1989, Harney County; economic emergency, Linn County, Philomath and Cottage Grove
	1983	State	5	Landslides due to heavy rain resulting in highway damage, home loss, loss of beach, Curry County; flooding (2), Malheur and

				Deschutes Counties; economic emergency, Harney County; commercial fishing disaster, Clatsop, Tillamook and Lincoln, Coos and Curry Counties
	1984	State	4	Inclement weather resulting in damage to power transmission lines, Union County; flooding (2), Malheur and Lake Counties; slide, Baker County
	1985	State	1	Erosion threatening sand spit which acts as buffer between Pacific Ocean and City of Waldport, Lincoln County
	1986	State	1	Flooding, Malheur County
	1987	State	2	Fire (2), Josephine, Jackson, Klamath, Lake, Clackamas, Douglas, Coos, Lane, Crook, Deschutes, and Polk Counties
	1988	State	4	Fire (4), Josephine, Jackson, Klamath, Douglas, Lane, Wallowa, and Umatilla Counties
	1989	State	4	Flooding, Wallowa County; fire (2), Wallowa and Baker Counties; high wind, hail storm, flooding, Klamath County
	1990	State	1	Flooding and severe winds, Clatsop and Tillamook Counties
PA	1980	State	1	Drought emergency
		Federal	2	Tornado; flash flood
	1981	State	1	Flash flood
		Federal	3-SBA	Fire; flash flood; flash flood/ice jam
	1982	Federal	1-SBA	Flash flood/ice jam
	1984	Federal	1	Flood
	1985	Federal	3	Tornado; flood (2)
	1986	Federal	1	Flood
RI	1982	State	1	Flood
	1985	Federal	1	Hurricane Gloria
SC	1984	Federal	1	Tornado involving 7 counties
	1989	Federal	1	Hurricane Hugo involving 24 counties
SD	1981	Federal	1	Drought
	1983	State	1	Drought
	1984	Federal	1	Flood
	1986	State	1	Drought
		Federal	2	Flood; drought
	1987	State	1	Wildfire
		Federal	1	Wildfire
	1988	Federal	2	Wildfire; drought
	1989	State	2	Drought; winter storm, fuel shortage

TN	1982	Federal	2	Floods
	1984	Federal	1	Flood
TX	1980	Federal	3	Hurricane Allen; Roscoe flood; Tropical Storm Danielle*
	1981	Federal	2	Lavaca flood; Mineral Wells flood
	1982	Federal	2	Paris tornado; Wichita Falls flood
	1983	Federal	2	Hurricane Alicia; Valley freeze
	1984	Federal	3	Cameron County flood; San Patricio/Harris flood; tornadoes*
	1986	Federal	1	Sweetwater tornado
	1987	Federal	2	Saragosa tornado; East Texas tornadoes
	1988	Federal	2	Hurricane Gilbert; Range fires
	1989	State	1	Valley freeze
		Federal	3	East Texas flood; spring storms; Tropical Storm Allison
UT	1983	Federal	1	Severe storms, landslides, flooding*
	1984	Federal	1	Severe storms, mudslides, landslides, flooding*
	1986	Federal	1	Heavy rains, snowmelt, flooding*
	1989	Federal	1	Dike failure, flash flooding*
VA	1980	State	1	Snowstorm
	1982	State	1	Flood
	1983	State	1	Snowstorm
	1984	State	1	Flood
		Federal	1	Flood
	1985	State	6	Mudslide; forest fire; floods (4)
		Federal	1	Flood
	1987	State	5	floods (3), forest fires (2)
	1988	State	3	Forest fires
	1989	State	2	Snowstorm, Hurricane Hugo
		Federal	1	Flood
VT	1984	Federal	1	Flood
	1989	Federal	1	Flood
	1990	Federal	1	Flood
WA	1980	Federal	1	Volcanic eruption, Mt. St. Helens
	1983	Federal	1	Severe storms, high tides, flooding
	1986	Federal	4	Flooding (3); dam failure (1)
	1988	Federal	1	Forest fire
	1989	Federal	1	Flooding
	1990	Federal	3	Flooding

WI	1980	State	2	Severe storms; flooding
		Federal	2	Forest fires; tornadoes and severe storms
	1984	Federal	2	Tornadoes (2)
	1985	State	2	Tornadoes and severe storms; flooding
	1986	Federal	2	Flooding (2)

Additional Note from WI:
Listed as state disasters are those incidents where Presidential Disaster Assistance was requested, but denied.

WV	1980	Federal	1	Severe storms, flooding*
	1984	Federal	1	Severe storms, flooding*
	1985	Federal	1	Severe storms, flooding*
WY	1985	Federal	1	Severe storms, hail, and flooding*

QUESTION 5

MITIGATION

States generally have codes or guidelines that regulate or guide the ways in which hazardous materials can be used, stored, or transported. Please indicate whether or not your codes or guidelines specifically address the natural hazards to which your state is susceptible and how (e.g. chemical storage facilities not allowed in floodplains or seismic zones, certain highways closed to hazardous material transport due to high avalanche or landslide potential. Also, please enclose a copy of your codes.)

AK No reply to questionnaire

AL This state does not have formal codes that address hazardous materials. However, the state and county emergency operations plans concentrate on hazard specific actions. These plans are too voluminous to provide by mail, but they are very much like the Colorado state/local plans. Your purpose could be well served by reviewing those plans.

AR No answer

AZ AZ State Fire Marshal uses the 1988 Uniform Building Code, Flood plains are a function of planning and zoning. There are no specific "natural hazard" rules pertaining to hazardous materials transportation.

CA Article 80 of the Uniform Fire Code and Title 19 of the California Code of Regulations require consideration of earthquakes in "mitigation planning" for facilities.

CO No answer

CT No reply to questionnaire

DC No reply to questionnaire

DE The Dept. of Natural Resources will not issue any permits in the 100 year flood plain zone. (for further info. call 302-739-3689)

FL In an emergency, roads would be closed as necessary. Local codes and ordinances may be in place.

GA Georgia has no codes regulating the storage, use or transporting of hazardous materials. Neither are there any guidelines relating natural disaster susceptibility to hazmat storage or transport. However, there are strict guidelines regarding storage, transport and disposal of hazmat waste.

HI Under development.

IA No answer

ID No specific codes are known.

IL State statutes regulate the ways in which hazardous materials can be used and stored. Other statutes address natural hazards to which our state is susceptible such as restrictions on hazardous waste storage facilities in flood plains. Building restrictions on fuel storage tank codes are also in effect.

IN State Plan identifies natural hazards and hazardous material, however, the relationship between the two are not addressed.

KS No reply to questionnaire

KY None, other than incidental provisions of state building code.

LA No answer

MA No answer

MD Floodplain codes on building (local ordinances)

ME Pesticides use and storage regulations restrict activities as they pertain to floodplains and wetlands.

MI Act by site requirements - floodplains and haz waste treatment facilities also state/fed permits to discharge to waterways.

MN I am aware of certain restrictions on specific roadways to transport vehicles during the spring thaw period. Also, Minnesota is a leader in wetlands protection and restricting development within floodplain areas. More specific information would require an extensive search effort in order to provide the detail the question asks. It is unclear what types or "codes" are requested. Most code documents, such as building codes, are only available for a fee.

MO None

MS None

MT No answer

NC To my knowledge, the state does not have more restrictive guidelines and codes than the federal government.

ND No answer

NE No reply to questionnaire

NH None

NJ It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.

NM No reply to questionnaire

NV We have 33 local jurisdictions enrolled in NFIP in which these types of facilities cannot be built in the floodplain. The State of Nevada is currently working on a seismic safety council which will address seismic hazards, and under the National Earthquake Hazards Reduction Program.

NY The state has adopted the Federal DOT Hazardous Material Transportation Regulations. State Environmental Conservation has regulations that pertain to use and storage of hazmat, but not related to natural disasters.

OH No answer

OK Oklahoma does not have any codes that regulate the way hazardous materials may be used, stored, or transported, except as related to RCRA [Resource Conservation and Recovery Act] regulated hazardous wastes. Regarding wastes, our regulations include requirements for the siting of hazardous waste treatment, storage, or disposal facilities outside of flood plains. Copies of those applicable statutes and regulations are included(S. Bill No. 28; S. Bill No. 32; ODH Bulletin 0525; and Excerpt from the Oklahoma Pesticide Applicators Law, Rules and Regulations). Other than these, we do not have codes or guidelines that specifically address the use, storage, or transportation of hazardous materials in regards to natural hazards. Generally, the state of Oklahoma has adopted and/or operates in accordance with applicable federal regulations.

OR OAR 340-120-015 governs the placement or storage of hazardous wastes in flood hazard areas, landslide areas, areas subject to seismic hazards, etc. Also, some (not all) comprehensive plans address hazardous wastes in those areas. Plans were approved by LCDC.

PA Pennsylvania's primary natural hazard is flooding. A copy of our Flood Plain Management Regulations is attached. Efforts are currently underway which may result in stiffer restrictions on the location of above- and underground hazardous materials storage tanks.

RI No answer

SC No answer

SD No answer

TN There is no state law in Tennessee that regulates or guides the way in which hazardous materials can be used, transported, or stored. A handful (but growing) number of local jurisdictions have enacted local ordinances that designate specific routes that transporters of hazardous materials must follow in that particular jurisdiction. Local regulations also designate "safe havens," or zones that can be used for the temporary parking of trucks that are transporting hazardous materials. Incorporated areas in Tennessee generally have land use plans and controls which regulate and/or guide the location of facilities that process, manufacture or store hazardous materials. In many instances, however, the facilities preceded the land use plans, and enforcement becomes problematic, particularly in rural counties. Generally speaking, there has not been a deliberate effort in Tennessee to utilize hazard and risk assessment data to guide or at least influence the location of facilities that either process, manufacture or store hazardous materials. There is evidence that the Title III LEPC's are beginning to assume more of an advocacy role when it comes to issues of this nature. Memphis-Shelby County, for example, is moving aggressively to incorporate seismic hazard risk data into land-use decisions relative to facilities that have hazardous materials.

TX For usage, a company must notify the Texas Water Commission that they are a generator of hazardous materials; exemption: less than 100 kilograms per month. Siting requirements generally follow EPA rules; however, Texas Senate Bill 1099 has imposed stricter rules than EPA. This does not allow new sites in the 100 year floodplain or near a fault. Transportation rules follow federal guidelines.

UT No reply to questionnaire

VA The only codes or guidelines are contained in Statewide Building Codes (BOCA Codes) and Floodplain Management Ordinance which are required by the National Flood Insurance Programs.

VT Federal codes apply

WA No answer

WI A number of different codes come into play, most of which are under the purview of the Department of Natural Resources. Further information can be obtained from DNR's Bureau of Environmental Analysis and Review at 101 S. Webster St., Madison (608)267-7536.

WV No reply to questionnaire

WY Wyoming has adopted the Uniform Fire Code. Wyoming adopted the codes stated in CFR Title 49, Fire Codes and Regulations available through the State Fire Marshall's Office, and certain cities have adopted flood zoning laws.

QUESTION 6

In relation to hazardous material storage, transport, or use, are there communities within your state that have different or more restrictive codes (relating to natural hazards) than state guidelines? (If "yes", please provide us with some examples.)

Yes 8 No 23 No reply 14 Unknown 3 Other answer 3

AK No reply to questionnaire

AL No Counties in Alabama do not have "home rule"; hence, most codes are contained in the state codes.

AR No answer

AZ No

CA Yes Santa Clara County Toxic Gas Ordinance

CO No answer

CT No reply to questionnaire

DC No reply to questionnaire

DE No

FL No (Unaware of any)

GA No

HI	No	
IA	Unknown	
ID	No	
IL	Unknown	
IN	Yes	Marion County Transportation Ordinance, Wayne County Transportation Ordinance.
KS	No reply to questionnaire	
KY	No	Note, however, that some communities (Louisville, Jefferson County, Anderson County, Lexington-Fayette County, Urbal County, metropolitan government) have local ordinances regulating hazardous materials. Louisville - Jefferson County is locally designated a "nuclear free zone."
LA	No answer	
MA	No answer	
MD	No	
ME	No	
MI	No	
MN	Yes	Probably. I can only presume that certain local governments may have more restrictive codes, but we do not have the resources to interview 87 counties and 900 cities.
MO	No	None that we are aware of.
MS	No	
MT	No answer	
NC	No	
ND	Yes	
NE	No reply to questionnaire	
NH	No	

NJ	It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.	
NM	No reply to questionnaire	
NV	Yes	Clark County has more restrictive codes on floodplain management, and is participating in the Community Rating System NFIP.
NY	No	
OH	No answer	
OK	No	
OR	No	
PA	Communities in this Commonwealth are required to adopt their own ordinances to ensure compliance with the National Flood Insurance Program (NFIP) and PA's <u>Flood Plain Management Act (1978-166)</u>. Copies of the <u>Suggested Provisions</u> for meeting NFIP minimum requirements are attached. It should be noted that any municipality not in compliance with flood plain requirements/regulations is denied <u>all</u> payments, for whatever purpose, from the Commonwealth's General Fund until compliance is attained.	
RI	No	
SC	Yes	County ordinances in Beaufort, Aiken and Lancaster Counties.
SD	No	
TN	n/a	Regulations that govern the storage, transport or use of hazardous materials are local.
TX	Yes	The cities of Austin and Houston are two communities which have more restrictive codes.
UT	No reply to questionnaire	
VA	Yes	Only in that some communities have added 1 foot to the Base Flood Elevation to determine the elevation for the "First Floor".
VT	No	
WA	Unknown	

WI	No
WV	No reply to questionnaire
WY	No

QUESTION 7

Does your state have a document which provides guidelines for mitigating the effects of technological emergencies caused by natural disasters? If so, please provide the year these guidelines were published.

Yes___ (Year______) No___

a) If "yes", can you provide us with a copy of those guidelines?
No___ Enclosed___ Under separate cover___

Yes 8 No 27 No Reply/Answer 14 Unknown 1 Other Answer 1

AK	No reply to questionnaire
AL	No
AR	No answer
AZ	No
CA	No. We have various plans dealing with emergencies in general and hazardous materials in particular, but do not have plans specifically for technological emergencies caused by natural disasters.
CO	No
CT	No reply to questionnaire
DC	No reply to questionnaire
DE	No
FL	No (not specific to this subject)
GA	Yes (1990) (no copy available)
HI	No
IA	No

ID	No
IL	Yes (enclosed)
IN	No (under development)
KS	No reply to questionnaire
KY	No
LA	No answer
MA	No answer
MD	Unknown
ME	No
MI	No
MN	No
MO	Yes (1982). Titled, "Hazardous Substance Emergency Response Plan" [copy unavailable]
MS	No answer
MT	No answer
NC	No - only existing document is the proposed "409" Hazard Mitigation Plan.
ND	No
NE	No reply to questionnaire
NH	No
NJ	It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.
NM	No reply to questionnaire
NV	Yes - 1990. No.
NY	No. Emergency mitigation plans do exist, but do not deal specifically with

NY	No. Emergency mitigation plans do exist, but do not deal specifically with spills caused by natural disasters.	
OH	No answer	
OK	Yes.	Our state's Emergency Operations Plan (EOP) dated 1988. (Enclosed is Annex P of the EOP).
OR	No	
PA	No	
RI	No	
SC	No	
SD	No	
TN	No	There is not a single document that sets forth guidelines for mitigating the effects of technological emergencies that are caused by natural hazards. *Hazard Management in Tennessee: A Community Handbook*, (due to be published by May 15, 1991) addresses this issue in general terms in the chapters on Hazard and Risk Assessments and Mitigation. A copy will be furnished to the Center in the latter part of May.
TX	Yes	Multi-year. Too many documents to enclose.
UT	No reply to questionnaire	
VA	No	
VT	No	
WA	Yes	(April 1991) State Flood Damage Reduction Plan encourages further work in this area.
WI	No	
WV	No reply to questionnaire	
WY	Yes. Varies: The Emergency Operation Plans are provided on all counties. 1985 Albany County LEPC conducted Hazard Assessment.	

QUESTION 8

In the following two questions, please rank your state on a scale of 1-5 (1=low, 3=moderate, 5=high):

a) How susceptible do you feel your state is to a natural disaster causing a hazardous material release or other technological emergency?

(low) 1-------2-------3-------4-------5 (high)

b) Are you satisfied with the steps your state has taken to reduce the possibility of such an occurrence?

(low) 1-------2-------3-------4-------5 (high)

c) Regarding (b) - why, or why not?

AK	No reply to questionnaire	
AL	A) 2 B) 2	C) It is difficult to achieve consensus within the Alabama legislature on issues such as these.
AR	A) 5 B) 2	C) Because of the funding to help train haz-mat teams and equipment that is needed for them.
AZ	A) 2 B) 4	C) General highway programs combined with hazmat transportation requirements are sufficient to prevent most hazardous materials transportation risks arising from natural hazards such as dust storms and flash floods.
CA	A) na B) 3.5	C) The question is too subjective to be meaningful. We have about 100,000 businesses which handle hazardous materials, of which some 5000 handle extremely hazardous material. A significant portion of our 30 million people live or work relatively close to one or more of these facilities. However, in polling my associates I find there is little agreement regarding how "susceptible" our state is. We have taken many steps to reduce the potential for damaging releases and have experienced no major chemical or technological disaster in the state, whether related to natural or man made causes. The most comprehensive attempts to find earthquake related chemical emergencies after the Loma Prieta event turned up mostly minor events.
CO	A) 4 B) 1	C) We really have not paid particular attention to this issue. It comes up after the fact as a consideration in the response and recovery phase, little has been done about it in the preparedness phase.
CT	No reply to questionnaire	

DC	No reply to questionnaire	
DE	A) 2 B) 4	C) Delaware is a very small area and is mainly threatened by water related disasters. Regulations are in place to mitigate this.
FL	A) 4 B) 3	C) Re: "B" - the rating is high because of the number of hurricanes and tornados that impact the state. Re: "C" - In some areas, conditions are good, in others they are not. There are growth management issues, e.g. the State tries to provide leadership, then local governments provide variances which allow building in areas that would be better left undeveloped. However, the State is trying to bring all the local governments into the National Floodplain Insurance Program (NFIP). The big test will be when a major hurricane impacts the coast which will make it possible to see if the coastal redevelopment plans hold. There are 4.5 million people currently residing in surge zones.
GA	A) 2 B) 5	C) We are satisfied because of the mitigation and high degree of preparedness that has been established and maintained regarding the nuclear power plant facilities and other technological areas.
HI	A) 2 B) 3	C) In process.
IA	A) 3 B) 3	C) No answer
ID	A) 4 B) 2	C) Has not been really addressed.
IL	A) 3 B) 3	C) While substantial measures are in place to handle satisfactorily any release of hazardous material resulting from natural causes, one primary area of concern is a hazard resulting from an earthquake. State and local building codes do not mandate substantially earthquake-proof construction.
IN	A) 3 B) 3	C) No answer
KS	No reply to questionnaire	
KY	A) 4 B) 3	C) Additional emphasis on management of hazardous materials use, storage, manufacture in flood plains and areas of high seismic risk is needed.
LA	A) n/a	B) n/a C) No answer

MA	A) 2 B) 3	C) Improvements are always possible
MD	A) 2 B) 4	C) No answer
ME	A) 1 B) 2	C) Stricter land use ordinances could protect floodplain construction.
MI	A) 3 B) 2	C) Difficult to do much - local zoning? Maybe.
MN	A) 1 B) 4	C) Minnesota's vulnerability to predictable (time, place, type) natural hazards is very low. The fact that no significant event in recent history bears this out.
MO	A) 5 B) 1	C) We have no authority to require even the most basic preventative action (such as Spill Prevention Containment and Countermeasures Plans) and Missouri is subject to significant threats from storms, flooding, tornados, and earthquakes.
MS	A) 3 B) 4	C) No answer
MT	A) 2 B) 3	C) We are not really sure one way or another. Based on historical data (Duty Officer Reports) Montana has not had a hazmat release generated from a natural "disaster." However, if the right natural disaster occurs in the wrong place (i.e., large magnitude earthquake near Helena's tank farm east of town) state regulations may not be adequate to prevent a major release.
NC	A) 4 B) 2	C) Route control of hazmat transport over highways susceptible to avalanches and landslides.
ND	A) 4 B) 2	C) The lack of "resources" to mitigate a hazardous materials release. Much more needs to be accomplished by "all" levels of government and the private sector.
NE	No reply to questionnaire	
NH	A) 2 B) 2	C) No answer
NJ	A) n/a	B) n/a C) It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.

NM	No reply to questionnaire	
NV	A) 5 B) 4	C) We are currently reviewing and are rewriting our state emergency plan which covers mitigation measures more effectively.
NY	A) 4 B) 4	C) Our major risk would be hurricane or earthquake. We have a hazardous materials plan, an earthquake planning program and a hurricane plan. This is all we can do with available resources.
OH	A) 1 B) 3	C) The state is strongly enforcing the SARA Title III program, the state and several counties have designated special routes for hazardous truck shipments, industries in Ohio report lowering their stockpiles, power plants have tremendous safeguard systems, Ohio does tremendous amounts of training of responders, individuals are monitored to not build in the flood zones, facility inspections are done on local and state levels.
OK	A) 3 B) 3.5	C) Generally, we are satisfied with the progress that Oklahoma has made regarding the reduction of the possibility of releases due to natural hazards. This is particularly true in light of the implementation of programs in waste minimization and pollution prevention. These and other initiatives are designed to replace hazardous chemicals with chemicals that pose little or no risk. Such reductions will reduce the number or amount of hazardous chemicals from commerce and therefore tend to remove these chemicals from the possibility of being impacted by natural hazards. Additionally, Oklahoma is a state that does not have large amounts of extremely hazardous materials vulnerable to the types of natural disasters likely to occur in this state. However, we can not be completely satisfied until all feasible steps have been taken to reduce their vulnerability to natural disasters.
OR	A) 3 B) 3	C) No answer
PA	A) 5 B) 3	C) In 1990, Pennsylvania enacted Act 165 which establishes a hazardous materials safety program. It represents a major step in reducing our vulnerability to hazmat incidents and establishes a Hazardous Material Emergency Response Fund. A copy of this act is attached.

RI	A) 3	B) 2	C) The potential of having a hazardous material release caused by a natural disaster in Rhode Island is strong. We have not had such an incident as far as we have been able to determine. Because of this fact steps to reduce the possibility of such an occurrence are not a high priority.
SC	A) 2	B) 3	C) No answer
SD	A) 3	B) 3	C) Generally hazardous materials are a local responsibility.
TN	A) 3	B) 2	C) No answer
TX	A) 5	B) 3	C) State and local governments are constantly improving technological capabilities to reduce the threat. However, the amount of hazardous materials generated within and transported through the State continues to increase. This increases the risk and challenges the capabilities of both State and local government within Texas.
UT	No reply to questionnaire		
VA	A) 4	B) 3	C) The natural disaster the State is most susceptible to is flooding followed by hurricanes. Local Jurisdictions that have defined flood plans and participate in the National Floodplain Insurance Program are the only localities that have any regulations that would apply to hazardous materials in a natural disaster. These floodplain regulations or ordinances do not address hazardous materials specifically, only in a category of storage of materials that may wash or float away. If the facility is not damaged more than 50% then the same operation may recover and continue to operate as before.
VT	A) 1	B)"yes"	C) No answer
WA	A) 4	B) 2	C) No answer
WI	A) 3	B) 3	C) In terms of its ranking in relation to vulnerability of other hazards and considering the availability of staff and financial resources, we feel that the State is doing the best it can.
WV	No reply to questionnaire		

WY	A) 4.5 B) 3	C) Wyoming is satisfied with the completion of the county plans and training provided to First Responders, LEPC staff and other emergency management personnel. However, there are limited funds available for equipment and maintenance for first responders and other hazardous materials cleanup.

QUESTION 9

"It has been suggested that despite apparent tremendous potential for technological emergencies resulting from natural disasters, the actual number of such incidents is relatively low. Do you agree with this statement? Why do you believe this is the case?"

Yes_35_ No Reply/Answer_9_ No_4_ Other Answer_3_

AK No reply to questionnaire

AL Yes In the past 20 years, Alabama has experienced a major hurricane (Frederic), numerous tornados, and, in the past 1 1/2 years, four Presidentially declared disasters (flooding and tornados). None of these has caused serious hazardous materials releases or spills.

AR No We have seen a tremendous increase in incidents in the past three years.

AZ Yes Careful handling due to Government/Industry concern (Preparedness and Training) and regulatory requirements has resulted in an excellent safety record.

CA Yes Our experience

CO Yes At least historically, to-date. Probably due to the fact that not much attention was given to technological disasters and therefore what might of occurred in the past was a lack of reporting. The secondary disaster being overwhelmed by the primary natural disaster and that was what was reported on.

CT No reply to questionnaire

DC No reply to questionnaire

DE Yes Low probability and good planning

FL Yes Actual occurrences of this type are low according to documentation.

GA	Yes	Perhaps the incidents are low as a result of strict standards of protection designed into technological areas to protect against natural disasters contributing to a high degree of technological emergencies.
HI	Yes	Not that many disasters and limited potential for release of hazardous materials.
IA	Yes	No answer
ID	Yes	Inadequate reporting and no significant incidents.
IL	Yes	Most major industrial facilities that handle hazardous materials have established on-site emergency preparedness procedures and consequently mitigation has been relatively effective.
IN	Yes	No incidents during reporting period.
KS	No reply to questionnaire	
KY	Yes	Relatively high level of corporate emphasis on safety, overall public safety awareness/concern of officials and effect of state building codes.
LA	No answer	
MA	Yes	1. Good luck. 2. Good site and emergency planning.
MD	Yes	Awareness and laws/codes
ME	Yes	Experience
MI	Yes	No answer
MN	Yes	Strictly speaking of Minnesota, I believe there is <u>not</u> a tremendous potential for such incidents, which is why they are low/nonexistent.
MO	Yes	Such incidents occur infrequently and are, therefore, a very small fraction of the total number of emergencies. When they occur, however, the effects have the potential of being widespread and substantial.
MS	Yes	No answer
MT	Yes	In Montana the number of incidents is low because of our low population density which does not require large industrial support, and the relative remoteness of the state is not conducive to the location of large industry in Montana. We are also very lucky.

NC No Although our current statistical data does not reflect this theory due to an inability to search databases of technological incidents caused by natural hazards, personal experience has indicated that the number of technological accidents due to natural disasters is commensurate with the potential.

ND No Only a small number were adequately recorded in the past. The next ten years will provide a better indicator.

NE No reply to questionnaire

NH Yes No answer

NJ It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.

NM No reply to questionnaire

NV Yes Nevada is a small state and it is not very populated.

NY Yes Low for major spills. If the probability were not low and many accidents occurred, we would see more mitigation efforts, such as building stronger tanks, or safer railroads.

OH Yes I agree there is a potential for this to occur but the wording, "apparent tremendous potential," seems quite strongly stated. I believe this statement based on my discussions with other state agencies that have people on board that have been in the business for upwards of 25 to 30 years and they do not recall such incidents. Also I agree with the findings of the report attached from the workshop in July that says they have no history of such incidents to any degree.

OK Yes There is general agreement that the answer to this question is "Yes" even though there is insufficient data to strongly support this position. It seems prudent to believe that, while the incidents are occurring, the damage to health and the environment is kept at a minimum due to the high degree of training and expertise in our first responders and other responders who support the on-scene commanders; to the success of such programs as pollution prevention and waste minimization; to adequate planning; and to a certain degree on good fortune. Regardless, Oklahoma will continue on its road to minimizing the potential for adverse impacts as a result of natural hazards.

OR Yes No answer

PA	Yes	Federal regulations governing hazardous materials storage and transportation, now backed up by Pennsylvania's own legislation.
RI	Yes	As stated in Questions 8, the potential is there for this type of emergency to be triggered by a natural disaster. I would say that Rhode Island has been fortunate up until this point that an incident like this has not happened yet.
SC	Yes	Lower volume of transport and production when warned of Hurricane.
SD	N/A?	Hazardous materials are stored and handled in such a way that they are not susceptible to incidents caused by a natural disaster.
TN	Yes	I agree with the statement. Earthquakes have the greatest potential for causing major technological emergencies. To date, there have been few earthquakes in the U.S. that are of the magnitude that would generate significant damage to facilities that store, use or transport hazardous materials. Of course, the relative lack of hazard induced technological emergencies does not preclude a major incident. I would argue that the New Madrid Seismic Zone is a prime candidate for major technological emergencies from an earthquake; our natural gas pipelines, for one, are physically deteriorating in much the same way as our nation's infrastructure.
TX	Yes	Most technological incidents are caused by human error and equipment failure. Therefore, while the overall threat from hazardous materials is substantial, incidents from natural disasters are low.
UT	No reply to questionnaire	
VA	No	Usually the disaster causing the incident is a large, more news worthy event, the hazardous materials incidents have usually been and basically will continue to be, of much lesser significance. The events have usually been more of a threat than a real disaster.
VT	Yes	Never had one in VT.
WA	Yes	Luck!! Plus the possibilities of the incident wasn't repeated; or analyzed as being in conjunction with a flood. Also, general awareness of hazmat incidents of all kinds has increased.
WI	Yes	Natural disasters generate "maximum" response effort, i.e. all available resources, both personnel and equipment, are committed or made available as needed. Thus, we believe many technological hazards are averted before they ever occur or are dealt with before they pose a substantial threat.

WV No reply to questionnaire

WY N/A The question is unclear. Who suggested this statement? The potential for a hazardous materials incident is high. However in Wyoming the incidents and the impact of the incidents that have occurred are low due to the sparse population and the state's geography. There are relatively great distances between the larger population areas in Wyoming.

QUESTION 10 - FIRST SUGGESTION

If you wished to further reduce your state's susceptibility to a technological emergency as a result of a natural disaster, what would be your top three mitigation suggestions?

AK No reply to questionnaire

AL Perform research to determine what kinds of HAZMAT releases have occurred as a result of natural disasters -- I am not aware of this being a problem about which much has been written.

AR More funds to train local people to be able to respond to haz-mat spills.

AZ Creation/designation of safe parking places for vehicles transporting very hazardous materials through areas with a history of natural disaster occurrences. These parking areas would need to be designed to protect the public and the environment in the event of a containment failure.

CA Continue our ongoing programs.

CO Identification of the extent of the existing problem. Survey--questionnaire--have to develop specific criteria to evaluate against. Publicize same.

CT No reply to questionnaire

DC No reply to questionnaire

DE A vulnerability study i.e. FEMA's CHIP

FL That hazardous waste and material storage sites be located away from the Category #1 storm surge impact area and the floodway as defined on FEMA (Federal Emergency Management Agency) rate maps.

GA Develop state codes for transporting new hazmat.

HI We have no recommendation.

IA Iowa has 57 counties that have EPCRA plans. Most counties have addressed the possibility of tech emergencies, the other 42 counties need to complete their assessments. Our top priority is to encourage all of Iowa's counties to address their vulnerability and then take steps locally to mitigate.

ID Proper design and construction of facilities.

IL Recommendation #101 from Illinois Hazard Mitigation Plan of 1991: Identify hazardous material sites in floodplain and take appropriate mitigation measures case by case.

IN No suggestion

KS No reply to questionnaire

KY Enhanced seismic-resistant design and construction requirements for facilities using, producing or storing hazardous substances keyed to seismic-risk mapping.

LA No suggestion

MA Siting

MD Plans

ME The elimination of chemical/fuel storage in 100 year floodplain and prohibition against any new construction which included them within this area.

MI Better siting restrictions for generators of haz waste - floodplains waterways etc.

MN Funding for research to more adequately determine the state's vulnerability, actions/rules/laws that currently address our vulnerability, and what further action/rules/laws may be needed to improve our preparedness posture.

MO Adopt basic safety codes that apply throughout Missouri and provide sufficient authority and resources to enforce these codes.

MS No suggestion

MT Geographic Information System (GIS) capability that identified natural and technological "Hot Spots," i.e., the location of pipelines and other lifeline systems in high seismic areas.

NC Strict enforcement or development of hazmat guidelines for building in floodplains/"tornado alleys"; "falling rock zones," etc.

ND Effective state and local planning: 1) operational planning; 2) mitigation planning (i.e. zoning, laws/ordinances, etc.)

NE No reply to questionnaire

NH No answer

NJ It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.

NM No reply to questionnaire

NV Project Oasis. Resources would be placed in strategic locations throughout the state so that local jurisdictions can use these resources to counteract the hazardous materials.

NY If anyone had the money, I'd suggest a study into the vulnerability of our coastal areas (for hurricanes) and our earthquake risk areas for large hazmat storage tanks and develop community-specific warning and evacuation plans for each high-risk situation. Some work on hurricane preparedness has been done thanks to U.S. Corps of Engineers, NOAA, National Weather Service, FEMA, and State and local planners, but more detailed work is needed to factor in hazmat. The FEMA Earthquake Preparedness Program should provide more emphasis on hazardous materials hazards that could be triggered by storm surge.

OH Instead of just the top three, I'll give you the ideas of all I talked to:
1) Have plans, warning and evacuation systems in place for such an effort.
2) Increase and enforce building codes, standards, structure specs.
3) Monitor proper selection sites for buildings to prevent against: a) earthquakes (identify fault areas); b) tornados (identify prone areas); c) follow flood plain standards (50, 100, 500 year); d) don't build facilities/tanks, etc., on banks or erosion areas; e) don't build too close to heavily populated areas.
4) If not in place, set earthquake standards.
5) For radiological/hazmat facilities--follow the building, spec. codes, etc., as set in spec, RCRA [Resource Conservation and Recovery Act], permits for hazardous waste facilities.
6) Regulate technical facilities on types, numbers of safety systems, diking areas, containment vessels, etc., they must have.
7) Enact laws to forbid transport of hazmat through hazard prone areas, if possible.

OK Continued emphasis on pollution prevention and waste minimization and development of more definitive guidelines for state-wide mitigation actions.

OR Earthquake bracing of pipelines and storage facilities that contain hazardous materials.

PA Strict statewide enforcement of codes regulating the storage and transportation of hazardous materials.

RI A project to identify chemical facilities in vulnerable coastal areas and inland flood zones.

SC Exercise and training.

SD No suggestion

TN Priority would be given to systematically incorporating hazard and risk assessments into the county and municipality land use plans, followed by a revision of zoning and other land use controls to reflect community risk to the spectrum of hazards that the jurisdiction is confronted with.

TX Restrict permitting of new hazardous waste facilities. Ensure facility owners can handle worst case scenarios for that geographic area.

UT No reply to questionnaire

VA Require local floodplain ordinances to prohibit the placement of hazardous materials and fuel storage tanks in the floodplain to include chlorine for water and waste treatment plants.

VT Secure tanks (in ground, etc.).

WA In response to this question, attached copies of: Washington State Flood Damage Reduction Plan (Interim), September 20, 1991; and, Hazard Mitigation Opportunities in the State of Washington, Report of the Interagency Hazard Mitigation Team, FEMA-883-DR-WA.

WI Stricter enforcement and adherence to the various codes.

WV No reply to questionnaire

WY Establishing regional safe havens for hazardous materials being transported in addition to the explosives (within the state). This possibly could be accomplished by charging a fee through Title III related state legislation for the transportation of hazardous materials. The fees collected could be used for safe havens and for equipment needed for responding to and handling hazardous materials incidents.

QUESTION 10B - SECOND SUGGESTION

If you wished to further reduce your state's susceptibility to a technological emergency as a result of a natural disaster, what would be your top **three** mitigation suggestions?

AK No reply to questionnaire

AL Determine what structural and non-structural mitigation measures could be taken to reduce this threat or the consequences of it. I suspect most of the structural measures would be the responsibility of industry.

AR Help fund trained people with the right equipment to contain spills.

AZ Designation of specific routes for vehicles transporting very hazardous materials through the State and enhanced cargo truck inspections capabilities. Determining factors in the selection of these routes should include history of natural disaster occurrences and the potential for environmental damage along the possible routes.

CA Accelerate our ongoing programs

CO Include this duality of potential hazards consideration into the hazard analysis and local emergency operations plan considerations.

CT No reply to questionnaire

DC No reply to questionnaire

DE Review of current regulations

FL No suggestion

GA Develop state codes for storage of new hazmat.

HI No suggestion

IA No suggestion

ID Containment and handling equipment related to the hazard.

IL Recommendation #203 from Illinois Hazard Mitigation Plan of 1991: Protect and tether storage tanks* located in floodplain. (*These are primarily those with farm chemicals.)

IN No suggestion

KS No reply to questionnaire

KY Expanded attention to hazardous materials facilities located in or near floodplains and near waterways, including design requirements and reporting procedures.

LA No suggestion

MA Emergency planning

MD Exercises

ME Stricter enforcement of OSHA standards for workplace safety and worker protection, training and equipping.

MI No suggestion

MN Funding for improved warning systems.

MO Adopt specific safety codes that pertain to high-hazard areas such as floodplains and high-risk seismic areas. Provide sufficient authority and resources to enforce such codes.

MS No suggestion

MT Enhanced capability to respond to a technological event.

NC No suggestion

ND Training: 1) first responders; 2) other emergency management staff.

NE No reply to questionnaire

NH No answer

NJ It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.

NM No reply to questionnaire

NV Stress better building codes and permit process.

NY The Federal Superfund Amendments and Reauthorization Act (SARA) of 1986, Title III required State-directed community planning for facilities with extremely hazardous substances. The Federal Clean Air Act of 1990 requires similar facilities to develop risk management plans, including the consideration of accidental release scenarios. The Federal Hazardous Materials Transportation Uniform Safety Act of 1990 establishes planning and training grants for hazmat spill preparedness. All three programs should include consideration of facility-specific or area-specific natural disasters as part of accident scenarios. In particular, the two 1990 acts, have not yet resulted in completed regulations. U.S. DOT and EPA regulations should require consideration of the most prevalent natural disaster risks in the planning process. For SARA Title III, there is little funding, so actions would be voluntary.

OH Instead of just the top three, I'll give you the ideas of all I talked to:
1) Have plans, warning and evacuation systems in place for such an effort.
2) Increase and enforce building codes, standards, structure specs.
3) Monitor proper selection sites for buildings to prevent against: a) earthquakes (identify fault areas); b) tornados (identify prone areas); c) follow flood plain standards (50, 100, 500 year); d) don't build facilities/tanks, etc., on banks or erosion areas; e) don't build too close to heavily populated areas.
4) If not in place, set earthquake standards.
5) For radiological/hazmat facilities--follow the building, spec. codes, etc., as set in spec, RCRA [Resource Conservation and Recovery Act], permits for hazardous waste facilities.
6) Regulate technical facilities on types, numbers of safety systems, diking areas, containment vessels, etc., they must have.
7) Enact laws to forbid transport of hazmat through hazard prone areas, if possible.

OK Continued training of all levels of responders. Plans for assignment of responsibilities and duties and before-the-fact training are keys to successful response and the minimization of damage to health, property, and the environment.

OR Facilities utilizing/storing hazardous materials will comply with NFIP state and local standards related to the 100 year base flood zone.

PA Continuation of on-going education efforts concerning education of county officials regarding the dangers and regulation of hazardous materials.

RI The requirement that all outside cylinders, for example a propane filled cylinder used for cooking, be secured to the ground or foundation of the home. This would greatly reduce the possibility of these tanks breaking free and floating on the surface of any flood and possibly cracking or getting punctured creating a hazardous material release.

SC Public Awareness/education.

SD No suggestion

TN The Tennessee Safety Congress - the state association of safety officials - is a useful vehicle for the dissemination of hazard mitigation tools, techniques, and strategies that can be integrated with existing safety programs to begin to minimize the risk of ALL Tennessee industries to natural and technological hazards.

TX Implementation of the Clean Air Act in 1993.

UT No reply to questionnaire

VA Implement a fee system for manufacture, users, storage, or transportation of hazardous materials to provide planning, inspection and enforcement of controlling regulations.

VT No suggestion

WA In response to this question, attached copies of: Washington State Flood Damage Reduction Plan (Interim), September 20, 1991; and, Hazard Mitigation Opportunities in the State of Washington, Report of the Interagency Hazard Mitigation Team, FEMA-883-DR-WA.

WI Generation of a greater awareness of the threat technological hazards as a result of natural disasters pose.

WV No reply to questionnaire

WY Establish regional (within the state) hazardous waste landfills and disposal sites. The sites would include industrial and community household hazardous waste disposal. The public involvement would also encourage proper handling and disposal of common hazardous wastes and protection of both urban and rural environment.

QUESTION 10C - THIRD SUGGESTION

If you wished to further reduce your state's susceptibility to a technological emergency as a result of a natural disaster, what would be your top three mitigation suggestions?

AK No reply to questionnaire

AL Examine existing state and local legislation, codes, et al by which other states have attempted to deal with this problem.

AR No suggestion

AZ Require limits for facility storage of Extremely Hazardous Substances commensurate with chemical toxicity effects in the event of a release in populated areas.

CA No suggestion

CO Seek authority for local government to regulate same, i.e., through the planning process or codes/ordinances.

CT No reply to questionnaire

DC No reply to questionnaire

DE Proper enforcement of existing regulations

FL No suggestion

GA Develop state codes for transporting hazmat during imminent natural disaster periods.

HI No suggestion

IA No suggestion

ID Proper siting of facilities and equipment with respect to hazard.

IL Recommendation #816 from Illinois Hazard Mitigation Plan of 1991: Provide safe haven information for business/industry based on plant floor plan and EOPs updates/exercises.

IN No suggestion

KS No reply to questionnaire

KY Management of transportation (rail, river, road) of hazardous materials during periods of potential/actual severe weather such as tornadoes, high winds, ice storms, flooding and other hazards.

LA No suggestion

MA Response equipment availability

MD Codes

ME Development of hazmat response teams including equipment, training and medical monitoring that inspects facilities and trains with facility personnel and local fire fighters.

MI No suggestion

MN Funding for emergency operations centers.

MO Provide technical assistance to businesses and local communities on technological hazards and how to prevent accidents from occurring under various scenarios.

MS No suggestion

MT Increased awareness of the natural/technological hazard interface on the part of local officials and emergency management personnel.

NC No suggestion

ND Equipment: 1) first responders; 2) other--additional warning devices, etc.

NE No reply to questionnaire

NH No suggestion

NJ It would be premature for us to respond since we are only now considering developing a state-level inter-agency hazard mitigation task force to incorporate technological hazards into the 406 plan prepared and annually updated since Hurricane Gloria.

NM No reply to questionnaire

NV Storage of hazardous materials to be in safe location, not near population centers.

NY Our primary concern is with protecting the public in a manner that also safeguards the emergency responders. Hazardous materials spills, regardless of the cause, can create sudden and serious risks for responders and we need to devote more effort and more resources to training for these responders such as that required by OSHA 1910.120. Most response organizations simply do not have the funds to provide enough training to meet these important objectives.

OH Instead of just the top three, I'll give you the ideas of all I talked to:
1) Have plans, warning and evacuation systems in place for such an effort.
2) Increase and enforce building codes, standards, structure specs.
3) Monitor proper selection sites for buildings to prevent against: a) earthquakes (identify fault areas); b) tornados (identify prone areas); c) follow flood plain standards (50, 100, 500 year); d) don't build facilities/tanks, etc.,

on banks or erosion areas; e) don't build too close to heavily populated areas.
4) If not in place, set earthquake standards.
5) For radiological/hazmat facilities--follow the building, spec. codes, etc., as set in spec, RCRA [Resource Conservation and Recovery Act], permits for hazardous waste facilities.
6) Regulate technical facilities on types, numbers of safety systems, diking areas, containment vessels, etc., they must have.
7) Enact laws to forbid transport of hazmat through hazard prone areas, if possible.

OK A more coordinated approach to general public awareness and education regarding chemicals, their uses, and the threats associated with hazardous materials. There are numerous education efforts underway in Oklahoma which are directed to the environmental education of one or more of the segments of our population. Education of the regulated community as well as education of the general public will clearly produce a society that recognizes the need to properly manage those materials that remain after minimization and prevention programs have been effected.

OR Siting of facilities in accordance with considerations for both population, density and soil liquefaction data.

PA Initiate an intensive education program at the primary and secondary school level to increase the awareness of hazardous materials found in every day situations; e.g., home, school.

RI No suggestion

SC No suggestion

SD No suggestion

TN The insurance industry can be an effective ally in a long term program to adjust industry insurance rates to reflect the adoption of mitigation measures that minimize the potential for disaster generated damages, economic losses, and injuries.

TX Contingency plans for persons who transport or use hazardous materials will be required by State law. Texas Water Code and Natural Resources Code rules; rules will be implemented by the end of 1991.

UT No reply to questionnaire

VA No suggestion

VT No suggestion

WA In response to this question, attached copies of: Washington State Flood Damage Reduction Plan (Interim), September 20, 1991; and, Hazard Mitigation Opportunities in the State of Washington, Report of the Interagency Hazard Mitigation Team, FEMA-883-DR-WA.

WI Closer coordination among federal, state, and local agencies which have responsibilities in these areas. Model guidance from FEMA and other feder agencies would also be helpful.

WV No reply to questionnaire

WY Establish appropriate truck routes throughout state that would accommodate the transportation of hazardous wastes safely. These truck routes could possibly include safe havens as described in a).