

INVESTIGATING HEALTH CONSEQUENCES FROM MAJOR FLOOD  
OCCURRENCES IN SOUTH-CENTRAL TEXAS THROUGH THE  
LENS OF FRAME THEORY AND ANALYSIS: ASSESSING  
AWARENESS AND COMMUNICATING RISK

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## **DEDICATION**

To my daughter and for my father,

z miłością ...

## **ACKNOWLEDGEMENTS**

It is with distinct pleasure that I acknowledge my dissertation chair, Dr. Denise Blanchard, and members of my committee: Dr. Jean Brender, Dr. Yongmei Lu and Dr. Ben Zhan. Their encouragement, guidance and support throughout this long process have made this accomplishment possible. I am honored to have them as mentors, colleagues and friends.

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## **ABSTRACT**

**INVESTIGATING HEALTH CONSEQUENCES FROM MAJOR FLOOD  
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December 2010

**SUPERVISING PROFESSOR: DENISE BLANCHARD**

A lack of awareness has many consequences, including our failure to note, much less document, occurrences of specific impacts or to give timely recognition to causal relationships. This is particularly true when we examine flood disasters. This research embraces and investigates the historical record in south-central Texas as it reflects the scope of health effects experienced by individuals and society as a result of major flood occurrences. The compilation of a record of deaths, injuries and disease following major

floods forms the basis for developing awareness materials to inform local officials who are responsible for health concerns and emergency management of the spectrum of recurrent impacts that floods can have on human health and society. If we are to adjust and apply appropriate measures to minimize the detrimental impacts of floods, we must first know the nature, extent, and potentiality of those impacts.

This research is guided by two major propositions. First, that it is possible to develop an account of data and information related to epidemiology and the flood hazard in south-central Texas for use by local leaders to implement safety (mitigation) and preparedness programs, thereby saving lives and properties as well as reducing adverse health impacts that could reduce quality of life. And second, that local leaders must activate, or implement, the first proposition by developing a process of communicating risk at the local government level that includes understanding the historical record of flooding in south-central Texas as it relates to health and flooding; developing risk communication materials designed for use by local leadership regarding health and flooding based on the historical analysis; educating and informing local leaders of the potential community-level risk from health and flooding; and, assessing the degree to which these materials, based on the historical record of health and flooding, increase awareness levels of local leadership.

By appropriately framing the limited available data, it is shown that an informative process based on empirical and systematic analysis can significantly influence the perspectives of decision makers who are responsible for communicating risk and directing appropriate response to ensure the public safety and well-being. Incorporating scientific data into the risk communication process led to the development

of a triple-context model in which the technical-scientific context includes identification of hazards and evaluation of risks by the qualitative risk-informed approach or, if sufficient data are available, by quantitative risk assessment. This technical-scientific context balances the socio-political and cultural contexts of risk communication.

# CHAPTER I

## INTRODUCTION

Colten and Dilsaver (1992) noted that hazards geography traditionally professes no formal interest in historical questions but emphasizes that the “retrospective viewpoint is essential to explain current conditions and to develop agendas for future resource management (6).” George Perkins Marsh (1864) recognized that the ravages committed by man and the destructive energies of nature seldom are manifest immediately; it is only over time that the cumulative impacts result in human awareness and we “are not justified in assuming a force to be insignificant because its measure is unknown” (465). This lack of awareness has many consequences, including our failure to note, much less document, occurrences of specific impacts or to give timely recognition to causal relationships. This is particularly true when we examine flood disasters. Berz (2000) notes that:

...for no other type of natural disaster have early warning methods become more operational, more reliable and hence more effective than for extreme hydrological events.....still account for about a third of all natural catastrophes, cause more than half of all fatalities, responsible for a third of overall economic loss, even though average under 10% of insured losses (3).

The hazards geography perspective may be enhanced by recognizing its parallelism with epidemiology where retrospective studies are a standard research method. Therefore, the research undertaken herein might best be described as disaster epidemiology. By simplest definition, epidemiology is the geography of disease.

Disaster epidemiology, therefore, focuses on the geography of disease resulting from or associated with natural hazards. This study might also be envisioned as falling within the domains of environmental geography, medical geography, environmental spatial analysis, or spatial epidemiology. Indeed it lies at the confluence of concerns that arise where the physical environment interacts with economic and social environmental influences.

### **Statement of the Problem through Propositions**

This research embraces and investigates the historical record in south-central Texas as it reflects the scope of health effects experienced by individuals and society as a result of major flood occurrences. The compilation of a record of deaths, injuries and disease following major floods forms the basis for developing awareness materials to inform local officials responsible for health concerns and emergency management of the spectrum of recurrent impacts that floods can have on human health and society.

The impetus for this research emanates from propositions that exist within each of the major theoretical constructs of hazards risk communication research literature, and are as follows:

1. that there is a lack of recognition by local health officials and emergency management personnel of the full range of hazards associated with the historical record of flooding, particularly as the impacts relate to the public health of the individual and society (e.g., Frech 2005; Mileti 1999).
2. that local governmental and non-governmental leaders have limited historical and geographical knowledge of the impacts of flood occurrences among all prior hazardous occurrences in their communities (e.g., Frech 2005).
3. that local health officials and emergency management personnel need to be apprised of previous health impacts from flood occurrence to aid in

their understanding of potential risk implications not only for the individual but for the community as a whole (e.g., Frech 2005).

4. that a model be defined of how risk might be communicated to local health officials and emergency management personnel based on information compiled from an historical record of flooding (e.g., Jonkman and Kelman 2005; Handmer 2000).
5. that the risk assessment paradigm assesses population-level risk and a mechanism is needed to allow individual policy makers or other stakeholders or members of the community to understand potential risk implications not only for the individual, but also for the community as a whole (e.g., Greenough, McGeehin, Bernard, Trtanj and others 2001).

Thus, informed by the above propositions, this research accomplishes the following objectives: 1) to establish an historical record of major flood events in south-central Texas for health disaster policy management; 2) to parlay this record into the development of risk communication materials for local leadership; 3) to educate local leaders of the historical concerns and issues; 4) to assess the impact of these materials on the perceptions and awareness levels of local leaders; and 5) to theorize a model for the communication of risk at the level of local government. However, as Deck and Kosatsky (1999) emphasize, risk communication is “not to ensure that the ‘correct’ decision is made” but rather, it is intended to ensure that the individual has “the correct inputs to decision making (S227).” Further, the model specified in this research is amenable to an all hazards approach to communicating risk and integrates appropriate ways in which community leaders and citizens should respond to short-term and long-term messages of potential hazardous occurrences.

Thus, the overall propositions that guide this research are as follows:

1. That it is possible to develop an account of data and information related to epidemiology and the flood hazard in south-central Texas for use by local

leaders to implement safety (mitigation) and preparedness programs, thereby saving lives and properties as well as reducing adverse health impacts that could reduce quality of life.

2. That local leaders must activate, or implement, proposition #1 by developing a process of communicating risk at the local government level that includes:
  - a) Understanding the historical record of flooding in south-central Texas as it relates to health and flooding;
  - b) Developing risk communication materials designed for use by local leadership regarding health and flooding based on the historical analysis;
  - c) Educating and informing local leaders of the potential community-level risk from health and flooding; and,
  - d) Assessing the degree to which these materials, based on the historical record of health and flooding, increase awareness levels of local leadership.

As outlined above, this research is conducted through the lens of “framing” analysis, a broad theoretical approach frequently used in communication studies, since scientists from various disciplines in the social sciences find the approach useful for analyzing how people understand situations and activities (Snow 1986). While discussed in greater detail in Chapter 4, the process of framing basically encompasses: 1) defining problems; 2) diagnosing causes; 3) making assessments and/or judgments through analysis; and 4) suggesting remedies (Entman 1993). Thus, the key chapters in this research include:

- Chapter 2, which defines the problem of understanding the impact of health-related problems and risks due to the flood hazard, and diagnosing causes through the creation of a history of flooding and associated health impacts in south-central Texas to compensate for the lack of data and information on flooding and health impacts -- information that could inform local officials in an attempt to reduce the health impacts in their local communities;

- Chapter 7 which establishes an historical record of epidemiology and health risks related to flood occurrences to inform local government officials (health-related and emergency management);
- Chapter 8 which presents the analysis of longitudinal analysis of the knowledge awareness levels of respondents toward historical flood events, prior to, and after, receiving an informational tool on health impacts associated with flooding; and,
- Chapter 9 which ties the entire study together through a discussion of overall assessments and remedies.

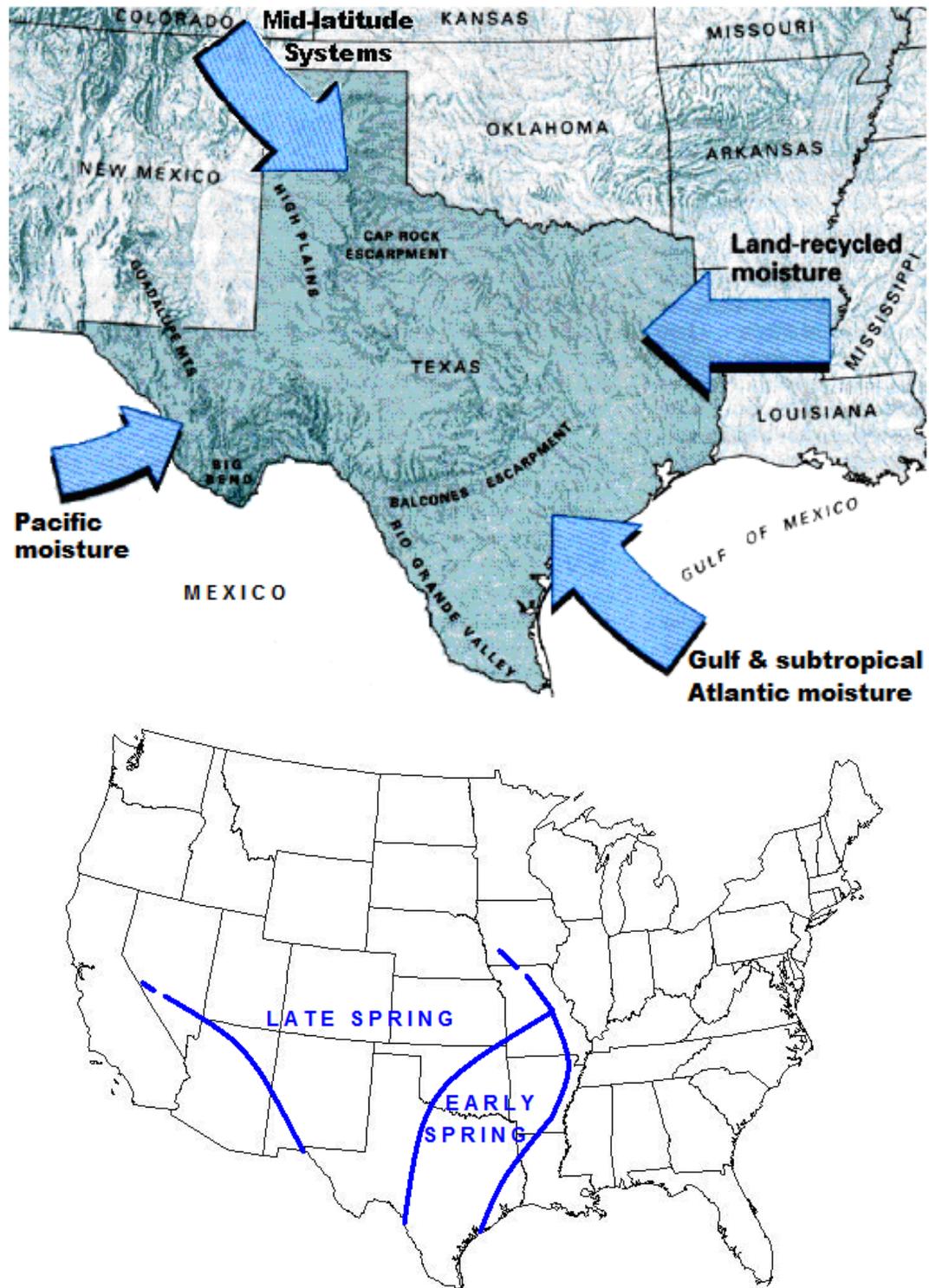
The remaining chapters are supportive, but nonetheless important for this research. Chapter 2 provides the background and context of prior research and policy from which the issues and concerns arise towards health-related effects due to flooding, and provides the rationale and need for the study. Chapter 3 discusses the three major perspectives of health risks and hazards and prior research on these subjects. Chapter 4 provides background on the use of “framing” in theoretical and applied research, and in this case, as it applies to hazards risk communication. Chapter 5 presents the context and background of the study area chosen for data collection and analysis, and Chapter 6 discusses the basic, two-phase mixed methods approach in research design, data acquisition and development of the risk communication tool. Consequently, a significant contribution is made toward effectively integrating epidemiology into the process of communicating risks and developing appropriate information materials, activities, and programs for prevention and mitigation within communities.

### **Perspectives on the Flood Hazard in Texas**

There is an old adage about everything being bigger in Texas. And historically, south-central Texas has led the nation in the frequency and magnitude of hazardous flood

events. Why? Geographically, Texas is unique. The State is located at the inland convergence of maritime tropical storms making landfall along the Gulf of Mexico, the flow of moisture from maritime tropical storms along the Pacific and Atlantic Coasts, and fronts generated by mid-latitude cyclonic systems. Hirschboeck (1991) recognized the consequence of these storm systems is a flood season in early spring in south-central Texas (**Figure 1**). With hurricane season extending through summer and into the autumn, tropical storms may produce a comparable flood season that prolongs the potential for flooding from significant precipitation events. But is bigger necessarily better? Many of the largest storms in the world with the greatest precipitation depths and durations ranging from about 1 to 48 hours have occurred in Texas. These occurrences produced a legacy of unexpected deaths and economic hardships, especially when maximum flood discharges were 4 to 5 times the 100-year peak discharge (Slade and Patton 2003).

Traditionally, local and regional public policy has been directed toward reducing the most serious impacts from major flood events throughout the United States and elsewhere. Typically, these impact are tallied in “deaths and dollars,” thereby focusing concerns on the number of fatalities that have already occurred, as well as on the economic impacts of remediating direct damage to physical structures (Jonkman, van Gelder and Vrijling 2003). From 1960 through 2002, approximately 715 individuals lost their lives in floods in Texas. Between 1955 and 2003, total flood damages (adjusted to 1995 dollars) in Texas were reported to exceed \$11.5 billion (Pielke, Downton and Barnard Miller 2002). This places Texas in the ‘top ten’ ranking for total damages and, if data for 1979 are included, then the ranking of the State jumps from 6<sup>th</sup> to 3<sup>rd</sup> (behind



**Figure 1.** Meteorological influences and seasonal flooding in Texas. The convergence of meteorological influences produces dramatic inland flooding (modified from Slade and Patton 2003), suggesting a seasonal flood-climate in south-central Texas in early spring (adapted from Hirschboeck 1991) that is compounded by potential late summer to fall tropical storms.

Pennsylvania and California), despite Texas having had low population densities for many of those years (**Figure 2**). Cartwright (2005) noted that, like the rest of the nation, the south-central United States (Federal Emergency Management Agency (FEMA) Region 6 - Arkansas, Kansas, Louisiana, Oklahoma and Texas) more commonly experiences recurring high-damage events from major hurricanes and tropical storms. Pielke and others (2002) noted that the frequency of severe floods in Region 6 increased from two, during the period 1961 through 1979, to nine during the period 1983 through 2001. This is consistent with the cyclical pattern of hurricanes over the decades.

The consequences of flooding have been escalating over time in contrast to the intentions of policy-makers, resulting in the dominance of a basic risk paradigm adapted from economics (Rehmann-Sutter 1998) beginning with the seminal work of Chauncey Starr in the 1960s, which attempted to provide a scientific basis for thresholds of risk which would be accepted by the public. Given the irregular, but recurrent nature of such severe storms in a region where population growth is expected to continue at a significant (20 to 30%) rate, future major and catastrophic storms should be expected to impact society with the potential for further loss of life and escalating damages. But do these parameters reflect the full measure of the disaster?

With significant foresight, Gilbert White (1942) urged a policy of “adjusting human occupancy to the floodplain, and at the same time, of applying feasible and practicable measures for minimizing the detrimental impacts of floods (2).” His characterization of the then prevailing national policy as “essentially one of protecting the occupants of floodplains against floods, of aiding them when they suffer flood losses, and

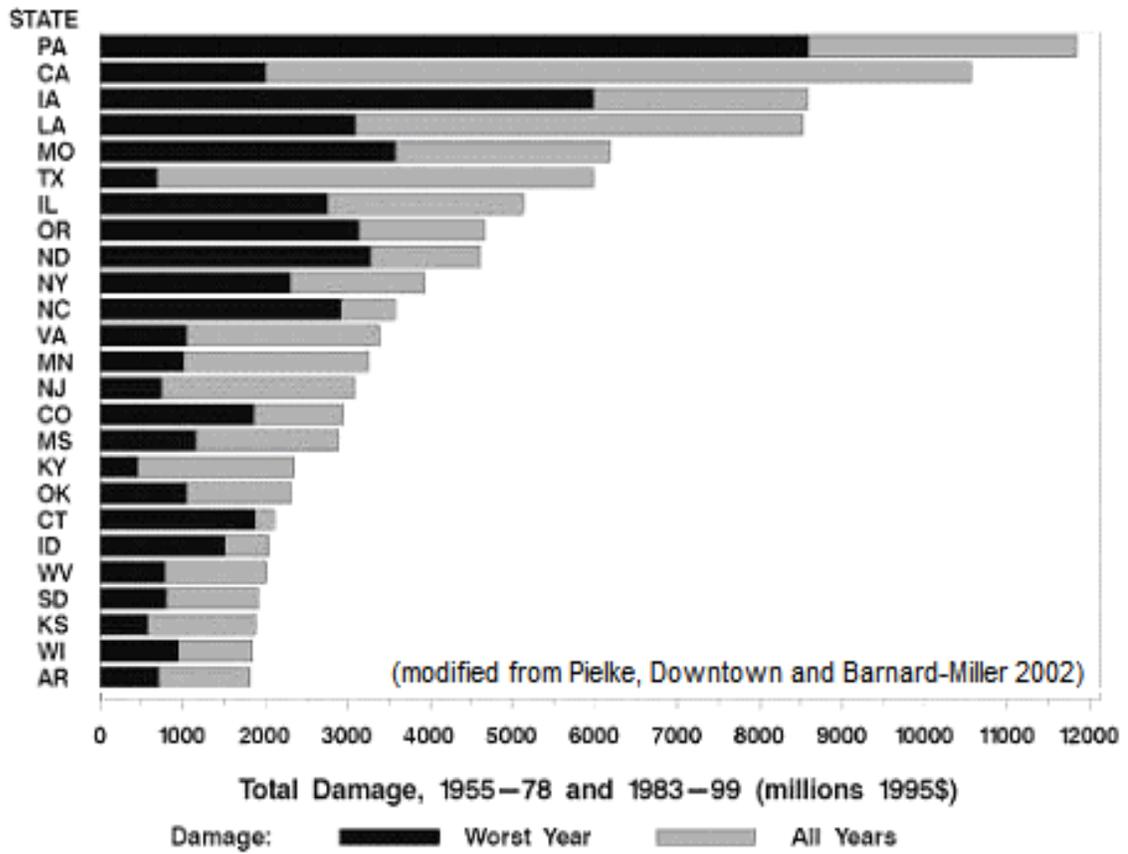


Figure 2. Top 25 states ranked by total estimated damages.

of encouraging more intensive use of floodplains” has unfortunately remained viable over the intervening decades (White 1942, 32).

If we are to adjust and apply appropriate measures to minimize the detrimental impacts of floods, we must first know the nature, extent, and potentiality of those impacts. And it is suggested here that only by knowing and fully appreciating those impacts can we begin to identify and encourage appropriate feasible and practicable measures. By doing so, several outcomes are apparent: 1) understanding of the risks associated with floods will be conveyed to all stake-holders, 2) we will begin to understand the frequency with which such events occur, 3) we will begin to estimate the magnitude of the short- and long-term costs and burdens on society and human health, and 4) we will begin to anticipate that those at risk will take appropriate actions.

### **Nexus between Science and Public Policy as it Relates to Flooding**

Both practical and theoretical frameworks must be considered -- in particular, the relationships among science, scientific research, and public policy as it is created by key decision makers (i.e., the gatekeepers), keeping in mind the potentially conflicting analytical paradigms utilized by these groups (Garvin 2001). The resulting problem must be approached from both practical and theoretical frameworks, incorporating aspects of hazard identification, risk assessment, and risk communication, that is, as Pielke (1997) notes, by linking scientific knowledge and societal needs. As noted by Payne-Sturges, Schwab and Buckley (2004, 28), “effective communication and translation of research facilitate the community’s ability to credibly represent the ...implications to policy makers and other stakeholders, thereby closing the loop between science and the

community.” This seems inherent in the definition of risk communication as stated by Covello, von Winterfeldt and Slovic (1986):

...any purposeful exchange of information ...the act of conveying or transmitting information between interested parties about (a) levels of health or environmental risks, (b) the significance or meaning of health or environmental risks, or (c) decisions, actions, or policies aimed at managing or controlling health or environmental risks (172).

However, few studies have emerged that address both human health and physical aspects of major floods in a comprehensive manner; thus, an understanding of the science is paramount and must be effectively communicated to gatekeepers and policy-makers who are responsible for optimizing policy to protect the public.

As noted by Christoplos, Mitchell and Liljelund (2001), scientific contribution to understanding risk must balance with the roles of policy-makers and the public in understanding risk to not only facilitate, but to emphasize disaster mitigation and preparedness. Peters, Covello and McCallum (1997) caution that the determinants of trust and credibility in scientific information will exhibit considerable divergence between policymakers and the public primarily due to knowledge and expertise, honesty and openness, and concern and care.

Parkes, Panelli and Weinstein (2003) emphasize that the intersections between biophysical and social environments are highly relevant, and are still often overlooked, but if considered in an integrated conceptual framework, then the complex problems of the environment, health and development may be understood and interventions can be optimized for maximum public gain. Perceived risk to health seems to be a major factor in determining whether or not people, as groups or as individuals, will take

environmental action (Seguin, Pelletier and Hunsley 1998). Similarly, Sjöberg, Moen and Rundmo (2004) note that demand for risk mitigation is most strongly related to seriousness of the consequences of the hazard.

Chapter 2 continues with a discussion of the role of local government officials concerning planning, mitigation, management, and communication of hazards towards the goals of protecting lives and properties of its citizens. The chapter identifies and defines health-related effects from flooding, and concludes with a rationale and need for this research.

## Chapter II

### THE ROLE OF LOCAL GOVERNMENT IN DISASTER MANAGEMENT: BACKGROUND AND CONTEXT

#### Recent Legislation Defining the Responsibility of Local Government in Disaster Management

In 1980, the United States Congress directed the National Science Foundation (NSF) to conduct a study of flood hazard mitigation policies and research. The resulting report included two major and unique findings that:

1. Primary responsibility for flood hazard mitigation efforts should be at the local government level.
2. Social aspects of floods deserve a great deal more attention (NSF 1980, 4).

In recognition that floods are the most significant natural hazard in the country, the 1980 NSF report also presented major conclusions and recommendations which included:

- ◆ Establishing high priority to flood frequency data research and improving frequency prediction methodology.
- ◆ Developing flood hazard mitigation strategies to reflect mixes of structural and nonstructural approaches appropriate to the circumstances.
- ◆ Expanding and coordinating data collection and reporting to correct serious deficiencies in the information available for use by those responsible for developing and maintaining flood hazard mitigation strategies and policies.
- ◆ Increased nationwide dissemination of educational and design information, as well as for research findings from the social and behavioral sciences.
- ◆ Because policy makers are bound by the realities of public opinion and the constraints of laws and regulations that are subject to change or reinterpretation, continuing study of public attitudes towards flood hazard mitigation measures.

- ◆ Evaluation by FEMA and researchers to assess the ways in which flood hazard mitigation is presented to residents of hazard prone areas and seek to develop information dissemination methods with greater impact than those presently in use.
- ◆ Seeking more knowledge of the short- and long-range mental and physical health impacts of floods, with special emphasis on the young, the elderly, the handicapped, and other special population groups (4-5).

The Disaster Mitigation Act of 2000 (Public Law 106-390, October 30, 2000) amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by, among other things, adding Section 322, “Mitigation Planning” which places particular emphasis on pre-disaster preparation and mitigation response. It requires local governments (‘local government’ is defined in Section 302 of the Act) to develop and submit mitigation plans as a condition of receiving project grants from the Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance program (FMA) for relief and assistance in the event of a natural disaster, including earthquakes, tsunamis, tornadoes, hurricanes, flooding, and wildfires. Further, the formal mitigation plan must outline processes for identifying the natural hazards, risks, and vulnerabilities of the area under the jurisdiction of the respective local government.

The Inland Flood Forecasting and Warning System Act of 2002, which authorized the National Oceanic and Atmospheric Administration (NOAA) through the United States Weather Research Program to conduct research and other activities relating to improved inland flood forecasting, strongly supported the contention that much work is still needed to fully address the research needs outlined by the 1980 NSF report.

In a natural disaster such as a flood, the regulatory communications that are issued include warnings, risk messages, evacuations requests or demands, messages regarding

self-efficacy, or the availability of relief resources. Flash flooding creates an immediate threat and compressed time frame for response. In the absence of scientific information, regulatory action and/or decision-making will be based upon competing socio-political and economic interests and perceptions (Correia, Fordham, Saraiva and Bernado 1998).

In geography, human ecology stems from the works of Gilbert White (1942, 1964) which focused on flood hazards primarily and associated decision-making and management issues related to floodplain use. Kates (1962), Hewitt (1983), Burton, Kates and White (1993) enlarged the study of hazards to include how individuals and society responds to extreme natural events. Hewitt (1983) further emphasized the social context of hazards, the social and temporal influences of hazardousness of place and the influence of social/cultural context on disaster outcomes.

Jurisdiction over land-use and public policy traditionally resides with local governments which results in wide variation in practices both geographically and temporally. Response to natural disasters such as floods is the principal responsibility of local jurisdictions that often have over-lapping areas of authority designed for disparate purposes. Such local authorities must address critical issues, often-times with little data or technical training or understanding – they are politicians if not in theory, then in practice. They all share the common goal (either implicit or explicit) of making decisions that are for the good of the public. In making decisions, policy-makers must consider such factors as existing or proposed land use and zoning practices, competing needs of compatible and sometimes incompatible uses, and the economic and social viability and prosperity of the communities within a region.

While there seems to be general recognition that flooding poses a hazard to people and property, the complex nature of the hazard and the risks it poses remain poorly understood (Correia and others 1998). Risk is inherent in natural disasters and humans assume that it can be reduced, managed or controlled; it cannot be eliminated. Risk assessment can formally be used to answer the following questions:

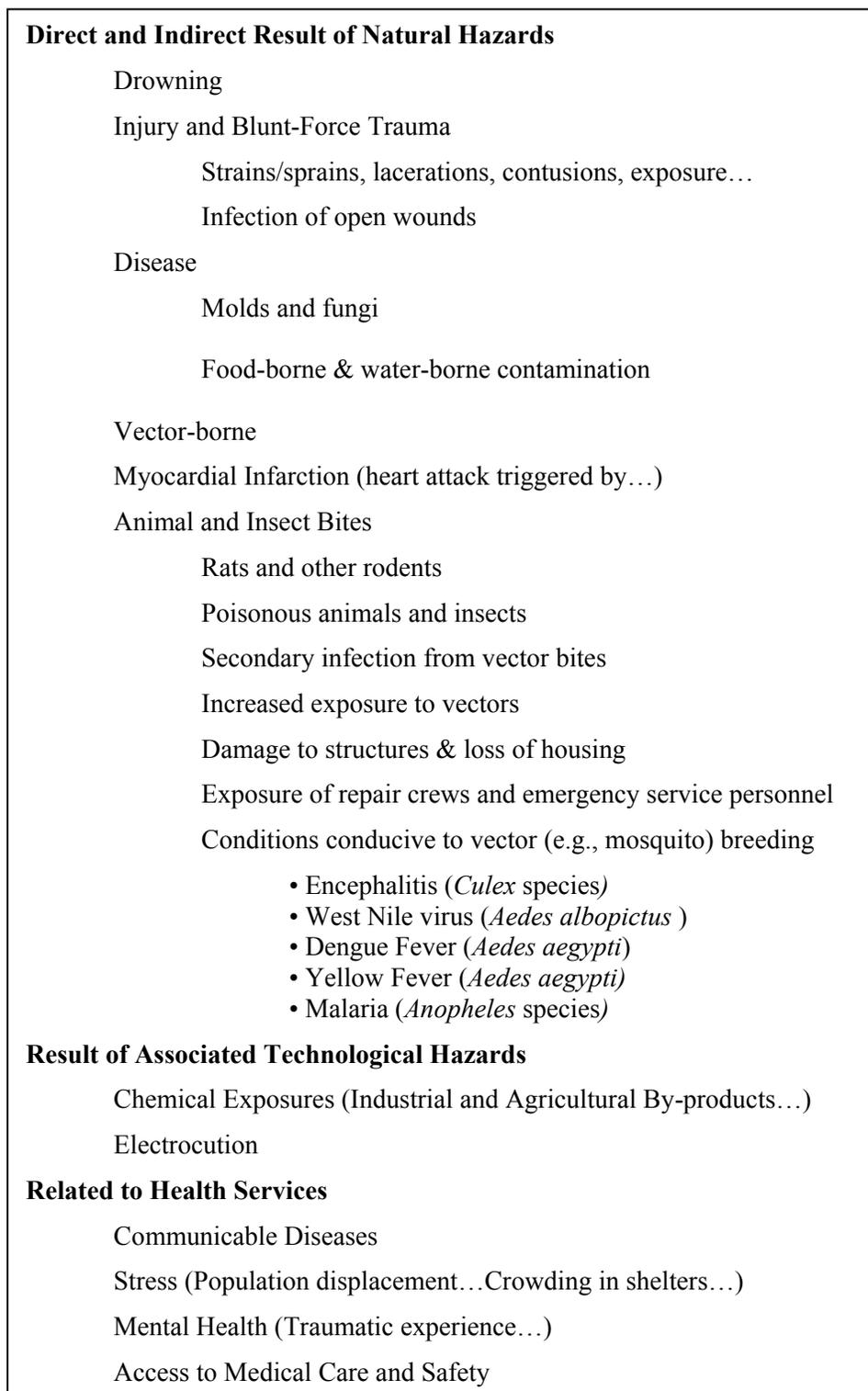
- ◆ What are the dangers?
- ◆ How likely are these?
- ◆ What are the consequences?

### **Creating Risk Communication Messages that Focus on Health Impacts from Flooding**

The need for understanding the health impacts of flooding around the world and adaptive societal responses to these impacts is recognized by the Tyndall Center for Climate Change Research. Noji (2000) noted the need for knowledge of the epidemiology of deaths, injuries and illnesses that is essential to determine effective disaster response, to provide public education, and to establish priorities, planning and training. Research by The Tyndall Center on “Health and Flood Risk: Strategic Assessment of Adaptation Processes and Policies” entailed a review of existing knowledge by surveying non-academic and academic literature for the purpose of synthesizing and assessing adaptation to the health risks of flooding and for developing a priority agenda for future research (Few, Ahern, Matthies and Kovats 2005). These activities culminated in an international workshop in the United Kingdom in July of 2004 which focused global attention on the spectrum of hazards associated with flood risks (Few, Ahern, Matthies and Kovats 2004).

Historically, central Texas has led the nation in the frequency and magnitude of hazardous inland flood events, though few studies have emerged that address both human and physical aspects of inland flooding in a comprehensive manner within the State. In October 2003, the International Institute for Sustainable Water Resources at Texas State University and the Guadalupe-Blanco River Authority jointly sponsored a conference to bring together academicians, professionals and agency personnel to begin sharing information and discuss problems associated with “Living in Flood Alley.” Conference attendees primarily focused on hydrologic characterization of floods or the mitigation of physical and technological hazards. Hanford (2003) provided a cursory review of the historic frequencies and magnitudes of floods in south-central Texas and the documented health hazards, as well as the potential short- and long-term health-related risks that might be associated with future flood events in this region. By combining the perspectives of hazards and epidemiology, the potential health-related impacts of flooding are intuitive and include direct and indirect effects on human health and needed health services (**Figure 3**). During the period from 1993 through 2002, only 20 deaths were documented within the Guadalupe-Blanco River system from flooding, while more than 7,200 persons were treated for flood-related injuries (Hanford 2003). This presentation elicited particular interest among conference attendees, demonstrating the need for increased awareness and desire for credible information upon which agency officials can make decisions and develop policy.

Health-related risks consequent to flooding result from increased exposure to vector-borne disease, electrocution or exposure to toxic chemical releases of associated technological hazards, contaminated food or water, or lack of access to needed medical



**Figure 3.** Potential health-related impacts of flooding. List of individual factors is modified from Hanford (2003).

care. Guptill (2001) suggested that such health effects might be anticipated as ‘aftershocks’ of a natural disaster along a timeline marked immediately by most deaths and injuries due to trauma, asphyxia or exposure; followed soon after by contamination of food and/or water leading typically to gastro-intestinal disease; and then, within a week or two, by vector-borne diseases.

Traditionally, throughout the United States, impacts of natural disasters in general and of major flood events, in particular, are reported using only two measures – the total number of deaths and monetary costs associated with damage and destruction. And traditionally, public policy at the local and regional level has been promulgated in reaction to past events in the hope of stemming such consequences the next time society is at risk. The concept of risk for health, safety and environmental decisions involves value judgments - a game with socially negotiated rules that reflect much more than probabilities and consequences of the occurrence of events (Slovic 1996, 6). As a result, there are significant disparities between actual and perceived risk, distributions of monetary expenditures, effectiveness of implemented policies and procedures to cope with risk. If policy is to be effective, it must be proactive rather than reactive (Godschalk, Beatley, Berke, Brower and Kaiser 1999, 528).

If proactive policy is to be developed in Texas, then we need to understand and assess the risks posed by past events in order to anticipate the expected risks that will be posed by future events. This is consistent with the critical aspects of sustainable hazards mitigation as defined by Mileti (1999), including:

1. to recognize the complex interface between earth and social systems,
2. to take responsibility for hazards and disasters,
3. to anticipate the uncertain and unexpected,

4. to reject short-term thinking,
5. to understand more fully the interaction of social forces with the occurrence of disasters, and
6. to embrace the principles of sustainable development (12-13).

Among his numerous suggestions on how sustainable hazards mitigation may be implemented, Mileti (1999) recommended that stakeholders:

- ◆ build consensus on a common agenda for disaster reduction;
- ◆ develop tools for improved decision making;
- ◆ measure progress to determine the need for future adjustments; and,
- ◆ consolidate knowledge about hazards.

Mileti (1999) also recommended establishing holistic government policies for disasters and development, as well as improving local and regional responsibility and capability (274).

The conceptual definition of risk assessment, promulgated in 1983 by the National Academy of Sciences, emphasizes functionality -- the use of the factual base to define the health effects of exposure of individuals or populations to hazardous materials and situations. As related to this research, this means going beyond the tally of deaths and dollars to develop a factual database of the full range of health effects that have affected the citizens of Texas during flood events. This entails comprehending past impacts, as well as potential future short- and long-term health-related consequences associated with flooding to assist in planning and resource allocation (Greenough, McGeehin, Bernard, Trtanj and others 2001).

The protection of public health in the event of a flood must emphasize not only prevention of death by drowning, but should also promote wellness by mitigating the

potential for physical injury, disease and psychological stress. The short- and long-term costs of such impacts on the public health, while typically not considered when tallying up the deaths and dollars associated with flood damages, may be more significant in terms of the burden on health care services and lost capacity for work and for normal life activities both in the short and long term.

- ◆ Do we know the value of these unseen costs in Texas?
- ◆ Would this information and understanding facilitate the development of effective policy to help protect the public?

### **Understanding the Impact of Health-Related Hazards Due to Flooding: The Need for Research**

This research developed an historical record of health impacts associated with each identified flood event that provided a much needed record of vulnerability by incorporating both qualitative and quantitative morbidity data on disease and injuries, and data on mortality, including trends over time. Data gleaned from historical literature and public records was more than occasionally incomplete, but adequate enough to offer a glimpse of past health-related impacts of flooding in Texas. This glimpse is clarified somewhat by analyses of known health-related impacts of the most recent flood events.

The epidemiological vulnerability record produced as a result of data collection facilitated characterization of the severity and frequency of the risks of exposure and informed the development of a predictive model addressing the frequency and magnitude of future flood events and the health-related impacts. The model was informed by Paton (2003) who outlined methods to integrate research results on health protective behavior with social-cognitive variables that motivate preparedness, intent to act, and culminate in actions that improve preparedness. His social-cognitive preparedness model recognizes

three phases: 1) motivators or precursors (critical awareness of hazards, risk perception or hazard anxiety); 2) intention formation (outcome expectancy, problem-focused coping and response efficacy); and 3) linking intentions and preparedness (sense of community, perceived responsibility, timing, and normative factors) (211-213). Such models obviously require 'translation' (Leiss 2001; Arkin 1989) of the scientific results into publicly understandable terms within a framework relating possible outcomes to a set of feasible risk control options along with a decision matrix of probable adverse health effects and possible risk reduction scenarios. Placing the social vulnerability (mortality and morbidity impacts) within a risk management framework facilitates the likelihood of mitigation and recognition of adaptive capacity to respond appropriately to flood hazards (Brooks 2003).

### **Risk Communication and Public Policy Regarding Health-Related Hazards**

One of the most difficult aspects of risk communication is to develop risk messages that are accurate and comprehensive (Arkin 1989). Covello (1992b) argues that most communicated risk in the United States involving science and technology issues must be targeted at a 12-year-old comprehension level. Effective message development recognizes that individuals are unique and each will respond depending upon their personal history of knowledge and experience. Dennis, Kunkel, Woods and Schrodt (2006) emphasize that:

...politicians and government leaders have the potential to either mitigate or exacerbate the impact disaster has on the citizens they represent, how they make sense of, interpret, and reframe disaster has serious implications for how victims experience it (209).

Scherer and Juanillo (1992) emphasize that preventive action or behavior is the primary factor in intervention strategies of public health promotion programs that may be classified as institutional strategies or communication strategies. In particular, they note that institutional strategies involve shaping public behavior through structural changes in the institutional arrangements of society and that there is a need for creating not only an informed public, but also informed experts and policy-makers with respect to environmental health risks. Scherer and Juanillo (1992) conclude that “the inclusion of health risks in the agenda of public health communicators would certainly change the configuration of theories and perspectives that are guiding present health change interventions.”

When health hazards are directly associated with environmental phenomena, there is significant need for combining understanding of the environmental hazard (in this case, floods and associated and consequent hazards that may be either natural and/or technological – “na-tech hazards”) with understanding of the potential health hazards (epidemiologic – “epi” hazards) that may result from the interaction of humans with adverse environmental conditions. This is true in urban and rural areas, where an understanding of the effects on people facilitates the definition of appropriate roles and activities for rural responders (Doherty 2004). Given these interactions between human health and the environment, two (of three) purposes typically served by risk communication as emphasized by Penning-Rowsell and Handmer (1990) remain paramount:

1. developing organized programs designed to raise hazard awareness, and
2. warnings of an immediate threat which are intended to elicit protective action (9).

Bernknopf and Karl (1998) state that interdisciplinary research and information derived from scientific data and associated process models can contribute to both policy analysis and decision-making by utilizing an integrated assessment. Traditional models of risk communication in hazards (Mileti 1999, Blanchard-Boehm 1998, Kasperson and Kasperson 1996) identify a process of communication which includes the issuance of a message (as generated by policy makers), followed by hearing, understanding, relating the information to individual perceptions of risk, confirming with social networks, and anticipating appropriate response.

Payne-Sturges, Schwab and Buckley (2004) note the need for effective communication and translation of research findings to facilitate the ability of the scientific community to credibly represent the implications of a study to policy makers and other stakeholders to close the loop between science and the community. Lack of awareness remains a significant problem. For instance, Frech (2005) discovered during the course of research while preparing a public education series on prevention of flood fatalities that “the most notable thing...was the extent of the flood problem in Texas and the lack of knowledge of ...general citizenry...and decision-makers” of disaster-related facts, including:

- ◆ Central Texas identified as the most flash-flood prone area in the United States by the National Weather Service.
- ◆ Texas leading the nation in flood-related deaths almost every year – averaging twice the next nearest state: California.
- ◆ Some 20 million of 171 million acres in Texas being flood-prone – more than in any other state.
- ◆ Texas having approximately 8 million structures in floodplains; 3 million of them being uninsured.

- ◆ Texas ranking among the top four states with repeat flood losses to the same properties.
- ◆ Texas having the fewest numbers of state employees devoted to disaster preparedness of any of the most populous states (61-62).

The keystone is establishing an effective message that results in public policy upon which to base mitigation, response and recovery. Therefore, an integrated assessment of data to characterize the hazard (i.e., floods in south-central Texas) and the associated epidemiological vulnerability (i.e., the types, extent and duration of related health impacts) formed the critical foundation of this research for developing awareness and providing effective information and education for affecting gatekeeper decision-making when formulating such policy. A new term, *epi-na-tech hazards*, is suggested here to encompass the interactions of all three arenas.

Further investigation by this research of the health impacts of Texas floods produced theoretical and practical value consistent with the goals of disaster epidemiology (**Figure 4**). The much needed research resulted in an empirically-derived historical framework for describing the magnitude and frequency of major flood events in south-central Texas, as well as the associated short- and long-term epidemiological vulnerabilities. Quantification of the health risks posed by floods allowed for an assessment of inferential processes that may have resulted in over- or under-estimation of potential impacts. The results may facilitate preparedness, response and recovery by demonstrating the need for proactively developing a surveillance system not only for flood-related deaths, but also for injuries and illnesses. Such efforts may also facilitate additional applied research aimed at preventing injuries, illness, and deaths by identifying

**Preparedness, Response, and Recovery**

- Surveillance of related deaths, injuries, and illnesses
- Assess needs of disaster-affected communities
- Evaluate programs, activities and operations

**Applied Research: Prevent Injuries, Illnesses and Deaths**

- Identify preventable risk factors contributing to disaster
- Conduct prevention effectiveness studies
- Refine surveillance and other methodologies

**Disseminate Knowledge Base of Disaster Epidemiology**

- Community at large
- State / local / foreign health departments
- Other Federal & International Agencies and Organizations
- Academic and Professional interest groups

**Figure 4.** Commonly recognized goals of Disaster Epidemiology.

preventable risk factors contributing to flood disasters, as well as subsequent prevention effectiveness studies.

In addition, this research provided a knowledge base of flood disaster epidemiology and the associated epi-na-tech hazards that can be disseminated to the community at large, to state and local health departments, to federal agencies and other organizations. It provided more accurate information about the risks and dangers posed by expected flood events helpful in training emergency management officials, policy makers, the public, and others regarding the dangers of inland flooding and risk management techniques. Findings from this research will be directly applicable to future studies that aim to extrapolate these findings to other regions subject to similar flood hazards and epidemiological vulnerabilities and to other types of hazards that may also produce similar health risks.

The following chapter focuses on prior research related to health-effects and hazards. Three perspectives form the basis of the literature and include: global warming and health hazards, developing nations and health hazards, and health hazards from prior flood events in North America.

## **CHAPTER III**

### **LITERATURE REVIEW**

Relevant research literature reflects three general perspectives: 1) that health risks are a future potential consequence of global warming; 2) that the majority of research on health impacts associated with floods in recent years has mainly focused on developing countries; and, 3) that health studies of impacts attributed to flood hazards have been principally studied within epidemiology. It is within the last decade that hazards researchers have begun to develop awareness of the need to study floods and the associated health impacts. The following sections summarize the relevant literature within these three general perspectives.

#### **Global Climate Change and Health Risks**

An overview of the recent literature reveals that health risks are most often empirically discussed as an anticipated effect of ‘global warming.’ Global climate has warmed since the last major episode of continental glaciation and, in particular, since the Little Ice Age that ended approximately 400 years ago. Awareness of this warming over the last century has led to a new preoccupation with human activities affecting the natural climatic regime, just as they are changing many other aspects of the environment (Reiter 2001). Without digressing into the futile debate on the significance and impact of anthropogenic greenhouse gases, it is accepted here that change and variability are

inherent in climate as the planet has experienced sequential glacial and inter-glacial episodes of reasonably comparable magnitude over at least the last 400,000 years. It is this change and variability with the associated potential for health risks that is of concern to this research.

Watson and McMichael state that, “global climate change is a qualitatively distinct, and very significant, addition to the spectrum of environmental health hazards” receiving consideration (2001, 64). They further note that, among other effects, climate change may: 1) alter the frequency and/or magnitude of extreme weather events (including floods), 2) result in the production of spores that produce allergenic reactions, and 3) alter the geography of infectious diseases (especially vector-borne diseases such as malaria and dengue which are very sensitive to changes in climatic conditions).

Conducting a national assessment of the potential consequences of climate variability and change, Patz, McGeehin, Bernard, Ebi and others (2000) identified five categories of health outcomes: temperature-related morbidity and mortality, health effects of extreme weather events, air-pollution-related health effects, water- and food-borne diseases, and vector- and rodent-borne diseases. Lack of local dose-response data and levels of uncertainty make prediction difficult, but certain demographic and geographic populations, including the young, the elderly, the poor, and those with compromised health are likely to be at increased risk (Patz et al. 2000; Longstreth 1999).

### **Preponderance of Studies Concerning Flood Hazard and Health Impacts Focused on Developing Countries**

Morrow (1999) asserts that most research on local vulnerability to natural hazards has been focused on the developing regions of the world. Few (2003) provides an

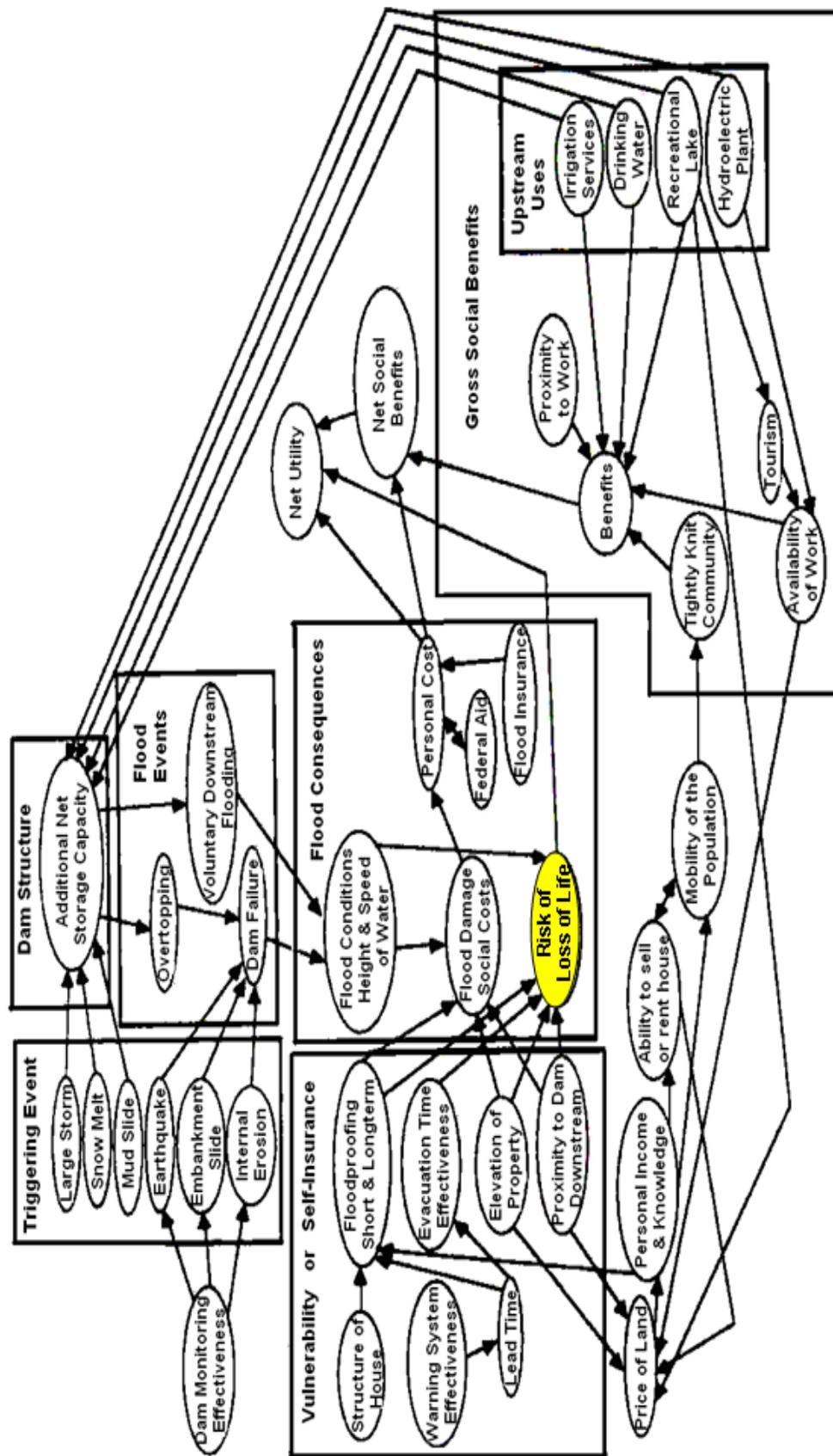
excellent overview of recent theoretical and applied research on vulnerability and resiliency of households and communities in flood-prone areas; his paper reflects the intensity of efforts in Latin America, Africa and Asia where poverty is a key determinant of the ability to mitigate, sustain or recover from the impacts of major flood events. Few and colleagues (2004) developed a strategic review of global flood risk issues and the related health outcomes, concentrating on key issues. Recognizing the weak evidence-base for assessing health impacts of floods, recommendations by Few and colleagues (2004) include strengthening general surveillance systems and enhancing specific surveillance following flood events in both developing and developed countries, as well as researching the impacts on health from the disruption of health services and other life-supporting systems.

### **Previous Research on Health Hazards and Flooding in Developed Countries Centered in Epidemiology**

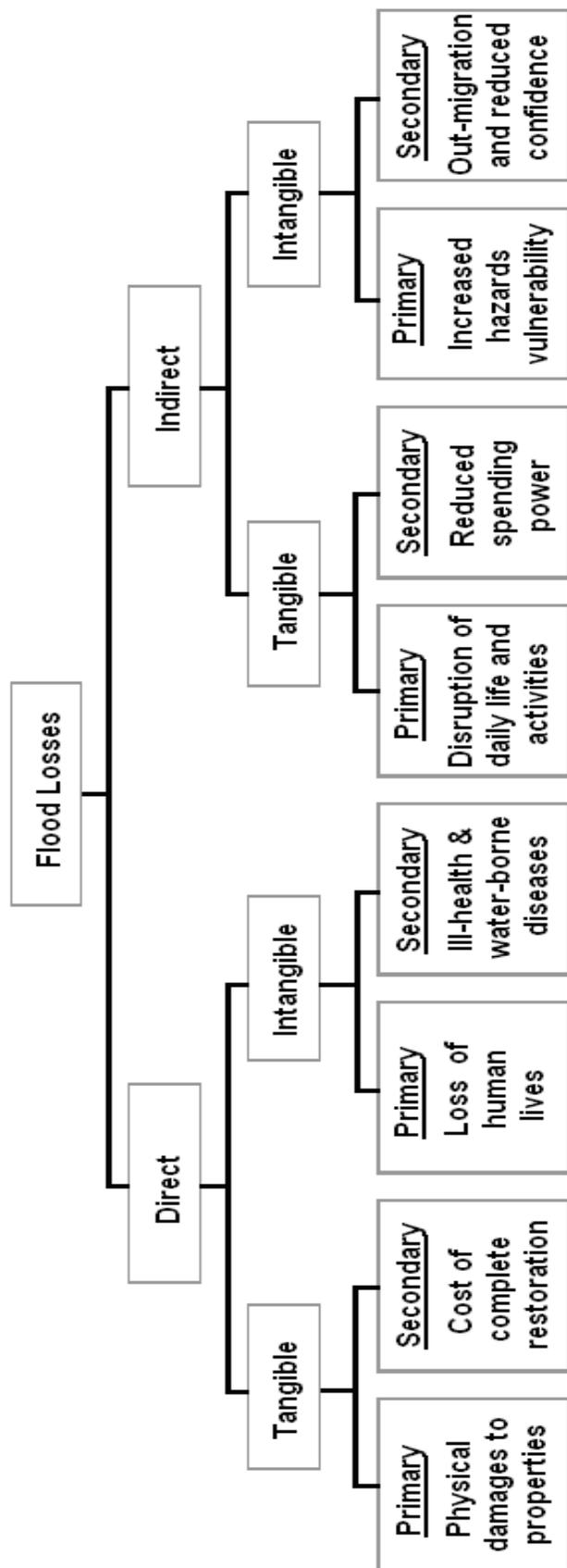
#### **Conceptualizing and Classifying Human Health Impacts from Flooding in North America**

Lave and Lave (1991) investigated the implications for communication based on public perceptions of the risks of floods. Their theoretical framework reflecting the complexity of factors that influence the consequences of flooding (**Figure 5**) incorporates physical, social, institutional, structural and cognitive factors. Despite having ‘explored individual perceptions’ of a number of health risks from other scenarios, they do not incorporate any health-related risk of flooding other than death.

Smith and Ward (1998) categorized flood losses as *direct* and *indirect* (**Figure 6**). Following this classification, attention is given to direct, tangible losses and to intangible,



**Figure 5.** Influence diagram for consequences of floods. The consequences of floods only include “risk of loss of life” but do not directly consider other health consequences (modified from Lave and Lave 1991).



**Figure 6.** Flood loss classification. Modified from Smith and Ward (1998), flood loss classification indicates health-related impacts are classified as secondary, intangible direct losses.

primary losses. Indirect losses and intangible, secondary losses (health impacts) are less obvious, yet may be equally or more important in the longer term (Stuyt, Reinders, van der Hoek, Hermans and others 2003; Gautam and van der Hoek 2003).

Flashflood-related deaths in the United States were assessed by three groups of researchers: 1) French, Ing, von Allmen and Wood (1983) for the period 1969 to 1981; 2) Mooney (1983) for the period 1977 through 1981; and 3) Jonkman (2005) for the period 1995 to 2000. Coates (1999) analyzed a long historic record of flood fatalities occurring in Australia during the period 1788 to 1996. These studies reported similar findings -- almost half of flash flood fatalities were vehicle-related with a higher proportion of male deaths. Mooney (1983) also indicated vulnerability of children and the elderly. These aggregate studies indicated the vulnerability factors of age, gender and activity.

Jonkman and Kelman (2005) investigated the causes and circumstances of flood disaster deaths and proposed a standardized method for classifying flood deaths which incorporates a framework of hazard and vulnerability factors leading to a specific medical cause of death (**Figure 7**). Use of this classification system allows for quantitative analysis of the deaths to determine frequency of occurrence by cause of death and surrounding circumstances, frequency distribution by age, gender, activity and behavior, by time of death, or by other factors. More recently, Jonkman, Maaskant, Boyd and Levitan (2009) conducted a preliminary analysis of loss of life caused by flooding in New Orleans after 2005 Hurricane Katrina. Their study examined the relationship between flood characteristics (e.g., water depth, flow velocity, rise rate and arrival times) and direct flood-caused mortality (typically drowning or physical trauma) for a low-lying area

Medical cause	Activity	Timing	Gender	Age	Lack of judgment
Drowning	As a pedestrian	Pre-Impact phase	Female	0-19 years	Yes
	In a vehicle	Impact phase	Male	20-59 years	No
	From a boat	Post-impact phase	Not reported	Older than 60 years	Probable
	During a rescue attempt	Not reported		Not reported	
	In a building			Uncertain within age group	
Physical trauma	In water				
	As a pedestrian				
	In a vehicle				
	On a boat				
	During a rescue attempt				
	In a building				
Heart attack					
Electrocution					
Carbon monoxide poisoning					
Fire					
Other					
Unknown or not reported					

**Figure 7.** Classification system for flood disaster deaths. Activities and judgment options modified from Jonkman and Kelman (2005).

protected by flood defenses, but excluded fatalities (approximately one-third of the total known fatalities) associated with the adverse public health situations (e.g., lack of medical services, chronic conditions, stress-induced heart attacks or stroke, violence and suicide). Overall, Jonkman and others (2009) indicated that their preliminary study was constrained by a lack of, or only limited, available data regarding both flood characteristics and cause of death.

Combs, Quenemoen, Parrish and Davis (1999) developed a definition and classification matrix to assess disaster-attributed mortality for creating and implementing sound policies to prevent mortality. Their approach was designed to be a standard method including all potential direct and indirect effects of exposures. Their case definition of disaster-related deaths along with a flow chart for determining and classifying disaster-related deaths are presented in **Figure 8**. Their associated matrix for coding, reporting and evaluating the manner, cause and circumstance of disaster-attributed deaths is presented in **Figure 9**. By applying this approach to more than 300 deaths in Dade County, Florida, during Hurricane Andrew in 1992, Combs and others (1999) demonstrated that consistent case classification and reporting provides necessary information about the relationship between exposures and health effects that is critical to identifying prevention policy needs.

McClelland and Bowles (1999) provided a listing of detailed scenarios illustrating generalized categories that result in deaths during catastrophic floods. It should be noted that there is a time bias toward excluding pre-impact and many post-impact fatalities, while including most impact phase deaths (Duclos and Isaacson 1987).

<b>Case Definition</b>	
<p>Disaster-related deaths are those caused by either the direct or indirect exposure to the natural disaster. Directly related deaths are those caused by the physical forces of the disaster. Indirectly related deaths are those caused by unsafe or unhealthy conditions that occurred because of the anticipation or actual occurrence of the disaster. These conditions include the loss or disruption of usual services, personal loss, and disruption of an individual's lifestyle.</p> <p>Use the following flow chart to help determine whether a death is disaster-related, and, if so, how that death should be coded on the Classification and Coding matrix.</p> <p>Refer to the Coding Guide for additional detail and clarification about circumstance categories. Refer to international classification standards for details and clarification about cause of death categories.</p>	
<b>Flow Chart for Determining and Classifying Disaster-Related Deaths</b>	
<p>1. Was death caused by the actual environmental forces of the disaster, such as wind, rain, floods, earthquakes, or by the direct consequences of these forces, such as structural collapse or flying debris?</p> <p style="text-align: center;">If yes -----&gt;</p> <p style="text-align: center;">If no, go to question 2.</p>	<p style="text-align: center;"><b>Directly Related Deaths</b> (caused by environmental forces)</p> <p>This death is <i>directly</i> related to the disaster; code in <b>Part I</b> of the Classification and Coding Matrix.</p>
<p>2. Did the environmental forces of the disaster lead to unsafe or unhealthy conditions that caused a loss or disruption of usual services (i.e., utilities, transportation, environmental protection, medical care, police / fire)</p> <p style="text-align: center;"><b>AND</b></p> <p style="text-align: center;">Did these losses or disruptions contribute to the decedent's death?</p> <p style="text-align: center;">If yes -----&gt;</p> <p style="text-align: center;">If no, go to question 3.</p>	<p style="text-align: center;"><b>Indirectly Related Deaths</b> (caused by loss or disruption of services)</p> <p>This death is <i>indirectly</i> related to the disaster; code in <b>Part II</b> of the Classification and Coding Matrix.</p>
<p>3. Did the environmental forces of the disaster lead to temporary or permanent displacement, property damage, or other personal loss or stress</p> <p style="text-align: center;"><b>AND</b></p> <p style="text-align: center;">Did these losses or disruptions contribute to the decedent's death?</p> <p style="text-align: center;">If yes -----&gt;</p> <p style="text-align: center;">If no, go to question 4.</p>	<p style="text-align: center;"><b>Indirectly Related Deaths</b> (caused by personal loss or lifestyle disruption)</p> <p>This death is <i>indirectly</i> related to the disaster; code in <b>Part III</b> of the Classification and Coding Matrix.</p>
<p>4. If this disaster had NOT occurred, would this decedent still be alive?</p> <p style="text-align: center;">If yes -----&gt;</p> <p style="text-align: center;">If no, this death is <b>NOT</b> disaster-related.</p>	<p>Return to question #1 to re-evaluate.</p> <p>If, after re-evaluation, status of this case is still uncertain, set it aside as a death that is <i>possibly</i> related to the disaster. Do <b>NOT</b> include this case on the Classification and Coding Matrix.</p>

**Figure 8.** Case definition and flow chart for disaster-related deaths. Determination and classification is derived through following the flow chart process (from Combs and others 1999).

Type of disaster: hurricane  
 Identification of disaster: Andrew  
 Location of occurrence: Date County, Florida  
 Date(s) of occurrence: 24 August 1992

Prevalence period: 22 Aug 92 – 21 Sep 92  
 Date collection period: 1 – 31 May 96  
 Name of person completing form: LEQ  
 Date(s) of completion: 31 Mar 96

Circumstances	Cause, Manner of Death: Accidental (A), Homicide (H), Suicide (S), Fetal (F), Undetermined (U)										Other	Allergies, adverse effects	Medical conditions	Infectious diseases
	Blunt, penetrating trauma		Other trauma		Exposure to elements, hypothermia	Poisoning		List cause, manner						
	Asphyxia, drowning	Acute	Late effects	Burns		Electrocution	Carbon monoxide		Other					
<b>Part I. DIRECT EFFECTS IF DISASTER = Environmental Forces</b>														
Atmospheric disturbance: <b>Wind &amp; storm surge</b>	A07 A15 A25 A26 A29	A01 A06 A08 A09 A13 A19 A21 A23 A24											N27 N36	
River or other flood waters														
<b>Part II. INDIRECT EFFECTS: Loss or Disruption of Services</b>														
Loss, disruption of transportation-related services		A04 A14 A32												
Loss, disruption of public utilities							A05 A31						N34 N41	
Exposure: industrial hazards														
Loss, disruption of usual access to medical health care											F18, maternal death			
Social disruption, anarchy														
<b>Part III. INDIRECT EFFECTS: Personal Loss, Lifestyle Disruption</b>														
Evacuation													N11 N12 N16 N17 N40	
Use of temporary shelter, provisions, displacement	A03			(A02)										
Preparation for disaster, Clean-up after disaster		A30 A35	A43 A44	A33									N22 N28 N37 N42 N38 N45	
Return to unsafe, unhealthy structures or environment		A10 A20												
Psychological stress, anxiety		S46											N39	

NOTE: For an occupationally - related death, the code is underlined. If death is volunteer relief worker, the code is placed in parentheses.

Figure 9. Classification and coding matrix for disaster-related mortality. All hazards mortality matrix from Combs and others (1999).

Ohl and Tapsell (2000) noted that, even in industrialized countries, there are few data on the short-term health impacts such as disease and injury due to flooding. Hajat, Ebi, Kovats, Menne and others (2003) concluded that health risks associated with flooding are surprisingly poorly characterized, resulting in uncertainty about the full range of potential health impacts of flood events from mortality to injuries, illness from contaminated water supplies, chronic health effects and mental health effects. Poole and Hogan (2007) included the following among the common mechanisms for injuries associated with flood-related disasters:

- ◆ Electrical injury from power lines, generators and equipment
- ◆ Carbon monoxide poisoning from generators and other motors
- ◆ Musculo-skeletal hazards
- ◆ Soft tissue wounds from debris and other hazards
- ◆ Hypothermia due to cold weather and water exposure
- ◆ Falls from heights during escape, rescue or recovery activities
- ◆ Dehydration from lack of adequate fluid intake
- ◆ Biohazards from endemic and waterborne agents and vectors
- ◆ Thermal stress and exhaustion from exertion and hot environments

As climatic conditions continue to change, there is increased concern for growing populations at greater risk for adverse health effects and the spread of disease. Particular concern exists in association with floods (Patz and Kovats 2002; WHO 2002) since they create conditions that are amenable to disease vectors and increase the likelihood of vector-human interactions.

In New York State, an apparent time-space cluster of leukemias and lymphomas in conjunction with a marked increase in the spontaneous abortion rate suggested

exposure to an unidentified flood-related environmental factor (Janerich, Stark, Greenwald, Burnett and others 1981). No other likely cause could be identified.

### **Assessing Health Risk from Prior Flood Events**

Following the Midwest floods, morbidity surveillance systems were initiated (CDC 1993a, 1993b) during the impact and recovery phases to: 1) monitor emergency shelters to identify disease outbreaks or clusters of adverse health events, 2) identify reported flood-related injuries and illnesses, and 3) assess interruptions of medical care. Reported impacts included carbon monoxide poisoning, lacerations and wound infections, sprains and strains, electrocution, exposure, and exacerbation of chronic illnesses. Flood-related illnesses included gastrointestinal distress and rashes/dermatitis. Damages to water systems and sewage-disposal systems were reported, complaints filed regarding rats and mosquitoes, and population increases of *Culex tarsalis* (a mosquito vector of western equine encephalitis) were measured significantly above baseline levels; however, no sero-conversions were detected in sentinel chicken flocks (CDC 1993a).

For the period 1975 through 1997, epidemics of arboviral encephalitis rarely followed flood-related disasters in the United States (Nasci and Moore 1998). Lack of a subsequent human outbreak of dengue fever, encephalitis or West Nile virus may be attributable to the absence of a prior drought period and attendant amplification of the virus (Shaman Day and Stieglitz 2002), despite the presence of the virus within mosquito populations (Cotton 1993).

The incidence of eye infections attributed to *Acanthamoeba keratitis* was more than ten times higher in counties in Iowa that had been affected by Midwest flooding

(Meier, Mathers, Sutphin, Folberg and others 1998). Direct health impact (pulmonary hemosideroses induced hemorrhaging) in water-damaged homes was attributed to inhalation of airborne fungi in Cleveland following the 1993 floods (Jarvis, Sorenson, Hintikka, Hikulin and others 1998). Indirect, delayed health impacts were found to be most consistent with the introduction of fecal matter by flood waters and the retention of enteroviruses in shellfish for as long as two months after these organisms have disappeared from impacted Gulf waters (Mackowiak, Caraway and Portnoy 1976).

A number of studies were conducted to assess impacts of the Midwest floods on health care service (Chartoff and Gren 1997; O'Carroll, Friede, Nojo, Lillibridge and others 1995; Blementhal 1994; Axelrod, Killam, Gaston and Stinson 1994) or related health impacts such as carbon monoxide poisoning (Daley Shireley and Gilmore 2001) or vector surveillance (Janousek and Kramer 1998). Studies have also been conducted to assess impacts from tropical storms and hurricanes in the southeastern states: motor-vehicle related drowning (Yale, Cole, Garrison, Runyan and Ruback 2003) and impacts on emergency medical vehicle service (Curry, Larson, Mansfield and Leonardo 2001) associated with 1999 Hurricane Floyd, as well as access to and medical needs associated with flooding caused by tropical storm Alberto in Georgia (Clinton, Hagebak, Sirmons and Brennan 1995).

Longmire, Burch and Broom (1988) reported increases in the number of patients treated for psychiatric problems and trauma following 1985 Hurricane Elena along the Mississippi gulf coast. Similar increases in psychopathology were reported following the 1993 Midwest floods, especially for residents living in small rural communities (Ginexi, Weigh, Simmens and Hoyt 2000). In addition, a retrospective paper by Tobin (2005) on

the national flood policy a decade following the 1993 Midwest floods assessed the mental health and psychological impacts associated with living in the hazard-prone region and reviewed the changes that have taken place since 1993 within a wider context.

Secondary, or indirect, health effects were observed by Ohl and Tapsell (2000) who noted that reported orthopedic injuries related to clean-up and repair of flood damage increased steadily over time until several weeks following flooding in North Carolina in 1999. Johnson and Glascoff (2001) reported on the role of public health educators for ensuring safe drinking water toward preventing disease from contaminated floodwater during the 1999 flooding in North Carolina. These researchers observed a number of unique hazards in rural areas, including: 1) deaths of thousands of farm animals; 2) animal waste from lagoons that overflowed; 3) large volumes of animal waste, carcasses, farm chemicals and gasoline and/or diesel fuel mixed with floodwaters; 4) floating coffins from graveyards; and, 5) an abundance of unwanted pests, such as, snakes, mosquitoes and fire ants.

Disaster-relief workers have also been known to be prone to heat-related injury or illness (Dellinger, Kachur, Sternberg and Russell 1996). Short-term assessment of health surveillance in Louisiana indicated a significant decrease in emergency care cases during two days of severe flooding in 1995, with consequent disruptions to health care service in more than half of the hospitals in the area (Ogden, Gibb-Scharf, Kohn and Malilay 2001); causes of treated injuries and illness were not recorded in most of the emergency departments of the hospitals studied.

Also of concern is the risk of re-emergent vector-borne diseases such as dengue fever or malaria or several variants of encephalitis, including West Nile virus which may

cause meningitis or encephalitis. The mosquito vector for dengue fever is present in Mexico, as well as being already extant in Texas and other southeastern states (Gubler and Clark 1995).

This chapter discussed prior research that focused on health-related hazards due to flooding; however, a paucity of research remains toward preventing and mitigating against health hazards and risk before, during and after a flood occurrence. To better understand the concept of “framing” or “frame analysis,” Chapter 4 begins with a broad outline and discussion of the many aspects and applications of framing in the social sciences, and ends by focusing on how this method is compatible and useful for understanding and communicating health-related risk from flooding. Typically, risk information addresses prevention measures for reducing potential damage to homes and property; however, a void exists in the research literature on the processes of communicating risk to individuals of possible exposure to illnesses and disease emanating from flood occurrences. The chapter utilizes the concept of “framing” to contextualize problems and concerns related to risk communication of health-related hazards from flooding. This approach allows for a deeper and more salient understanding of the issues.

## **CHAPTER IV**

### **FRAMING ENVIRONMENTAL ISSUES FOR COMMUNICATING RISKS OF HEALTH IMPACTS ASSOCIATED WITH FLOODING**

This chapter begins with a general explanation and discussion of ‘framing’ as a method of analysis and its utility for anchoring and understanding problems, issues, and/or conflicts within their contexts. Next, framing is discussed as it specifically relates to seemingly ‘intractable’ environmental problems and conflicts. The chapter ends with a short description of framing as applied to this research.

#### **The Theory of Framing**

Within numerous disciplines, framing provides a paradigm for understanding and evaluating communication and behavior and has been applied to a number of very different issues in science communication, including risk communication and health (Kaufman, Elliott and Shmueli 2003). Dahinden (2004) agrees that one of the strengths of the framing concept is that it is independent of the very issue under consideration; therefore, it is a suitable theoretical tool for cross-issue comparisons. Framing theory encompasses a rhetorical approach that focuses on how messages are created, as well as how messages are perceived, judged and processed (Hallahan 1999). Framing is also a psychological and cognitive process for enabling the sorting and interpretation of

information within each frame and for comparison between frames. Furthermore, frames may be changed by “reframing.”

Framing theory and frame analysis is a broad theoretical approach and applicable at all levels of analysis, for example: 1) individual (intrapersonal) decision frame (Tversky and Kahneman 1981); 2) between individuals (interpersonal group) reflected in the work of Donnellon and Gray (1990), Pinkley and Northcraft (1994) and others; and 3) between groups (organizational, inter-organizational) and cultures (Taylor 2000; Schön and Rein 1994; Snow, Rockford, Benford and Worden 1986). *Frame alignment* occurs when individual frames projected by an initiator group “align” with, that is, become congruent and/or complementary with a participant group which allows for comparison between levels; for example, the individual matches ideological assumptions, values and norms of the social group (Snow and others 1986, 464).

Entman (1993) summarized the framing process as follows:

Framing essentially involves *selection* and *salience*. To frame is to *select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation* for the item described...Frames, then *define problems* – determine what a causal agent is doing with what costs and benefits, usually measured in terms of common cultural values; *diagnose causes* – identify the forces creating the problem; *make moral judgments* – evaluate causal agents and their effects; and *suggest remedies* – offer and justify treatments for the problems and predict their likely effects (52).

By increasing salience, the framing process increases awareness, makes information more meaningful, or memorable to the audience. It increases the probability that receivers will perceive the information, discerns meaning, process the information, and store it in memory (Fiske and Taylor 1991) and, therefore, increases the likelihood

for appropriate action or response. Salience and frequency of the hazard are the two factors which determine 'how available' a particular environmental hazard is and will increase the perceived probability of future risk (Alberton 2003). Framing health-related impacts associated with flooding will be critical to communicating the historical data and information that is critical to governmental officials and decision-makers.

### **Framing as a Method of Analysis**

Framing functions by providing contextual clues that prime and guide decision making and inferences drawn by message audiences. Kahneman and Tversky (1979) suggest that the simple positive-versus-negative framing of a decision operates as a *cognitive heuristic* or rule-of-thumb to guide decisions involving uncertainty of risk. Negative information is weighted more heavily than positive information in developing association and expectation and prompting people to engage in more effortful processing or message elaboration (Hallahan 1999).

Lewicki, Gray and Elliott (2003) emphasize that framing provides an heuristic method for determining how to categorize and organize data into meaningful information, that is, to develop a perspective that need not be static through time. Framing and reframing allows organizing, sorting and predicting based on the available information. As such, it is inherently a qualitative method of analysis. Framing is a complex process in which an individual or group may hold multiple (Benford & Snow 2000; Benford 1997) or contradictory frames that can be revised or transformed under certain circumstances (LaBianca, Gray and Brass 2000; Putnam and Holmer 1992; Mather and Yngvesson 1980-81), hence, its usefulness in evaluating the degree of intractability of a

problem and conflict resolution. However, following the definition of Entman (1993), the concept of framing should not be limited to conflict resolution.

### **Typologies of Framing**

A number of typologies of framing have been presented by various researchers (Gray 2003, 1997; Vraneski and Richter 2003, 2002; Hanke, Gray and Putnam 2002; Miller 2000; Kaufman and Smith 1999; Hallahan 1999; Levin Schneider and Gaeth 1998). Specific frames resonate among these typologies since framing, in general, is a concept that provides a perspective, identifies the scale of worldview, and reflects the underlying assumptions that guide interpretation and definition of particular issues.

Levin, Schneider and Gaeth (1998) identified three distinct types of *valence*, or positive-negative framing effects: attribute, goal, and risky choices. With valence framing, objectively equivalent information results in different judgments and decisions, assuming no risk was involved, with positive framing consistently leading to more favorable evaluations than negative framing; this typology was later tested empirically (Levin, Gaith, Schreiber and Lauriola 2002) to show relative independence among these frames. Kaufman and Smith (1999) investigated framing and reframing in land-use change disputes. They adopted this basic list and proposed frame types and subtypes: 1) substantive: complete story, zero-sum; 2) loss/gain; 3) characterization: self-characterization; 4) process; 5) outcome: zero risk, justice; 6) aspiration; and 7) complexity: science-as-truth, science-as-deception.

Hallahan (1999) incorporated attribute and risky choice effect frames into seven models of framing appropriate to public relations: situations, attributes, choices, actions,

issues, responsibility and news that are linked by contextualization. The framing of attributes (i.e., the characterization of objects, events and people) encompasses spatial and temporal characteristics, as well as focusing on positive or negative (gain versus loss) aspects that could influence decision making.

Miller (2000) developed, compared, and explored four models of societal processes by which framing occurs through a case study of science policy and the impacts of climate change over three decades in the United States. He suggested that societies arrive at stable, collective frames of meaning for environmental values and policy through:

1. Framing as narrative – emphasizing meaning (as opposed to scientific facts), facilitating understanding the historical (temporal) dynamics, links disparate elements of a story (characterization, setting, plot, theme, etc).
2. Framing as modeling – implicit or explicit modeling of human and natural systems to find tractable, meaningful policy approaches by coupling simplification and specification to construct understanding of knowledge and values.
3. Framing as canonization – narratives becoming central to the creation and maintenance of social order by institutionalization in processes of governmental decision-making.
4. Framing as normalization – producing knowledge and policy-making constrained by assumptions or embedded norms, evolving unintentionally and with little awareness of basic shifts in societal attitudes, or persisting long after the original ideas and value judgments have lost credibility.

Hanke, Gray and Putnam (2002) offered predictions of four general types of frames commonly used by environmental participants: risk, conflict management, power and views of nature. Emphasizing the finding that ‘risk is inherently subjective’ (Slovic 1992), they used risk frames to capture perceptions of the levels of environmental risk (safe → unsafe) using an impact/severity matrix. Further, the researchers asserted that

conflict management frames are either collaborative or non-collaborative, allowing distinctions among stakeholder groups which help to explain motivation or avoidance toward dealing with the conflict. Among various potential power frames, they analyzed voice, expertise, and force-threat. Their two dimensions of views of nature may be summarized as 'use' and 'regenerativity.' The use spectrum ranges from preservation – conservation – exploitation while the regenerativity spectrum ranges through various degrees of sustainability from fragility – robust – invincible. Hanke, Gray and Putnam (2002) also used two typologies from risk perception (technical versus lay perspective) and social movement theory (stereotypically radical, liberal or moderate), respectively. They suggested that understanding the frame patterns held by participants is more important than interest-based stakeholder groupings and that the impacts of framing on the social environment of organizations contributes to the intractability of inter-organizational conflict.

In responding to the need for a more systematic frame analysis, Gray (2003) identified three primary (generic) and five additional frames -- social control, risk, whole story, power, and loss-gain -- that are salient and critical to the dynamics of environmental conflicts. The generic identity, characterization and conflict management frames are generally consistent with the typologies discussed above. Identity framing is based on socio-demographics and place-based identity such as race, gender, ethnicity, location where people live or work, role in society, and personal interests; the strength and salience of identity tends to remain constant over time and may be a crucial factor in the degree of intractability of an issue. Characterization framing is a view of others (rather than self) and arises out of attributions of causality and responsibility such that

participants (victims) place blame or anonymously ascribe consequences to situational factors. Conflict management framing involves fact-finding, cooperation, expert authority, legal/political/ economic actions, and ‘common sense.’ In power frames, Gray (2003) incorporated authority, resources, expertise, personal, coalitional / relational, sympathy / vulnerability, moral / righteous, and voice, as well as recognizing that force / threat may be implicit in regulatory actions. Risk frames are necessary to view the types and levels of risk associated with environmental hazards, typically through cost-benefit analysis. Contingent valuation analysis has been applied to determine public acceptance of potential risk (Mitchell and Carson 1989), gain-loss framing of health risks (Tversky and Kahneman 1981), and loss aversion (McCusker and Carnevale 1995).

### **Environmental Conflicts as Understood through Framing**

Recent research on environmental conflicts has shown that parties in conflict (Gray 1997; Vaughan and Siefert 1992; Otway Maurer and Thomas 1978) or those confronting environmental threats (risk) or deterioration (Steg and Sievers 2000; Wildavsky and Dake 1990) may develop disparate perceptions of appropriate frames. For example, Vaughan and Siefert (1992) use frames to define whether a problem exists, and if so, what the problem is. Framing involves a representation process and an interpretive process:

- ◆ What is the problem about?
- ◆ Why is it occurring?
- ◆ What are the motivators of the parties involved?
- ◆ How should the problem be resolved?

Gray (2003) further outlines the role that framing plays in the creation, evolution and perpetuation of environmental issues, such that framing:

- ◆ Defines issues
- ◆ Shapes what action should be taken and by whom
- ◆ Provides self-protection
- ◆ Justifies a stance taken on an issue
- ◆ Mobilizes people to take or refrain from action(s)

Elliott (1988) noted that distinct differences exist between frames developed by technical versus lay populations; the technical approach stresses prediction and prevention of risks while lay-persons will stress risk detection and damage repair from risks that have occurred. This distinction has been challenged by Rowe and Wright (2001). The involvement of the public in environmental conflicts requires understanding the dimensions of the complexity of public involvement, personal responses to health and safety issues, the science pertinent to such socio-scientific issues and the way knowledge of science is represented and disseminated (Tytler, Duggan and Gott 2001). Research by Johnson and Slovic (1998) suggests that prediction uncertainty is, in itself, a source of conflict between lay and technical parties and remains part of the game of risk (Slovic 2001). As Burgess (1994) suggests, there are numerous sources of technical risk and uncertainty when addressing environmental problems. Health professionals, particularly those in health communication, often frame their messages regarding the possibility of harm to public health as risk communication (Reynolds and Seeger 2005; Heath 1994; Covello 1992a).

## **The Intractability of Environmental Conflicts**

Environmental issues can be extraordinarily complicated since most involve multiple substantive issues, participants and perspectives. Miller and Colosi (1989) summarized the complexities which can involve questions of science, engineering, economics, law, politics, and public acceptance. Despite involving many branches of science and engineering, there may be little or no hard knowledge or data but there may be strongly divergent perspectives as to potential impacts and solutions to a problem once it is perceived. Economic and political impacts may be local, regional or national, predictable or unprecedented, generally acceptable or highly biased. Environmental issues often involve multiple governmental agencies, public interest groups, private corporations, and private individuals with pronounced imbalances of power among these participants and lack of agreement on the issues (Dietz 2001; Gray 1997; Hamilton 1991) or differences of values or worldviews among the participants (Caton-Campbell and Floyd 1996; Tribe, Schelling and Voss 1976). Laws and regulatory guidance evolve (Priest 1990) and may even conflict among relevant jurisdictions. Negotiations are often conducted in the public venue and can evoke rational consideration or emotional outrage.

Environmental issues stem from disagreements about facility siting issues, technical debates on environmental policy choices, or uncertainties regarding the level of environmental risk facing the public (Ozawa 1991; MacDonnell 1988). Dietz (2001) anticipated more and even sharper environmental issues in the 21<sup>st</sup> century as current trends continue to persist with population growth by increasing demand on resources and space, human engagement in and alteration of the physical environment, and climatic variation.

The theoretical literature has focused on identifying overarching characteristics of intractable conflicts or case studies of the nature and dynamics of intractability (Deutsch and Coleman 2000; Innes and Booher 1999; Sipe 1998; Blackburn and Bruce 1995; Kriesberg, Northrup and Thorson 1989); however, empirical research on environmental disputes is limited (Sipe 1998; Caton-Campbell and Floyd 1996; O'Leary 1995). What is meant by intractable conflict? Webster defines intractability as, "hard to manage; unruly or stubborn, hard to work, manipulate, cure [and] treat." The complexity of environmental issues noted above is certainly compatible with this definition.

The term "conflict" is generally used synonymously throughout the literature with the term "dispute." Putnam and Wondelleck (2003) recognized important distinctions that separate these two processes: "conflict" based on fundamental underlying incompatibilities that divide parties and "dispute" as an episode actualized in specific issues and events. Therefore, a dispute may be an issue underlain by conflicts which tend to make it more intractable. Intractability is a perception that may change over time (Hunter 1989). One might conceive of "resolution" as the antithesis of intractability; however, as with most environmental concerns, resolution does not mean the conflict is solved but rather, in general, that mutually acceptable decisions have been made for an interim of time. Burgess and Burgess (1996) point out that decisions or actions in an environmental episode function as band-aids and are temporary in nature.

History, perceptions and identity are inherently present in the escalation of issues and are also intrinsic to managing conflict and contributing to sustainable interactions. Two of the most powerful tools for creating sustainable interactions include acknowledging history and building awareness, especially since the progression of events

and patterns of response that develop over time and influence the social psychology should complement the political and economic analyses typically used by society (Seymour 2003). Frame usage is linked to the intractability of environmental disputes (Hanke, Gray and Putnam 2002); however, worldviews may account for patterns of risk perception (Sjöberg 1998; Wildavsky and Dake 1990). Understanding the relationships among history, awareness and social psychology which facilitate framing of identities may be critical to transforming intractable environmental issues into resolvable issues.

Intractability is a dynamic process in that perceptions shift over time as internal processes and external events contribute to variability. While length of time comprising a conflict (Kriesberg 1993, Rubinstein 1998) has been listed as a characteristic of intractability, length alone may not be a causal determinant (Northrup 1989).

Environmental issues are best viewed as a continuum ranging from problem solving with common goals ↔ through tractable disputes with integrative potential ↔ to intractability (Putnam and Wondolleck 2003). Disputes become more or less tractable depending on the participants, social system parameters, the conflict processes, and the issues. For some environmental disputes, the major source of controversy lies in the issues or in discordant or diametrically opposed values and beliefs that underlie the issues. Research suggests moral/value-based issues, high-stake distributional claims, or significant risk and human safety issues contribute to the intractability of environmental disputes (Coleman 2000; Kriesberg 1998; Burgess and Burgess 1996; Burgess and Burgess 1995; Burton 1987; Ury, Brett and Goldberg 1988). Using a medical analogy, Burgess and Burgess (1996) view destructive conflict as a pathological process (however, the conflict itself is not pathological) and seek to "cure" the underlying causes through constructive

confrontation as an incremental, rather than holistic, approach which examines, diagnoses, and (it is hoped) treats each aspect of the underlying causes separately. They note that escalating expression of concerns for human health and safety may lead to “analysis-paralysis” where yet another study replaces efforts toward conflict resolution.

### **The Use of Framing within the Context of this Research**

Since the public increasingly expects government to provide protection and relief from natural disasters, policy makers must accept an increasing burden when making decisions. It is believed by this researcher that a risk-informed approach would allow and facilitate public officials making informed decisions prior to issuing policy to minimize and mitigate the impacts of the hazards associated with flooding on the health and well-being of the public. Therefore, any information presented to policy makers must be framed in such a manner as to not only reflect their function and level of experience, but it must also be in language that reflects their ability to comprehend the science.

### **Risk-Informed Guidance**

While there is a general recognition that natural hazards pose risks to people, property, and the environment -- the extent of the danger is not well understood. Risk is inherent in natural events - it can be reduced and managed, but it cannot be eliminated.

Risk assessment practice attempts to answer the following questions:

- ◆ What can go wrong?
- ◆ How likely is it?
- ◆ What are the consequences?

Regulatory approaches can be risk-based, risk-informed, risk-informed performance based, or other variations of these. In the risk-based approach, decisions or regulations are heavily based on risk assessment calculations, without other considerations. Because such an approach places a heavy burden on risk computation, which may suffer from lack of data or models or imperfect consideration of scenarios, its application is limited. In the risk-informed approach, risk insights are used in conjunction with other information, both quantitative and qualitative, in making safety decisions. Because risk-informed approaches allow for the logical structuring of decisions by including relevant factors, they are of more practical value.

Effective use of a risk-informed approach requires an understanding of the relevant factors and the relationships among these factors. In a risk assessment, which is a systematic and comprehensive approach, the likelihood of initiating events, as well as the likelihood of the various outcomes that may result from each initiator, is a concern. In assessing likelihood, a fundamental issue is the metric to be used. Likelihood can be expressed in terms of probability, and the combinations needed to yield the various outcomes can be computed by the use of logic and probability theory. However, the data that go into such calculations may entail significant uncertainties. Unless these uncertainties are explicitly acknowledged, the viability of the whole approach in decision making is compromised.

Decision-makers are increasingly faced with issues of risk. It appears beneficial for them to have available an easy-to-apply means for making decisions in a manner that allows flexibility in choosing the level of risk deemed appropriate. This is possible if the decision process is structured in a risk framework as outlined above. In addition, most

local governments have neither the resources nor the in-house expertise to develop such a structure. Rather, what is needed is a risk-informed approach with an appropriate level of abstraction that is easy to understand and use at all levels of government both in the decision-making process and in communicating with the target audience. Following implementation of selected options, audience response can be monitored to determine whether risk control measures are effective. An iterative process can, over time, continue to reduce overall risk.

For environmental concerns, there are many stakeholders—policy makers, planners, local officials, property owners, residents, and health service providers. They all should be knowledgeable about the risks so that informed guidance can be provided. Involvement and a shared commitment among these interested parties, effective communication, training, and procedures can make managing the risks associated with flooding more effective. A well-thought-out risk management framework that identifies potential risks, measures the risks and identifies a set of mitigation alternatives would facilitate discussions among the stakeholders. Such risk-informed guidance system should include three interrelated components:

1. Decision framework informed by risk analysis
2. Guidelines based on the analysis that are reasonable in the socio-political and cultural context
3. Alternative actions that could be taken on the basis of the guidelines

Thus, technical context should be recognized as a critical interactive component of all phases of risk communication and risk management. This research anticipates that the risk communication model is the optimal tool for local policy makers to develop and

use for educating and informing their community citizens of potential threat toward health-related risks and hazards due to a flood occurrence. Discussed below, the conceptualized model for hazards risk communication of Penning-Rowse and Handmer (1990) was adapted to this research and revised to incorporate this necessary technical/scientific context with input and feed-back continuing throughout the risk communication process.

### **Risk Communication and Decision Making**

The moral and statutory obligations of governing agents to communicate information on risks to the public they serve, has long been recognized. These legal and moral or ethical obligations must be met within a complex, evolving socio-political and cultural context that affects the implicit or explicit design of the communication system, the receipt and comprehension of risk information, and the feedback. Penning-Rowse and Handmer (1990) emphasize that the lack of risk communication information may contravene formal and informal rights established in an enterprise society and affect the aims and objective of the governing body. Conceptually, they have outlined the roles and interaction among risk communicators and their audience (**Figure 10**), recognized by this research as Dual Context Risk Communication.

Alberston (2003) notes the importance of regulatory action to reduce or eliminate risk of adverse effects on the environment or on health when harm is usually large, spread among many victims over time, when the events are not rare, and when standards or requirements are easy to find and control. Most messages issued to the public are designed to induce behavioral change by presenting a threat and describing a behavior

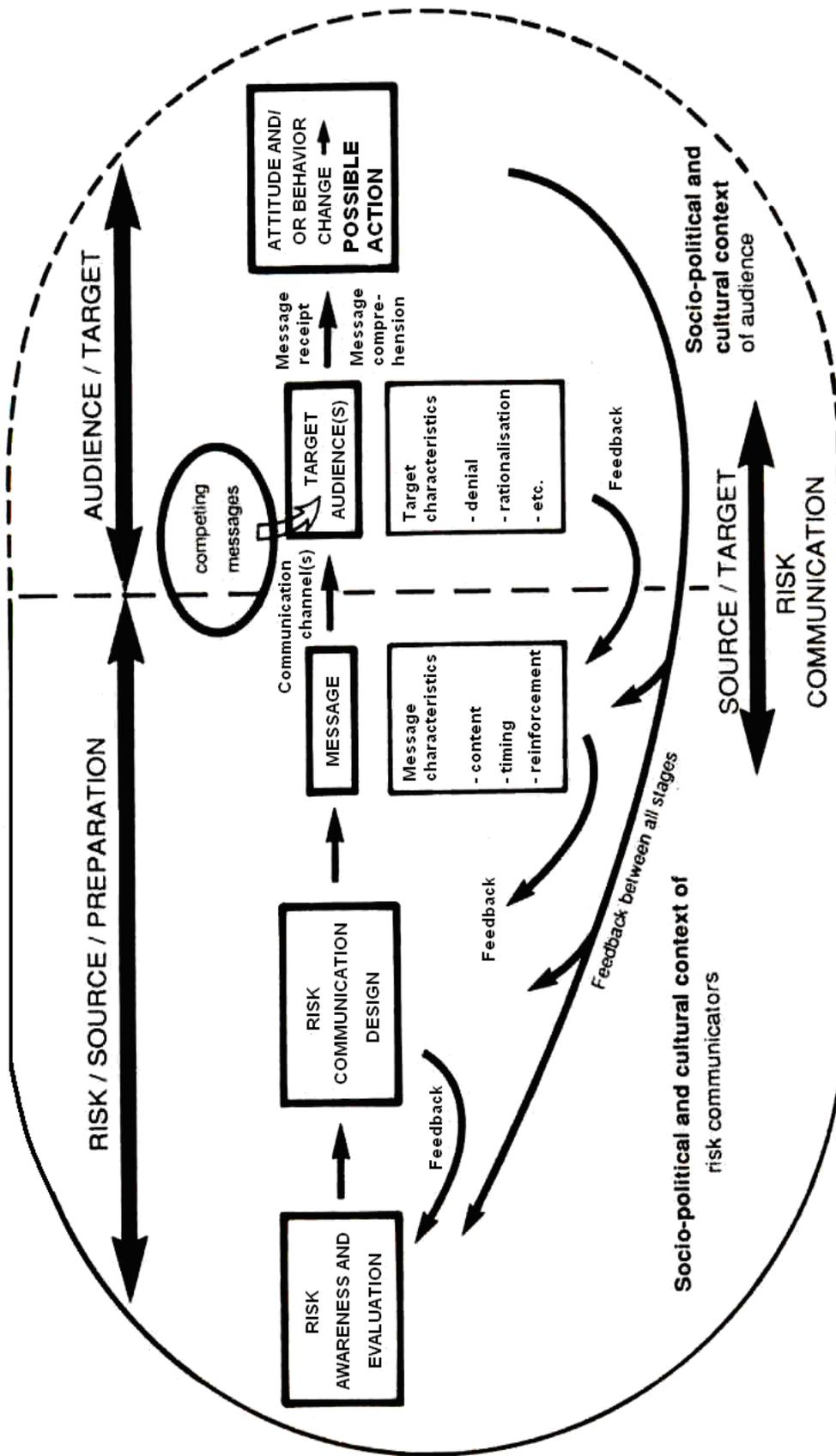


Figure 10. Dual context risk communication model. From Penning-Rowsell and Handmer (1990), who outlined socio-political and cultural contexts in a Dual Context Risk Communication Model.

that may alleviate the threat. The efficacy of such a regulatory message is the effectiveness or feasibility that following the regulatory recommendation will alleviate the threat or risk (Handmer 2000); self-efficacy refers to the belief that the recommendation can or will be followed (Witte, Meyer and Martel 2000). Such environmental regulation is driven by recent and memorable instances where perception may lead to systematic errors. The strengths and weaknesses of disaster surveillance during Hurricane Katrina in 2005 in New Orleans, Louisiana (Fleischauer, Young, Mott and Ratard 2007) emphasize the value of passive, active and electronic surveillance for estimated case loads, for injuries and illnesses, and for sustainable long-term surveillance. However, they also note that active surveillance is resource intensive and despite best efforts still resulted in missing data (~50% demographics, ~35% clinical and epidemiologic data).

A risk-based approach to making decisions or formulating regulations is heavily reliant upon risk assessment calculations with little or no consideration of other factors. Such reliance on computation may suffer from lack of data or models or imperfect consideration of scenarios. In risk assessment, the likelihood of initiating events, as well as the likelihood of various outcomes that may result from each initiator, depending on the metric used. Likelihood is typically expressed as probability computed using logic and probability theory applied to statistically valid, detailed data. However exacting the computational process, the underlying data may inherently possess significant uncertainties that, even if they are explicitly acknowledged, may compromise the resultant risk assessment.

An alternative is a risk-informed approach in which risk insights are used in conjunction with other quantitative and qualitative information to make decisions. By allowing for logical structuring of decisions to include relevant factors and the relationships among these factors, the risk informed approach also provides more practical value. It allows for involvement and a shared commitment among interested parties (e.g., policy makers, planners, industry and the public) as well as facilitating effective communication, training and procedures. Effective risk communication is an interactive process of timely and credible information and opinion exchange (NRC, 2003) designed to raise the level of understanding of relevant issues and actions.

The first half of this research, Chapters I through IV addressed the first two steps that comprise the process of framing theory toward understanding health-related impacts from the flood hazard. These steps included defining and setting forth problems or issues, providing background, and “diagnosing causes” or identifying factors. Chapter V presents a brief description of the Study Area chosen for this study, followed by the steps in framing of judgments or assessments, and remedies in Chapters VI through VIII which form the qualitative and quantitative analyses of this research.

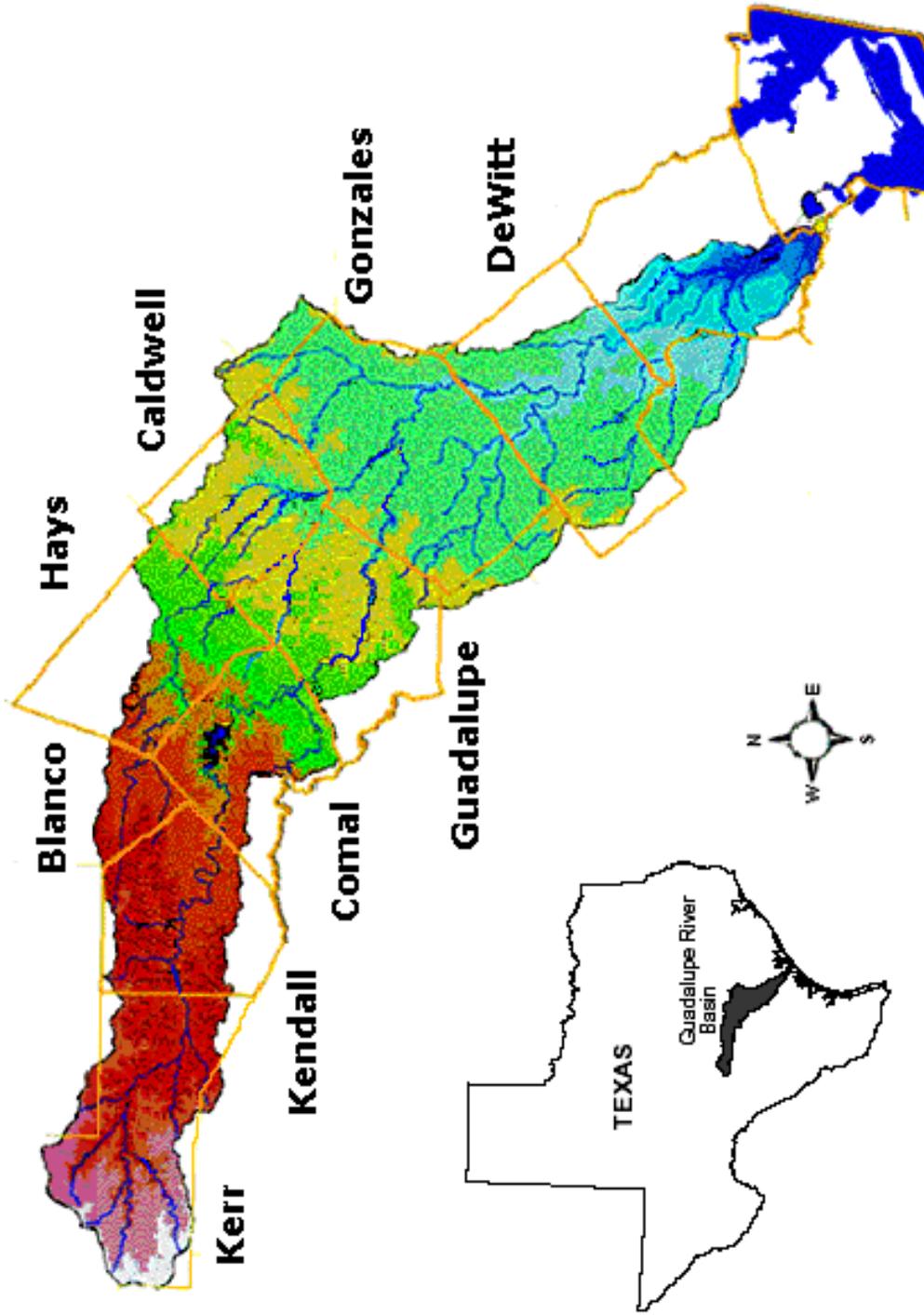
## CHAPTER V

### STUDY AREA

As established earlier, this research addresses health-related impacts within the geographic confines of south-central Texas, a region of great cultural and socio-economic diversity. One of the most populous river basins in south-central Texas is the Guadalupe River.

#### **South-Central Texas Study Area**

The Guadalupe-Blanco River system (**Figure 11**) was selected for the study region based upon its administrative structure, geographic location, hydrologic history, and rapidly growing residential and urban population. Under the joint control of local, regional and national agencies, this river basin encompasses approximately 6,040 square miles extending from the Hill Country between Austin and San Antonio to the Gulf of Mexico. The Guadalupe Valley Hydroelectric Division of the Guadalupe Blanco River Authority (GBRA) operates six powerhouses and pass-through dams (with very limited flood management capabilities) built along the river in the 1920s and 1930s. While additional structural flood-control measures are under consideration (Earl 2004), Canyon Lake Dam is the only flood-control dam on the river that maintains reservoir waters in storage for urban, industrial and agricultural users. Canyon Lake is co-managed by the GBRA and U.S. Army Corps of Engineers, and waters above the reservoir are managed



**Figure 11.** Study area in south-central Texas. Most of nine principal counties are encompassed by the Guadalupe River drainage basin which decreases in elevation from Kerr County southeast to the Gulf of Mexico.

by Upper Guadalupe River Authority (UGRA) conservation and reclamation district. The Guadalupe River originates in Kerr County at about 1,800 feet above mean sea level and flows approximately 410 miles through a 6,070 square mile drainage area. The 30-year (1961–1991) mean annual precipitation in the basin ranges from about 30 inches near the headwaters to an average of approximately 40 inches near the Gulf. For the period of record from 1935 through 2002, the annual mean discharge of the Guadalupe River into Guadalupe Bay is 1,932 cubic feet per second at gauging station 08176500 Guadalupe River at Victoria (Gandara 2003).

Canyon Dam, which forms Canyon Lake, was completed in 1964 for flood control, water storage, hydroelectric power generation, and recreational uses. Canyon Lake has an average surface area of 8,240 acres and storage capacity of 386,200 acre-feet. With the closing of the dam, the Guadalupe River became a regulated river over much of its length, rarely subject to the wide range of natural flows that are typical of this region. For the period of record from 1964 through 2002, the annual mean discharge below the dam is 489.5 cubic feet per second of regulated stream flow at gauging station 08167800 Guadalupe River at Sattler (Gandara 2003). The San Marcos River, tributary to the Guadalupe River in Gonzales County, provides the only regular inflow below Canyon Dam. The San Marcos River is spring-fed, with annual mean discharge from the springs of 170 cubic feet per second (Gandara 2003).

Spring-fed headwaters derived from the Edwards Aquifer are joined by surface runoff and provide high water quality that makes the river attractive to Texas residents and tourists while supporting rich and divergent ecosystems. While there are occasional rapids in the upper reaches where the river flows across limestone bedrock, for the most

part the river is rather placid; local pool levels fluctuate with rainfall and may be dry during periods of drought.

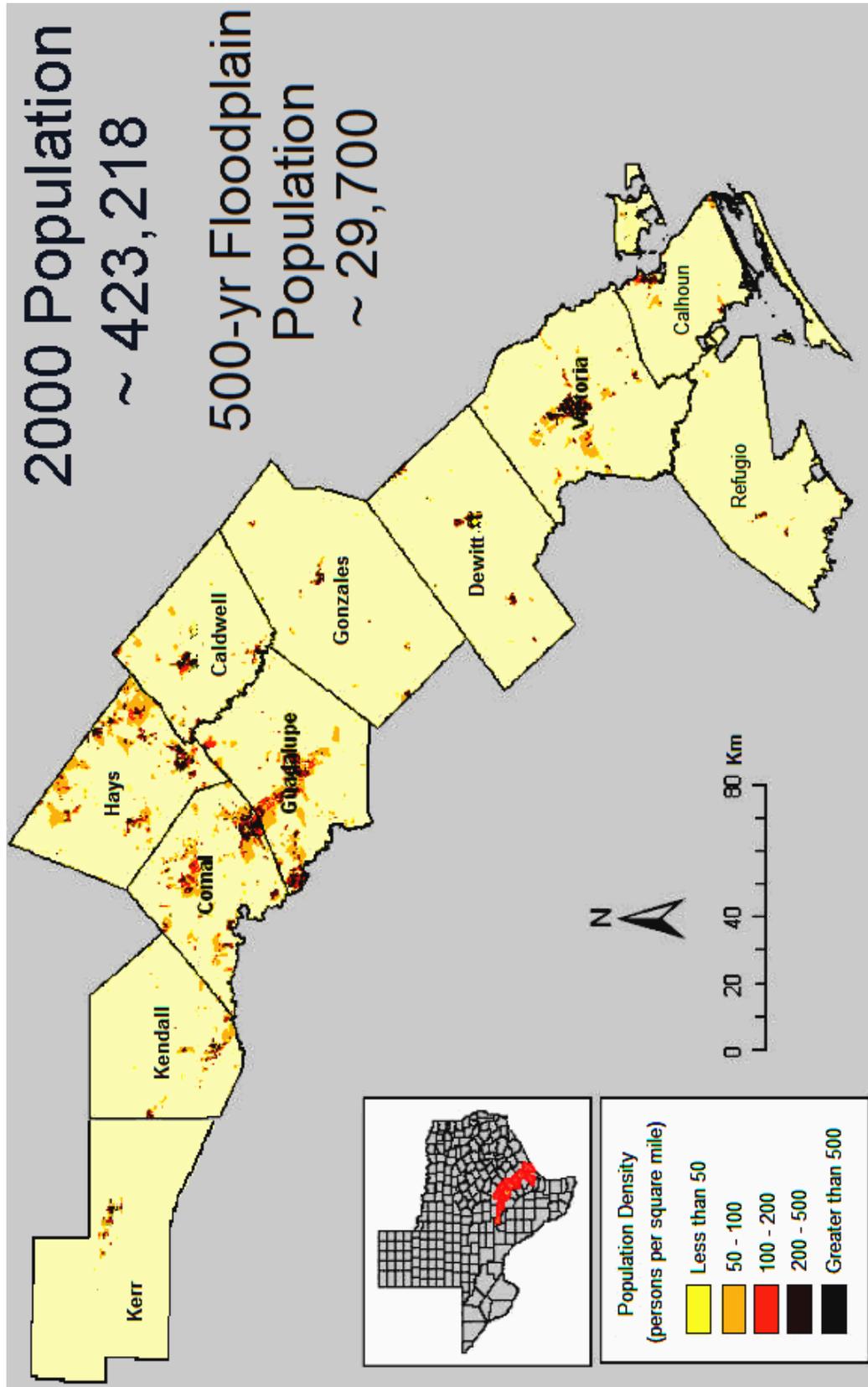
Population within the Guadalupe River Basin is concentrated in urban areas in Hays, Comal, Guadalupe, Caldwell and Victoria counties (**Table 1, Figure 12**). South-central Texas is experiencing rapid urban and suburban population growth, with an ethnically diverse population dependent on the river for water supply, recreation, and economic support. The population is projected to double by the year 2040. This same population becomes vulnerable to the risks of unexpected major flood events, particularly those 29,700 persons living within the 500-year floodplain (GBRA 2004). Shifts in climate, development, and consequent erosion patterns will likely make this region (or sub-regions of this basin) subject to continued or escalating flood risks in the future, making the related health impacts topics of high importance and affirming the need to connect science and public policy (Toman 1998). Results of such basic research must be conveyed to regulatory and administrative agencies in a format that will clarify risks and consequences of expected flood events and augment training, emergency management, and policy making to protect the public. Hence, the need for proper framing of appropriate technical data on floods and flood-related health consequences.

Flood records dating back to the mid- to late 1800s and stream gauge monitoring since the early 1900s provide a long historical record reflecting at least 18 major floods exceeding the designated 100-year event for this river system (**Figure 13**). These events include the 1998 and 2002 floods which have been described as 500-year events. The interval between historic floods which exceed the 100-year flood level ranges from 4 to as many as 14 years (Hanford 2003). As noted by Hunt (2005), focusing mainly on the

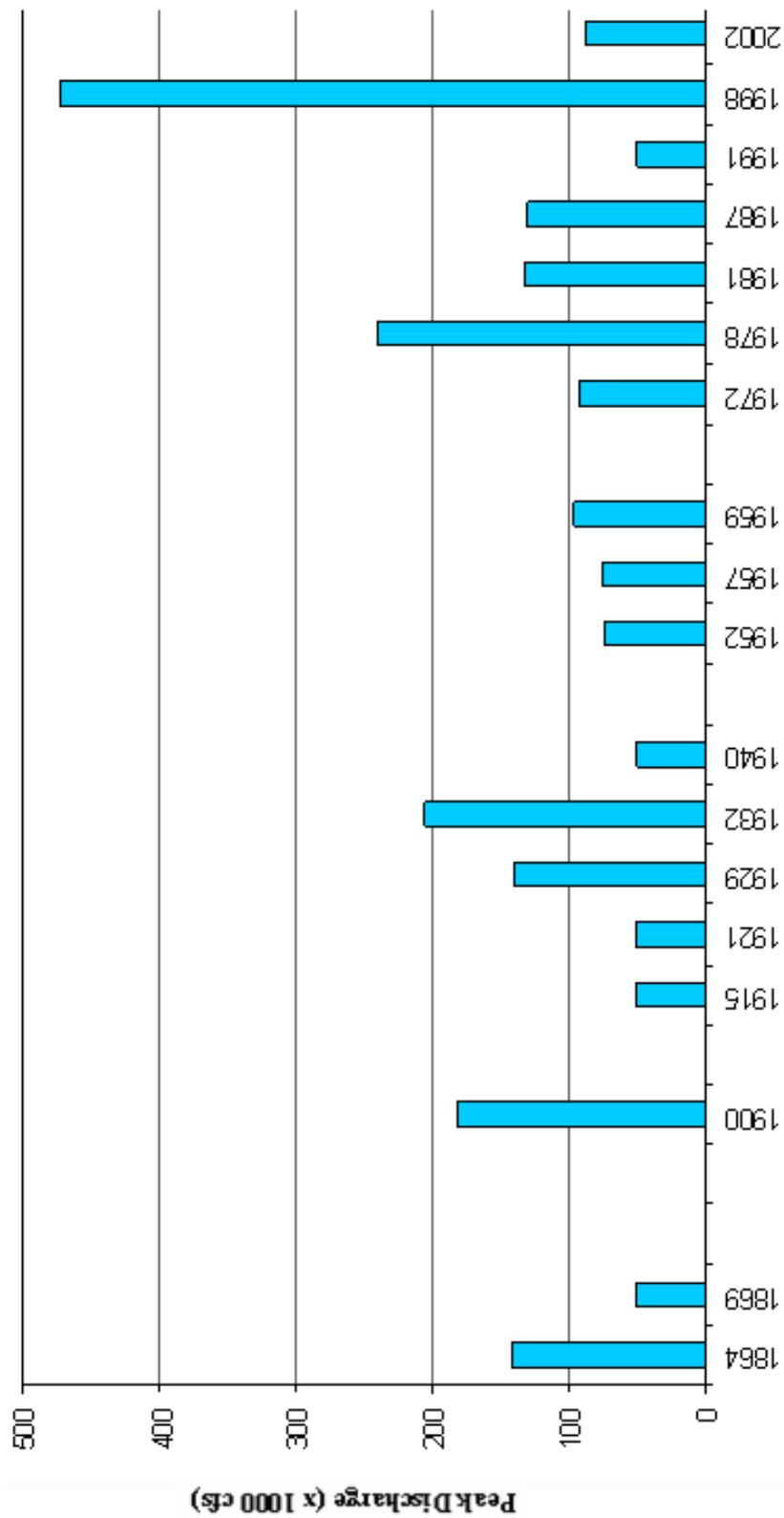
**Table 1.** Guadalupe River Basin Land Area and Population by County in 2000.

<b>County</b>	<b>Land Area * (square miles)</b>	<b>Population * In 2000</b>	<b>Population Density (persons/square mile)</b>
Caldwell	546	32,194	59
Calhoun	512	20,647	40
Comal	562	78,021	139
DeWitt	909	20,013	22
Gonzales	1,068	18,628	17
Guadalupe	711	89,023	125
Hays	678	97,589	144
Kendall	663	23,743	36
Kerr	1,107	43,360	39

\* Land area and population data from GRBA (2004).



**Figure 12.** Population density in the Guadalupe River Basin in 2000. Less than 10 percent of the population lives within the 500-year flood plain.



**Figure 13.** Major historic flood events on the Guadalupe River. Peak discharges exceeding the 100-year flood were compiled from Slade and Patton (2003), Slade and Persky (1999) and Asquith and Slade (1995).

extreme value data to derive a 'return period' provides a more reliable (and often more alarming) estimate of further extreme events which may serve as motivation to develop effective mitigation policies.

Intervening droughts may also play a role in the severity of the succeeding flood when convergent climatic conditions draw in significant moisture and produce intense precipitation events of long duration. During the resultant floods, the river takes on a very dynamic character. For example, on July 1, 2002, the Canyon Lake Dam spillway north of New Braunfels began overflowing for the first time since the reservoir was filled in 1968. Torrents of water cut a new bedrock channel (Barranca de Caliza) 200 yards wide, up to 33 feet deep, and over a mile long, devastating a residential subdivision, flattening houses, uprooting trees and erasing a park.

### **Health Impacts of Floods in South-Central Texas**

Mortality and morbidity data for Texas has been included in the National Climatic Data Center (NCDC) Storm Events Database (**Tables 2 and 3**). A preliminary review of NCDC data for the period 1960 to 1996 indicates a total 4,629 flood fatalities in the United States, with 56% occurring in vehicles driven into flood waters. Texas contributed 619 fatalities during flash flood events (**Table 2**), with males accounting for the majority (79%) in vehicle-related deaths. Texas has the dubious distinction of being the only state to have at least one flood fatality in each year, with an average of 17 flood-related deaths per year and at least 10 deaths in each of 25 separate years during this interval (Hanford 2003).

**Table 2.** Reported Flood Mortality and Morbidity Data for Texas, 1960-2002.

<b>Time interval</b>	<b>Deaths</b>	<b>Reported injuries</b>
1960 - 1996	619	(not reported)
1997 – 2002	96	6889
1997	21	239
1998	41	6357
1999	2	7
2000	9	12
2001	9	233
2002	14	41

Summarized from National Climatic Data Center (NCDC) Storm Events Database

**Table 3.** Flood Mortality and Morbidity Reported in the Guadalupe River Basin, 1997-2002.

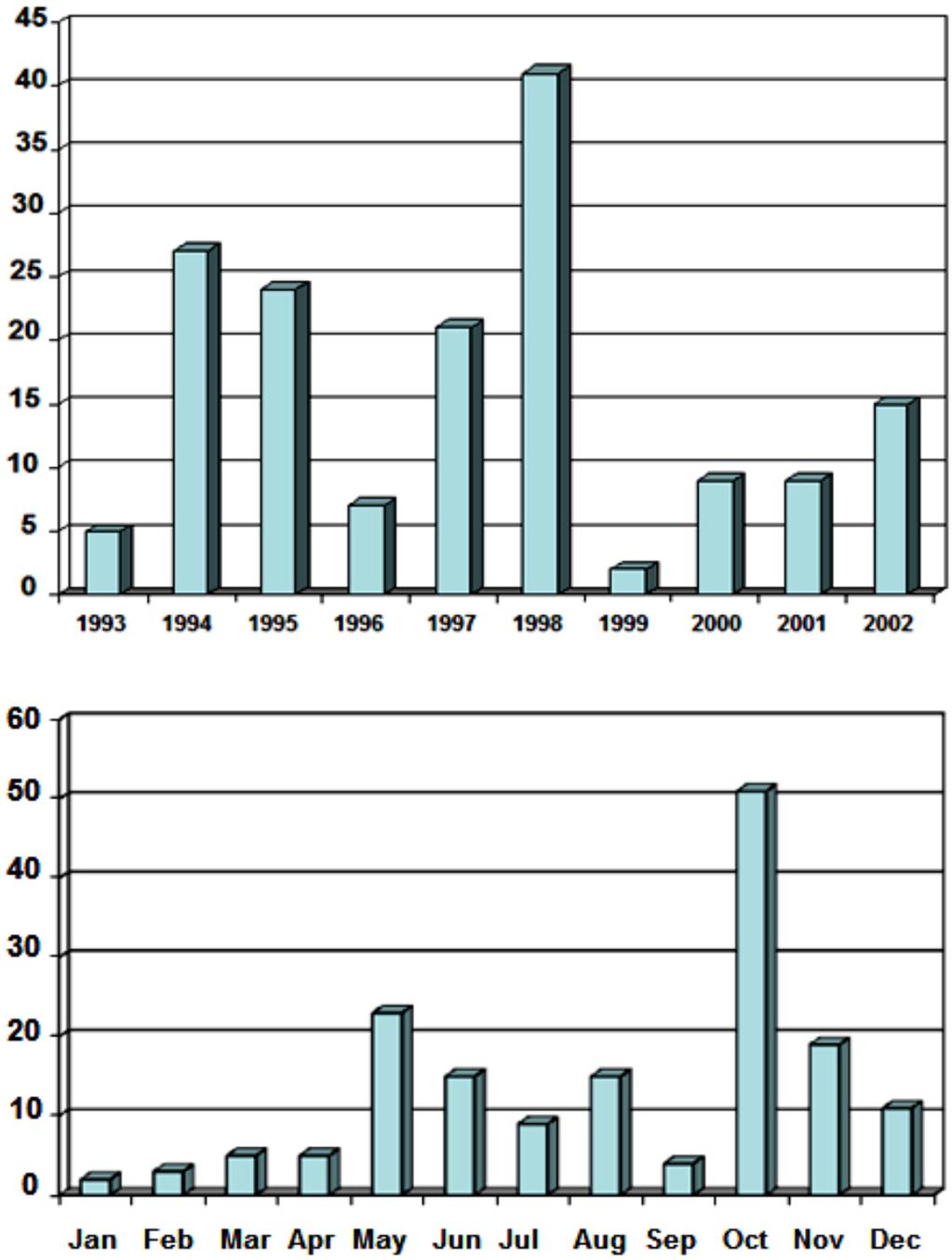
<b>County</b>	<b>Fatalities</b>	<b>Reported injuries</b>
Blanco	1	10
Caldwell	6	695
Comal	2	1620
DeWitt	0	1370
Gonzales	0	1405
Guadalupe	5	1829
Hays	2	277
Kendall	1	20
Kerr	1	20
Total	18	7246

Summarized from National Climatic Data Center (NCDC) Storm Events Database

An analysis of flood-related deaths for the decade 1993 to 2002 indicates variability from year to year, but with some seasonality of occurrence reflected in the highest numbers of deaths occurring during the summer months and again beginning in October (**Figure 14**), skewed by the October 1998 flooding associated with Tropical Storm Allison across southern Texas. Kremer and Zane (1999) indicated flood-related deaths for the October 1998 flood included six deaths in Caldwell, four deaths in Comal and five deaths in Guadalupe counties based on medical examiner records supplemented by information from the Bureau of Vital Statistics to identify both direct and indirectly-caused deaths. They concluded that most deaths from this storm were directly caused and were primarily due to drowning; twice as many decedents were male versus female. Causes of the 29 direct and 2 indirect deaths attributed to the October 17-20, 1998, floods included 24 drowning, 3 cardiac origin, 3 multiple trauma, and one from hypothermia (CDC 2000).

While Texas led the nation in five of the six years between 1997 and 2002 in flood fatalities, almost 6900 injuries were reported in Texas during that same interval (**Table 2**). Almost 20 percent of Texas flood fatalities occurred within the Guadalupe River basin and more than 7200 injuries were reported (**Table 3**). (Note: The discrepancy in injuries is a reflection of the inherent uncertainties in the national database.) National database information is not available for other health-related impacts of the flooding.

The number of evacuees exceeded 7,000 during flooding in October 1998 that was centered in the Guadalupe River system and impacted urban centers from San Antonio to Houston. The numbers of injuries are likely significantly under-reported. The CDC (2002) noted that 4 percent of surveyed households reported at least one person



**Figure 14.** Texas flood-related deaths, 1993 through 2002. The distribution of deaths are shown by year and month. A total of 159 fatalities were compiled from the National Climatic Data Center (NCDC) Storm Events Database.

injured after the onset of flooding in Houston in 2001. Additionally, the study in Houston noted almost 13 percent of surveyed households reported at least one person with illness that occurred within one week after the onset of flooding.

The question of indirectly related deaths is often difficult to resolve. For example, Brenner, Lillibridge, Perrotta and Noji (1994) reported on the death of a 68-year old woman who died of burns and smoke inhalation when her non-flooded mobile home in Bartlett, Texas, caught fire. The fire was due to short-circuiting in the electrical wiring caused by fire ants. Although the mobile home was not flooded, the fire ants apparently had crawled up a utility pole and into the main circuit-breaker panel to escape flood waters that completely surrounded the mobile home. Local authorities investigating the cause of the fire found that the circuit-breaker panel was filled with dead fire ants. Brenner and others (1994) caution that the public health problem of electrical fires associated with ant infestations of electrical devices, especially in flood disasters, should be recognized.

The next chapter (VI) turns to a discussion of the general research design for the establishment of an historical record. This discussion will be fully developed in Chapter VII, as well as introduce the information tool that will be tested in Chapter VIII.

## CHAPTER VI

### RESEARCH DESIGN, DATA SOURCES ACQUIRED, AND DEVELOPMENT OF AN INFORMATION TOOL

The research design employs a mixed methods approach referred to by Creswell as a two-phase “explanatory design.” The intent of this design is to link the results of the first method which is qualitative in nature to help develop or inform the second method which is quantitative (Creswell 2007, 75-78). In this design, Part I, which relates to Proposition #1 calling for the establishment of an historical record of health-risks due to flood occurrences, consists of outlining the available data and information related to epidemiology and the flood hazard in south-central Texas appropriately framed for use by local leaders to implement safety and preparation programs, thereby saving lives and properties. Part II of this study relates back to the presentation of data sources in the first phase, and was designed to accomplish several objectives: a) establish the historical record of flooding in south-central Texas as it relates to health and flooding; b) develop and test a risk communication tool by local leadership regarding health and flooding based on the historical analysis; c) educate and inform local leaders with respect to the potential risks from health and flooding; d) discuss the creation of information materials and dissemination to community citizens; e) assess the degree to which these materials, based on the historical record of health and flooding, increased awareness levels or changed the perceptions held by local leadership. This last one is under (c). The rationale for this approach is that the qualitative data and the subsequent historical record, supports

and informs the second phase, to test a risk communication tool. The analysis of both phases together provides a general understanding of the two goals of this study.

### **Part I: Sources of Data Acquired Towards Developing a History of Health Impacts and the Flood Hazard**

The paucity of extant data on health-related impacts of floods has resulted in an increase in the usage of qualitative research methods in the geography of health and health care (Curtis, Gesler, Smith and Washburn 2000; Baxter and Eyles 1999, 1997; Elliott 1999; Cutchin 1999; Dyck 1999; Kearns and Gesler 1998; Jones and Moon 1987; among others). Specifically, Morse (1994) describes qualitative research as, “essential to the knowledge development of the health care disciplines.” Dyck (1999) contends that qualitative methodology has the potential for re-conceptualizing issues that frame investigation of relationships among place, people and health.

Shifts in climate, population growth and land use patterns will likely result in escalating flood risks in the future, resulting in significant impacts and the need to address potential impacts of future flood events on the health of both the individual and society. Understanding of inland flooding and health risks will be improved by characterizing the frequency and severity of flood events and associated human health impacts in south-central Texas. The results of this basic research are conveyed in an appropriate and useful format for facilitating use by regulatory and administrative agencies that are responsible for providing information about the risks and consequences of expected flood events in training emergency management officials, policy makers, the public, and others as appropriate. Results are framed in a summary “Fact Sheet” for ease of dissemination for informing decision makers and improving their level of

understanding of the potential health-related impacts associated with inland flooding in south-central Texas. The effectiveness of communicating this scientific/technical information to policy-makers was confirmed by empirical testing.

An empirical investigation of flood hazards and epidemiological vulnerabilities in the Guadalupe-Blanco River system collected and synthesized available data for both flood events and the associated health impacts. Results for Part I, potential data sources are listed in **Table 4** and potentially relevant analytical methods are listed in **Table 5**. Since the data for this study were not collected within a focused surveillance program, the data and consequent results were qualified to provide a measure of the health impacts on society and provide some measure of justification for the need for a focused surveillance program.

## **Part II: Assessment of Awareness Levels from Historical Research and Plans to Test a Risk Communication Tool**

### **a) Establishing the Historical Record of Flooding in South-Central Texas as it Relates to Health-Related Impacts of Flooding**

#### **Recurrence Intervals and Magnitudes of Floods**

The historical record of flood events facilitated hazard identification and exposure assessment interpreted as a measure of the frequency of flood occurrence and the magnitude of the respective flood events within the study area as representative of conditions in south-central Texas. Available data were also tabulated on the date and duration of the respective flood events and the cause and type of flooding. These data were tabulated, with source identification and cross-reference, and will constitute the historical record of flood hazards within the study area. Data sources include, but were

**Table 4.** Potential Data Sources.

<b>Source</b>	<b>Database</b>
National Climatic Data Center of the U.S. National Weather Service	Storm Events Database
Centers for Disease Control	WONDER (Wide-ranging ONline Data for Epidemiologic Research) Compressed Mortality File
Em-Dat of World Health Organization	Emergency Events Database
Texas Department of State Health Services	➤ Trauma Registry Hospital Discharge Data ➤ Compilation Reports
Other	➤ Literature

**Table 5.** Potentially Relevant Analytical Parameters.

<b>Parameter</b>	<b>References</b>
Flood character	Stuyt and others 2003
Flood frequency	Asquith and Slade 1995, 1997
Years of potential life lost (YPLL)	Gardner and Sanborn 1990
Quality-adjusted life years (QALY)	Morrow and Bryant 1995 Hofstetter and Hammitt 2002 Sen and Bonita 2000
Disability-adjusted life years (DALY)	Morrow and Bryant 1995 Hofstetter and Hammitt 2002 Sen and Bonita 2000
Flood-related mortality	Jonkman and Kelman 2005 Combs and others 1999

Not limited to, U.S. Geological Survey historic daily mean and peak-flow discharge stream gauging data, historical records, available literature, and local agency and public records.

Type of flood can be categorized by rate of onset and duration to distinguish flash floods from other events that may have a slower rate of onset but may be of longer duration. Four categories of floods have been identified by Stuyt and others (2003): 1) flash floods of a few hours duration, 2) single event flood of long duration, 3) multiple-event floods, and 4) seasonal floods. Based on an analysis of 1,300 world-wide floods, Jonkman (2002) suggests that flood mortality is mainly determined by the type of flood and that mortality rates are relatively constant for river floods, regardless of location. Reported durations and types of flooding in the study area can be reviewed to determine the characteristic flood type for this area.

Frequency analysis of discharge, based on past records, is commonly used to predict the magnitude of an event that will be equaled or exceeded once every given number of years, on average. The frequency of occurrence of an individual event is referred to as the average return period or recurrence interval, expressed in years (IACWD 1982). The recurrence interval does not imply regularity of occurrence and does not address cumulative probability over a period of years.

In general, the standard approach for flood-frequency estimation is to consider maximum annual floods over a given period of time and obtain the best empirical fit of the chosen statistical distribution to the data set. In addition to the normal, extreme-value and Pearson distributions, Riggs (1968) also presents graphical fitting since it requires no assumption as to the type or characteristics of the distribution and can be extended over

the time-data interval. The limitations of these types of statistical approaches of flood frequency analysis to predict flood magnitude are discussed by Kidson and Richards (2005).

The 100-year flood (the peak stream flow that has a one percent chance of being equaled or exceeded in any given year) has been determined for the Guadalupe River system (e.g., Asquith and Slade 1995, 1997). However, when the gauging period is limited or if environmental characteristics within a drainage basin are rapidly changing, such as the rate of urbanization, then accuracy significantly decreases and potential flood impacts may be grossly under-estimated (Bell and Tobin 2007; Malamud, Turcotte and Barton 1996). A simpler method of approaching the potential for flooding is to estimate the crude recurrence interval reflected by the available historic record. A crude recurrence interval will be calculated using the raw number of flood events that equal or exceed the 100-year flood flow rate over the available historic time period to identify a characteristic recurrence interval for the study area.

### **Health Impacts on Society**

The American public must be educated to value prevention, since the benefits may be much greater than the dramatic medical or surgical treatment (Helzlsouer and Gordis 1990). The impact of disasters caused by natural hazards on the public health must be assessed in order to appreciate the value of prevention. Methods for defining disease burdens and for guiding resource allocations are needed by health care professionals and decision makers. Death is the crudest measure of health status and in recent years the importance attached to mortality as an indicator of health status has

diminished (Sen and Bonita 2000). Resource allocation decisions are economically based, that is, the benefits obtained per dollar expended or value for the money. A number of health policy approaches have been developed for measuring and valuing human life that can be used to assess the impact on society of disease related to disasters caused by natural hazards. These include years of potential life lost (YPLL) as a measure of disease mortality burden on society and the related metrics of quality-adjusted life years (QALY) and disability-adjusted life years (DALY) as measures of the combined dimensions of morbidity and mortality, respectively (Morrow and Bryant 1995).

Years of potential life lost (YPLL) involves estimating the average time a person would have lived and their death is assumed to be premature (Gardner and Sanborn 1990). This measure quantifies social and economic loss owing to premature death and mathematically weights the total deaths by applying values to death at each age. Both QALY and DALY incorporate impacts before death, such as disability or reduced quality of life; this may be difficult to determine due to limitations of the basic data (Sen and Bonita 2000). These approaches provide a means of framing health-related impacts in terms of benefits (gains) or costs (losses) that can contribute effectively to decision making (Rothman and Salovey 1997). Assessment of the relative value impacts can provide a measure of relative risk and improved knowledge of impacts that improves subject awareness and communication with professionals (Edwards, Elwyn, Dovey, Matthews and Pill 2001). Helzlsouer and Gordis (1990) state that:

...other patterns of infectious disease have resulted from changes in the geographic spread of existing diseases, from the development of new populations at risk, or from changes in the virulence, pathogenicity, or modes of transmission of infectious microorganisms (196).

The factors need to be assessed with respect to the occurrence of natural hazards to determine the relationship among populations at risk and the environmental epidemiology and etiology of disease.

The development of an historical record of health impacts due to flood events were tabulated as a measure of vulnerability and risk, as well as costs to society, as discussed above. Both qualitative and quantitative data were collected, including, but not limited to, morbidity due to disease and injuries, as well as mortality data. Data sources included, were not limited to, historical records, available literature, and available agency and public records. Proportional morbidity was calculated for short-term intervals following flooding. Because the record of health impacts of historic floods was found to be incomplete, this research was limited to health-related impacts of the 1998 or the 2002 flood events. Cases from available data included those persons reported as injured during the flood event, but differentiated from residents of the flood plain who were also exposed but did not report injuries.

Hospital discharge data are routinely used to address issues of public safety, including the tracking of injury rates, inpatient costs, patient characteristics, and outcomes for specific types of injuries, and the formulation of injury prevention programs (Schoenman, Sutton, Kintala, Love and Maw 2005). The digitized trauma registry data of the Texas Department of State Health Services (TDSHS) contains reported injuries in 2002; a data request submittal was submitted subsequent to a March 25, 2005, meeting with TDSHS staff including Ms. Linda Jones, Program Manager, Environmental Epidemiology, Injury Surveillance and EMS/Trauma Registry Team. The request included a time interval of one-month prior to, during, and three months following the

2002 flood and requested traumas reported by relevant ICD (International Statistical Classification of Diseases and Related Health Problems) codes. Pertinent ICD codes are listed in **Table 6**.

Acknowledging that this research had received Texas State University Institutional Review Board (IRB) exemption (**Appendix A**), the TDSHS provided digitized hospital discharge data for the fourth quarter of 2002, a time period which encompassed the October 2002 flooding in south-central Texas. Records were extracted for the counties of concern that were reported by the medical facilities in the respective counties. The extracted records were reviewed to determine if ICD diagnostic codes of concern were listed as primary or any secondary diagnosis.

The epidemiological vulnerability record facilitated characterization of the health risks of exposure including severity and frequency. Data analysis included qualitative assessment of the hazard and vulnerability data for each event, as well as trend analysis. For health impacts, risks were calculated for mortality and injury during attendant flood exposures. For small data sets, appropriate non-parametric statistical tests were performed, with 95% confidence intervals.

Measuring and valuing human life can be used to assess the impact on society of disease related to disasters caused by natural hazards. These include:

- ◆ Quality-adjusted life years (QALY) and disability-adjusted life years (DALY) as measures of the combined dimensions of morbidity and mortality (Morrow and Bryant 1995)
- ◆ Years of potential life lost (YPLL) as a measure of disease mortality burden on society (Gardner and Sanborn 1990)

**Table 6.** ICD-9 and ICD-10 Diagnostic Codes Associated with Flood Hazards.

ICD Code	Designation *	Condition
ICD-9	E908	Cataclysmic storms and floods resulting from storms
ICD-10	X38	Victim of flood
	X38.0	Home
	X38.1	Residential Institution
	X38.2	School, other institution and public administrative area
	X38.3	Sports and athletics area
	X38.4	Street and highway
	X38.5	Trade and service area
	X38.6	Industrial and construction area
	X38.7	Farm
	X38.8	Other specified place
	X38.9	Unspecified place

\* International Statistical Classification of Diseases and Related Health Problems

For example, based on the number of reported cases, hospitalizations and deaths, Meltzer, Rigau-Pérez, Clark, Reiter and Gubler (1998) used DALY to develop a more credible estimate of the burden to society of dengue, placing it *on par* with the impacts from many other infectious diseases generally considered more important. Hofstetter and Hammitt (2002) note QALY and DALY are sensitive to less severe illnesses that affect larger numbers of individuals, particularly when the severity of the illness is difficult to assess. To calculate QALY/DALY for the study area, the number of cases, severity of the disability, length of disability, and age of onset were needed. Since these data were available for only a very few persons reported injured, then not even aggregate or estimated values could be developed or approximated for QALY/ DALY values.

Similarly, mortality data for Texas and for those deaths within the Guadalupe River basin were analyzed using the classification system (**Figure 7**) outlined by Jonkman and Kelman (2005). Based on information available, deaths were classified by medical cause and the associated vulnerability and risk factors (timing, age, gender, activity, other) and were cross-referenced. Descriptive statistics were calculated for distribution of deaths by age, gender, activity and timing. Tabulated data were analyzed for frequency, crude rates and proportions, trend, and associations between variables using standard epidemiological methods (Abramson and Gahlinger 2001). In addition, tabulated data were analyzed by distribution and circumstances of deaths in aggregate for the State and for the river basin.

The Guadalupe-Blanco River Authority (GBRA 2004), in accord with requirements of the Disaster Mitigation Act of 2000, prepared a Hazard Mitigation Plan for 2003-2008, entitled, "Hazard Mitigation in the Guadalupe River Basin: Protecting the

Region Against All Hazards.” This Plan includes listing the total number of persons living in the floodplain by county, as well as the present (i.e., year 2000) and projected racial and ethnic population data by county. Only the total population data were used to calculate morbidity and mortality rates, since more detail data were not available for fatality or morbidity victims.

**b) Development of Risk Communication Materials Designed for Use by Local Leadership Regarding Health and Flooding Based on the Historical Analysis**

As discussed above, results of the assessment of flooding and consequent health impacts are presented in a “FACT SHEET” that presents a listing and explanation of the risks and potential consequences associated with recurrent flood events in south-central Texas. The Fact Sheet includes text, tabular, and graphical information on flood risks and associated health impacts. The results of this basic research are framed in an appropriate and useful format to facilitate use by regulatory and administrative agencies responsible for providing information about the risks and consequences of expected flood events.

**c) Educating and Informing Local Leaders of Community Potential for Risk from Health and Flooding**

The Fact Sheet on Flooding and Potential Health Hazards was distributed to representative local government officials who were invited to participate in empirical testing (as discussed below) of the effectiveness of communicating the data and information related to epidemiology and the flood hazard in south-central Texas.

Participants were representative of ‘local government’ as defined in the Disaster Mitigation Act of 2000 (Public Law 106-390):

- A. a county, municipality, city, town, township, local public authority, school district, special district, intrastate district, council of governments..., regional or interstate government entity, or agency or instrumentality of a local government;
  - B. an Indian tribe or authorized tribal organization, or Alaska Native village or organization; and
  - C. rural community, unincorporated town or village, or other public entity, for which an application for assistance is made by a State or political subdivision of a State.
- d) Assessing the Degree to which these Materials, Based on the Historical Record of Health Impacts and Flooding, Increased Awareness Levels of Local Leadership**

The effectiveness of communicating risks to policy-makers was tested empirically by conducting a two-part survey. The survey was conducted in two phases. Decision makers included local government agency personnel (consistent with the Disaster Mitigation Act of 2000 definition) within the Guadalupe River basin (“gate keepers”) and health professionals whose positions would place them potentially on the frontline of disaster response were invited to participate in the survey process. Those survey respondents who completed Part I of the survey and indicated their willingness to further participate in the research received Part II of the survey by mail. Questions in Part I of the survey were repeated in Part II to evaluate longitudinal knowledge awareness. Survey instruments are presented in the **Appendix B** and **Appendix C**, together with survey announcements and the completion reminder card that were used to improve the number of participants responding and completing Part II of the survey.

Because gate-keepers represent a limited population, questionnaires were distributed to local government representatives. Following a personal invitation to participate in the research, each person received a packet that included an announcement letter of introduction and a copy of Part I of the survey. Part II of the survey was subsequently mailed to willing participants and the packet included an announcement letter, the survey questionnaire, and a self-addressed, postage paid mailing envelope for submitting the completed Part II survey.

Questionnaires were number coded to maintain individual anonymity, but to allow for paired comparison of initial and follow-up responses to facilitate longitudinal analysis for potential shifts in perspectives. Results were tabulated and statistically analyzed to assess the variables attendant with conceptual behaviors of the risk communication model and to determine the longitudinal changes in perceptions of local government decision-makers before and after consideration of the FACT SHEET data.

**e) Theorizing a Model of Communication for Local Leadership Regarding Health Impacts from the Flood Hazard**

The results of the empirical study were to test the effectiveness of an information tool which, in future research, might serve as the beginning stage in defining a predictive model of risk communication for addressing the anticipated frequency and magnitude of future flood events, and the potential health-related impacts. Using the methods outlined by Paton (2003), the results of the research on health protective behavior can be integrated with social-cognitive variables that motivate preparedness, intent to act, and culminate in actions that improve preparedness. The social-cognitive preparedness model recognizes three phases: 1) motivators or precursors {critical awareness of

hazards, risk perception or hazard anxiety); 2) intention formation (outcome expectancy, problem-focused coping and response efficacy); and, 3) linking intentions and preparedness (sense of community, perceived responsibility, timing, and normative factors). The model will employ ‘translation’ (Leiss 2001; Arkin 1989) of the scientific results into publicly understandable terms in a framework that relates possible outcomes to a set of feasible risk control options in a decision matrix of probable adverse health effects and possible risk reduction scenarios. Placing the social vulnerability (mortality and morbidity impacts) within a risk management framework can facilitate the likelihood of mitigation and recognition of adaptive capacity to respond appropriately to flood hazards (Brooks 2003).

To implement this research design and support the development of the tool for communicating data on floods and flood-related health risks, it was necessary to develop the historical record. Chapter VII outlines the process of developing the historical record for both the State of Texas and, in particular, the Guadalupe River basin. Specific sources and quality of the data acquired from those sources is assessed to describe the completeness of the available historical record of health impacts and flood hazards in the study area.

## CHAPTER VII

### DEVELOPING AN HISTORICAL RECORD OF MORTALITY AND MORBIDITY ASSOCIATED WITH FLOODING

Data on mortality and morbidity associated with flood events in the Guadalupe River basin were retrieved for evaluation from the following data sources:

- ◆ Global Active Archive of Large Flood Events
- ◆ Emergency Events Database
- ◆ Compressed Mortality File
- ◆ Texas Hospital Discharge Data
- ◆ Spatial Hazard Events and Losses Database for the United States
- ◆ National Climatic Data Center (NCDC) Storm Events Database

The following sections briefly discuss each of the potential data sources, focusing on the potential for providing appropriate mortality and morbidity data. The characteristics of the sources and the usability of the data are assessed. Mortality data from the NCDC Storm Events Database are analyzed using the model of Jonkman and Kelman (2005). The NCDC Storm Events Database mortality data supplemented by other sources is also assessed by applying the classification matrix of Combs, Quenemoen, Parrish and Davis (1999). Causes of morbidity are discussed.

The resultant compilation demonstrates that it is possible to develop an account of data and information related to epidemiology and the flood hazard in south-central Texas for use by local leaders to implement safety (mitigation) and preparedness programs,

thereby saving lives and properties, as well as reducing adverse health impacts that could reduce quality of life. It is also demonstrated that the historical record of mortality and morbidity associated with flooding is incomplete and that significant future efforts must be directed toward developing an account of data and information that will support appropriate epidemiological analysis to provide for appropriate scientific input to the risk communication process that can lead to better informed decision making to reduce adverse impacts and protect the public.

### **Developing the Historical Record**

#### **Global Active Archive of Large Flood Events**

The Global Active Archive of Large Flood Events is maintained by the Dartmouth Flood Observatory (<http://www.dartmouth.edu/~floods/Archives/index.html>) and it incorporates information derived from news, governmental, instrumental, and remote sensing sources. The Archive includes events occurring during since 1985, updated as data become available for more recent events. Data tabulation for each event includes dates, fatalities, and the number of persons displaced. Data are aggregated for each event across the area impacted and therefore cannot be analyzed on a local basis, providing only global or regional perspectives. The Dartmouth Flood Observatory acknowledges that inconsistencies are an integral part of the archive database because it combines data from different information sources over two decades.

### **Emergency Events Database**

Since 1988, the Centre for Research on the Epidemiology of Disasters (CRED) has maintained an Emergency Events Database (EM-DAT) to support humanitarian action at national and international levels. Core data is contained in EM-DAT on the occurrence and effects of over 16,000 mass disasters in the world from 1900 to present. In addition to providing information on the human impact of disasters, such as the number of people killed, injured or affected (displaced), EM-DAT provides disaster-related economic damage estimates and disaster-specific international aid contributions.

EM-DAT is compiled from various sources, including United Nations agencies, non-governmental organizations, insurance companies, research institutes and press agencies. CRED has standardized data compilation, validation and analysis by event and makes the database available for unrestricted query access. However, data inconsistencies are common. Guha-Sapir and Below (2002) conducted a comparative analysis of EM-DAT with two other global natural disaster data sets, finding that scientific rigor is used to maintain the databases which served broad communities of users. Further, they found the three databases were complementary but methods of standardization vary among the passively collected data sets. At a more detailed level, they found differences in time intervals and that comparisons between databases were inhibited by differing conceptual purposes (e.g., socio-economic versus human impacts).

### **Compressed Mortality File**

The Compressed Mortality File (CMF) data set is published by the U.S. Department of Health and Human Services (US DHHS), Centers for Disease Control and

Prevention (CDC), and the National Center for Health Statistics (NCHS) Office of Analysis and Epidemiology. The WONDER (Wide-ranging Online Data for Epidemiologic Research, <http://wonder.cdc.gov>) online databases utilize an ad-hoc query system for the analysis of public health data, including the Compressed Mortality File (CMF). The CMF is a county-level national mortality and population data base spanning decades, derived from the U.S. records of deaths (death certificates) since 1979. Counts and rates of death can be obtained by place of residence (country, region, state, and county), age group, race, gender, year, and underlying cause-of-death (4-digit ICD code or group of codes). Crude death rates and age-adjusted death rates can be calculated, provided that sufficient data exist.

The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially (**Table 6**), and to prevent confusion about the significance of any specific disease code, data queries are separate.

**ICD 10 Codes for Mortality 1999-2006** - The CMF was queried for flood deaths (ICD-10 code X38) by year and by gender for each of the counties of concern in the Guadalupe River basin for the period from 1999 through 2002. No flood deaths are listed for any of the counties of concern during that time interval.

**ICD 9 Codes for Mortality 1979-1998** - The CMF was queried for flood deaths (ICD-9 code E908) for deaths caused by cataclysmic storms and floods resulting from

storms for each county of concern in the Guadalupe River basin for the period from 1979 through 1998. The query results included a total of five deaths: one in Caldwell County, one in DeWitt County, and three in Kendall County. Other queried annual results were suppressed due to confidentiality constraints to protect personal privacy for 1989 and later years for counties with census year populations of less than 100,000 and five or fewer deaths based on only one or two years of data. An additional query for flood deaths tabulated by gender aggregated over the interval 1979 through 1998 returned a tabulation of 3 deaths each in Caldwell, Comal and Kendall Counties, 2 deaths each in Guadalupe and Victoria Counties, and 1 death each in Gonzales, Hays and Kerr Counties. These limited query results could, therefore, not be subjected to further analysis.

### **Texas Hospital Discharge Data**

Upon request and review of Texas State University Institutional Review Board (IRB) exemption status, the Texas Health Care Information Collection Center for Health Statistics of the Texas State Department of Health Services provided access to the digitized Texas Hospital Discharge Data for the third and fourth quarters of 2002. These two quarters were selected because the discharge data were available in digitized format and the data encompassed the October 2002 flood. A total of 12,705 and 12,730 individual records for the 3<sup>rd</sup> and 4<sup>th</sup> Quarters of 2002, respectively, were digitally extracted from the Texas Hospital Discharge Data for the nine counties in the Guadalupe River basin study area. The extracted records for each quarter were electronically searched to determine the frequency of ICD-9 (E908) and/or ICD-10 (X38) diagnostic codes indicative of flood victims (**Table 6**). No individual record indicated either of the

diagnostic codes reflective of flood victims or of cataclysmic storms and floods resulting from storms for either primary or any secondary diagnosis.

In assessing the effectiveness of E codes to identify submersion fatalities, Smith and Langley (1998) suggest that using a single E code fails to accurately assess causative factors, particularly when the fatality is attributed to a motor vehicle accident. They note that drownings are multi-factorial and not well described by single cause. Such contributory factors might include exposure or hypothermia, cardiac origin, or blunt trauma. Smith and Langley (1998) recommend multiple-cause coding and use of free text narratives to improve the value of the vital statistics. By not using multiple E codes to designate contributory factors or associated conditions, the number of deaths by drowning may be underestimated and therefore not provide data necessary to improve policies for injury or fatality prevention. Recording multiple causes of death recognizes that a flood-related fatality may be the result of a sequence of events. The critical question then becomes: Would this death have occurred in the absence of the flooding event?

### **Spatial Hazard Events and Losses Database for the United States**

The Spatial Hazard Events and Losses Database for the United States (SHELDUST™) is a county-level hazard data set for 18 different natural hazard events, including floods (HVRI 2009). For each event the database includes the beginning date, location (county and state), property and crop losses, injuries and fatalities compiled and geo-referenced by the Hazards & Vulnerability and Research Institute at the University of South Carolina. The data were derived from existing national data sources, including the

National Climatic Data Center's (NCDC) monthly Storm Data publications for events that caused one or more fatality (according to NCDC Storm Data) since 1960. **Table 7** presents event, injury and fatality data derived from queries for each county of concern in the Guadalupe River basin over the period of history included in the SHELDUS™ database through 2002. The SHELDUS™ data base distributes human injuries evenly across multiple counties where necessary; thus, there are fractional injuries attributed to some events in some counties. The resultant query data from the SHELDUS™ database are therefore not suitable to detailed analysis to assess health-related impacts associated with flood events in south-central Texas.

#### **National Climatic Data Center Storm Events Database**

The Storm Events Database is maintained by the National Climatic Data Center (NCDC) of the U.S. National Weather Service. The NCDC Database can be queried by hazard type (including flooding), by geographic area (state or county), and by time (in years). As discussed above, a number of national and international databases for flood events incorporate data from the Storm Events Database; however, the exact manner in which data are incorporated is equivocal. To determine the flood fatalities and injuries reported for counties encompassing the Guadalupe River basin the NCDC Storm Events Database was queried and the results are discussed in the following sections.

**Mortality by Activity or Setting of Occurrence** - Queries of the NCDC Storm Event Database returned a total of 19 reported deaths for the Guadalupe River basin during the period 1997 through 2002, as illustrated in **Figure 15**. Detailed review of the

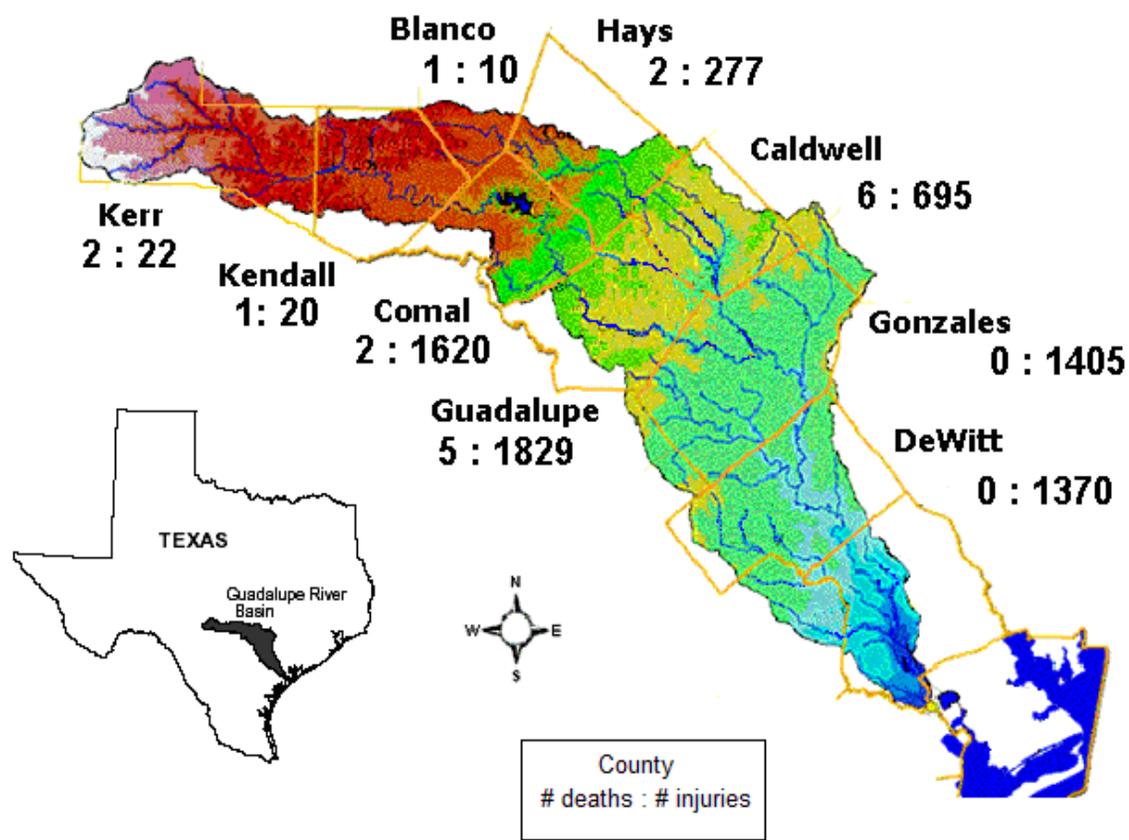
**TABLE 7.** SHELDUS™ Database Query Results for Flooding Events with Injuries or Fatalities by County, 1972 through 2002.

<b>Begin Date</b>	<b>Year</b>	<b>County</b>	<b>Injuries *</b>	<b>Fatalities</b>
7/17	1987	Blanco	4.71	0.00
11/15	2001	Blanco	10.00	1.00
<b>Total</b>		<b>Blanco</b>	<b>14.71</b>	<b>1.00</b>
10/17	1998	Caldwell	41.67	0.00
10/17	1998	Caldwell	500.00	6.00
10/17	1998	Caldwell	50.00	0.00
11/15	2001	Caldwell	20.00	0.00
<b>Total</b>		<b>Caldwell</b>	<b>611.67</b>	<b>6.00</b>
5/11	1972	Comal	200.00	17.00
6/22	1997	Comal	10.00	0.00
10/17	1998	Comal	187.50	0.00
10/17	1998	Comal	800.00	2.00
10/17	1998	Comal	50.00	0.00
<b>Total</b>		<b>Comal</b>	<b>1247.50</b>	<b>19.00</b>
10/17	1998	DeWitt	187.50	0.00
10/17	1998	DeWitt	100.00	0.00
10/18	1998	DeWitt	500.00	0.00
8/31	2001	DeWitt	20.00	0.00
<b>Total</b>		<b>DeWitt</b>	<b>807.50</b>	<b>1.00</b>
10/17	1998	Gonzales	187.50	0.00
10/17	1998	Gonzales	41.67	0.00
10/17	1998	Gonzales	30.00	0.00
10/18	1998	Gonzales	500.00	0.00
<b>Total</b>		<b>Gonzales</b>	<b>759.17</b>	<b>0.00</b>
5/11	1972	Guadalupe	0.00	1.00
6/22	1997	Guadalupe	20.00	0.00
10/17	1998	Guadalupe	187.50	0.00
10/17	1998	Guadalupe	137.50	0.00
10/17	1998	Guadalupe	500.00	4.00
<b>Total</b>		<b>Guadalupe</b>	<b>845.00</b>	<b>5.00</b>

TABLE 7 - continued.

<b>Begin Date</b>	<b>Year</b>	<b>County</b>	<b>Injuries</b>	<b>Fatalities</b>
5/15	1970	Hays	0.00	2.00
12/19	1991	Hays	0.00	1.00
6/8	1997	Hays	7.00	2.00
10/17	1998	Hays	41.67	0.00
10/17	1998	Hays	25.00	0.00
10/17	1998	Hays	100.00	0.00
11/15	2001	Hays	20.00	0.00
<b>Total</b>		<b>Hays</b>	<b>193.67</b>	<b>5.00</b>
7/17	1987	Kendall	4.71	0.00
6/22	1997	Kendall	5.00	0.00
10/17	1998	Kendall	10.00	0.00
<b>Total</b>		<b>Kendall</b>	<b>19.71</b>	<b>0.00</b>
7/17	1987	Kerr	4.71	10.00
<b>Total</b>		<b>Kerr</b>	<b>4.71</b>	<b>10.00</b>
<b>TOTAL</b>	<b>1970 - 2002</b>	<b>All Counties</b>	<b>4503.64 *</b>	<b>47</b>

\* Note: SHELDUS™ records distribute human losses (fatalities and injuries) evenly across multiple counties where necessary, resulting in fractional data, where events covered multiple counties. Since the database is tabulated from other sources, human losses are often under-reported.



**Figure 15.** Flood fatalities and injuries in the Guadalupe River Basin. Data derived and compiled from the National Climatic Data Center (NCDC) Storm Events Database for 1997 through 2002. Note: deaths in Comal County as derived by tabulated query.

NCDC Storm Event Database event records indicated a total of 20 reported deaths as listed in **Table 8**. These 20 deaths comprise approximately 21 percent of the 96 fatalities in the entire State of Texas during that time interval. Comparing the number of fatalities reported with the population in 2000 reported for the respective counties indicates very low crude rates of 0.02 to 0.03 per 1,000 persons for Blanco and Caldwell Counties, and rates that are an order of magnitude lower for fatalities in all other counties throughout the river basin.

Review and analysis of the NCDC Storm Event Database event records allowed compilation of fatality details using the classification system of Jonkman and Kelman (2005); **Table 9** depicts the results. Drowning caused 85 percent (17 of 20) of all fatalities, including 13 persons associated with vehicles, one attributed to failure of rescue attempt and three persons swept from their homes. Two persons ( $2/20 = 10\%$ ) died of heart attacks, either awaiting rescue or during rescue. One person drowned as a result of electrocution shock ( $1/20 = 5\%$ ). No other causes of flood-related fatalities were reported.

The NCDC Storm Event Database records for flood-related deaths occurring 1997 through 2002 in the entire State of Texas were reviewed and classified following the system of Jonkman and Kelman (2005); the results for a total of 96 fatalities are summarized in **Table 10**. It is noted that in one event, a victim was pregnant; however, the death of the unborn child is not included in the number of fatalities.

In the State of Texas during the period 1997 through 2002, most deaths (92 of 96 = 95.8 %) were caused by drowning (Figure 16). For those drowning deaths where activity was reported, the majority of victims were in a vehicle (47 of 96 = 49 %); vehicle

**Table 8.** Crude Rates for Fatalities and Injuries by county, 1997 through 2002.

County	Land Area (square miles)	Population In 2000	Population Density (persons/square mile)	Fatalities	Injuries	Fatalities Crude Rate (per 1,000)	Injuries Crude Rate (per 1,000)
Blanco	714	8,418	12	1	10	0.0198	0.199
Caldwell	546	32,194	59	6	695	0.0311	3.598
Comal *	562	78,021	139	3	1,620	0.006	3.461
DeWitt	909	20,013	22	0	1,370	0.000	11.409
Gonzales	1,068	18,628	17	0	1,405	0.000	12.571
Guadalupe	711	89,023	125	5	1,829	0.009	3.424
Hays	678	97,589	144	2	277	0.003	0.473
Kendall	663	23,743	36	1	20	0.007	0.140
Kerr	1,107	43,360	39	2	22	0.008	0.085
Total				20	7,248		

\* Number of fatalities adjusted from 2 to 3 based on review of NCDC storm event record.

**Table 9.** Flood Deaths in the Guadalupe River Basin Reported in NCDC Storm Events Database, 1997 through 2002. Deaths are classified following the system of Jonkman and Kelman (2005).

Medical Cause	Number	Activity	Timing	Gender	Age	Lack of Judgment
<b>Drowning</b>	7	Driving vehicles in flood waters	Impact phase	?	?	yes
<b>17 of 20 = 85 %</b>	1	Passenger in vehicle attempting low-water crossing	Impact phase	Female	19	yes
	2	Drove low-water crossing; returned later to retrieve stalled car; vehicle swept into river	Impact phase	Male	Young adult	Yes, returned to flood waters
	1	Second attempt to drive low-water crossing; vehicle swept downstream	Impact phase	Male	63	Yes, 2 <sup>nd</sup> attempt
	1	Driving vehicle; swept into river by flood waters; unable to escape car	Impact phase	Female	82	?
	1	Drove vehicle unexpectedly into rapidly rising flood waters; escaped vehicle but drowned	Impact phase	Male	Young man	yes
	1	Driving thru low-water crossing; rescue attempt failed as victim unable to hold on	Impact phase	Male	64	yes
	3	Swept from homes by flood waters	Impact phase	?	?	?
<b>Heart attack</b>	1	Suffered heart attack during unknown activity; died awaiting rescue	Impact phase	Male	?	?
<b>2 of 20 = 10 %</b>	1	Suffered heart attack during unknown activity; died while being rescued	Impact phase	Male	?	?
<b>Electrocution</b>	1	Accidentally touched live wire while in boat; shocked and died of drowning as a result of shock	Impact phase	Male	?	?
<b>1 of 20 = 5 %</b>						
- Physical trauma						
- Carbon monoxide	0					
- Fire						
- Unknown						

**Table 10.** Flood Deaths in Texas Reported in NCDC Storm Events Database, 1997 through 2002. Deaths are classified following the system of Jonkman and Kelman (2005).

Medical Cause	Number *	Activity	Timing	Gender	Age **	Lack of Judgment
<b>Drowning</b> 92 of 96 = 95.8 %	10 (R 1 ?)	In vehicle	Impact phase	2 M 1 F 7 ?	< 20	?
-- in vehicle 47 of 96 = 49 %	20 (R 2 F, 1 M)	In vehicle	Impact phase	10 M 9 F 1 ?	20 – 59	probably
-- as pedestrian 2 of 96 = 2 %	7 (R 1 M)	In vehicle	Impact phase	5 M 2 F	60 +	probably
-- on horseback 1 of 96 = 1 %	2	In vehicle	Impact phase	2 M	?	?
-- in boat /kayak 3 of 96 = 3 %	8	In vehicle	Impact phase	8 ?	?	?
-- in a building 12 of 96 = 12.5 %	2	As pedestrian	1 Impact 1 Post-impact	1 M 1 F	20 – 59	yes
-- while playing 6 of 96 = 6.25 %	1	On horseback	Impact phase	1 M	20 – 59	yes
-- not reported 21 of 96 = 28 %	3	In boat or kayak	Impact phase	3 M	20 – 59	probably
During rescue 14 of 96 = 15%	12 (R 9 ?)	In a building	Impact phase	12 ?	?	?
	6	While playing	Impact phase	4 M 1 F 1 ?	< 20	yes
	21	Not reported	Impact phase	2 M 1 F 18 ?	3 Adult 18 ?	?
<b>Heart attack</b> 2 of 96 = 2 %	2 (R 1 M)	Unknown	Impact phase	2 M	?	?
<b>Electrocution</b> 1 of 96 = 1 %	1	In boat; shocked by live wire then drowned	Impact phase	1 M	?	?
<b>Unknown</b> 1 of 96 = 1 %	1	?	?	?	?	?
<b>Physical trauma, Fire, or Carbon monoxide</b>	0					

\* R indicates victim died during rescue attempt.  
\*\* Reports of “adult” were interpreted as being in the 20 - 59 year age group, “young adult” or “child” as being less than 20 years of age, and “elderly” as 60 years of age or greater.

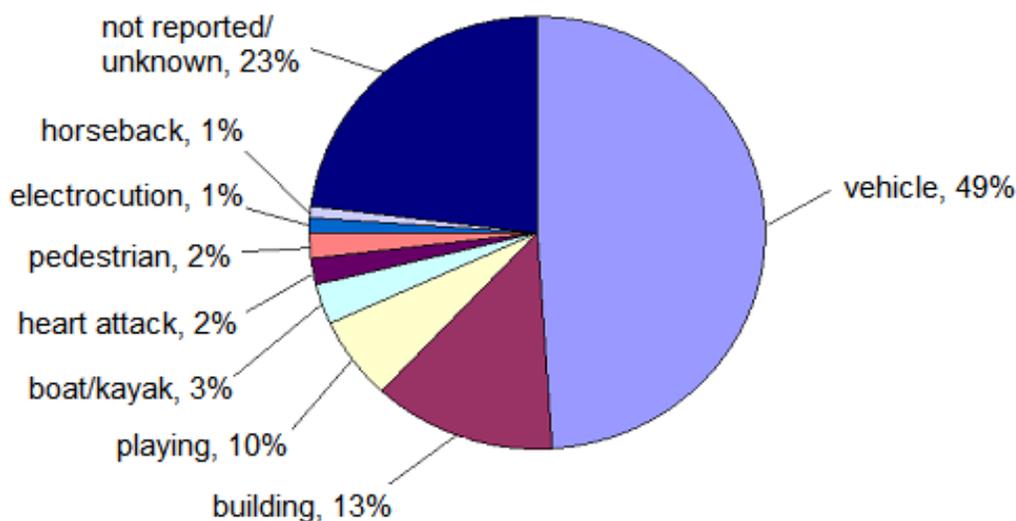
types included cars, pickup trucks and sport-utility vehicles. Other specific activities of drowning victims included pedestrians (2 of 96 = 2 %), on horseback (1 of 96 = 1 %), in a boat or kayaking the flood waters (3 of 96 = 3 %), and while playing (6 of 96 = 6.25 %) or being in a building (12 of 96 = 12.5 %).

Specific activity was not reported for approximately 28 % (21 of 96) of the drowning deaths. Oklahoma provides a basis for comparison. Azeredo (2001) reported a total of 75 flood-related hospitalized or fatal submersion injuries for the period 1988-2000; 65 of which (85 %) were fatal. The male to female ratio was 2:1 and 48 % of the injuries involved vehicles (**Figure 16**).

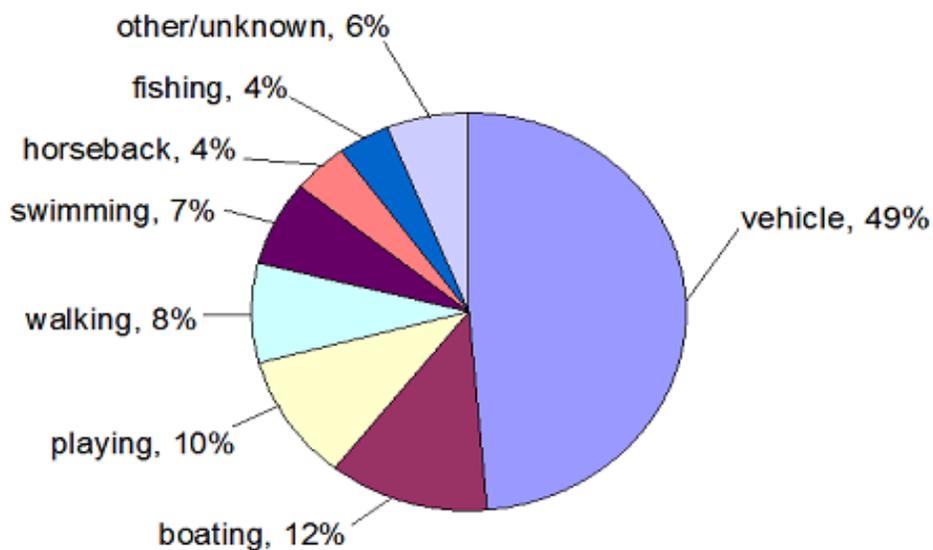
**Fatalities by Timing of Event Stage and Flood Type** - During the period 1997 through 2002, almost all flood-related fatalities (94 of 96 = 98 %) in the State of Texas and all flood-related fatalities in the Guadalupe River basin occurred during the impact phase of the event. One fatality in Texas occurred in Austin when a pedestrian slipped on debris left from a flood, fell into remaining flood waters and drowned during the post-impact phase. Details were not reported for one event and therefore, timing of the event could not be determined.

Thirty-nine of the 53 reported events in Texas were reported as “flash flood”, while 13 events were reported as “flood” and one event was reported as “river flooding.” When flood events lasted for more than a few hours, flash flood waters evolved into “flood” or “river flooding.” A total of 38 fatalities are listed in association with “flood” waters. Deaths associated with flood and river flooding included 2 adult male boaters, one adult on horseback, one adult male dying following electrocution, 2 adult males

### Flood-Related Fatalities by Type of Activity in Texas, 1997 through 2002



### Flood-Related Injuries & Fatalities by Type of Activity in Oklahoma, 1988 through 2000 (from Azeredo 2001)



**Figure 16.** Comparison of activities reported for flood events in Texas and Oklahoma. In Texas, deaths were reported for 1997 through 2002 and, in Oklahoma, flood-related injuries and fatalities were reported for 1988 through 2000.

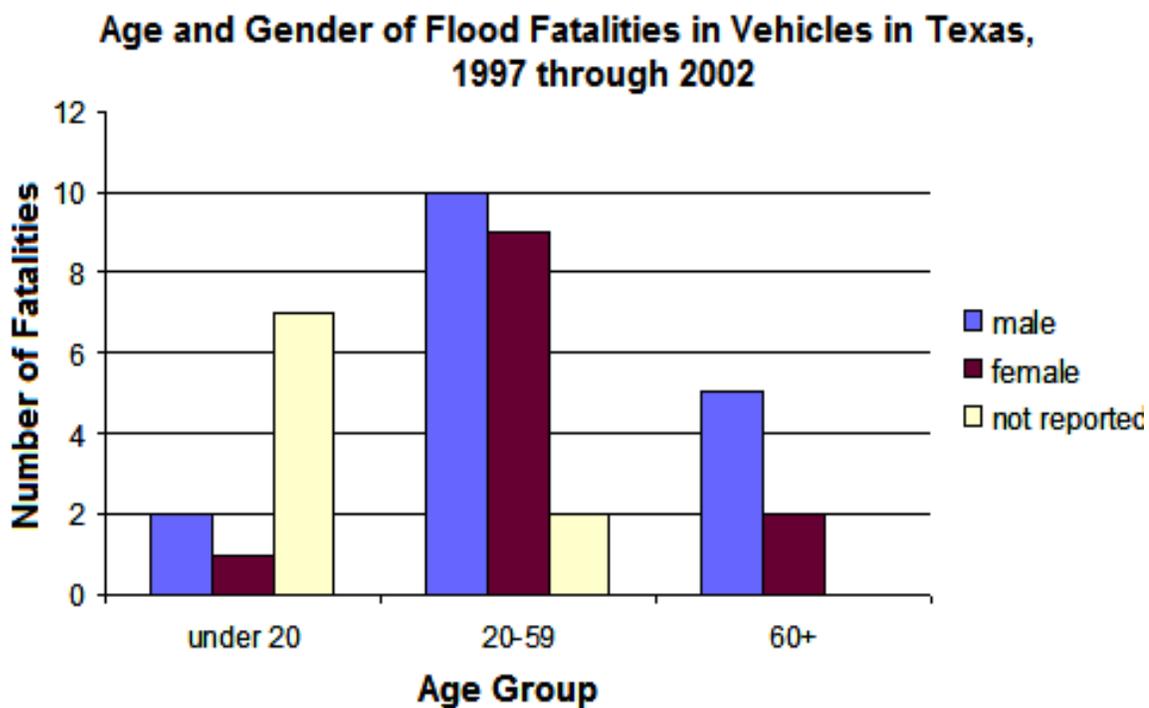
dying from heart attacks, 2 male youths playing near flood waters, and 8 persons (4 children and 4 adult males) in vehicles. Activities, gender and ages were not distinguished for the other “flood water” victims.

**Fatalities by Activity, Gender and Age** - Gender and/or age were not reported for a number of fatalities for victims participating in the various reported activities; these are noted on **Tables 9 and 10**. For flood deaths in the Guadalupe River basin, gender was reported for 50 % (10 of 20) of victims, included two females and eight males.

For flood deaths in the State of Texas, gender was reported for 50 % (48 of 96), including 33 males and 15 females over the period from 1997 through 2002. This percentage is comparable to the 49 % gender reporting rate for the NCDC Storm Events database for flood related deaths over the period from 1959 through 2005 (Ashley and Ashley 2008).

As shown in **Figure 17**, the greatest number of fatalities in motor vehicles in the State of Texas was adults ages 20 to 59, with essentially the same numbers of male and female victims. For the elderly age 60 and older, there were more than twice as many male as female victims suggesting a greater risk for elderly men. For children through young adults up to the age of 20, the gender of most victims was not reported, suggesting the need for more complete reporting.

**Table 11** lists the various causes of death and activities reported for flood-related fatalities in the United States, Texas, and the Guadalupe River basin. For the United States, the data are from Jonkman and Kelman (2005) for regional case events for the period 1992 through 2001, consistent with their classification system for flood disaster



**Figure 17.** Gender distribution by age group of flood fatalities in vehicles in Texas. Age and gender are known or were inferred by age group for flood-related fatalities for 1997 through 2002.

**Table 11.** Causes of Death Associated with Flooding in the United States, in Texas and on the Guadalupe River.

Cause of death / activity		United States *	Texas **	Guadalupe River **
<b>Drowning</b>		<b>67.1 %</b>	<b>95.8 %</b>	<b>85 %</b>
	In vehicle	18.4 %	49 %	70 %
	As pedestrian	45.4 %	2 %	0 %
	From boat	0.7 %	3 %	0 %
	In building	2.6 %	12.5 %	15 %
	Playing	--	6.25 %	0 %
	On horseback	--	1 %	0 %
	During rescue attempt ***	--	15 %	5 %
	Unknown / unreported		28 %	0 %
<b>Physical trauma</b>		<b>9.8 %</b>	<b>0 %</b>	<b>0 %</b>
<b>Heart attack</b>		<b>4.6 %</b>	<b>2 %</b>	<b>10 %</b>
<b>Electrocution</b>		<b>4.6 %</b>	<b>1 %</b>	<b>5 %</b>
<b>Carbon monoxide poisoning</b>		<b>0.7 %</b>	<b>0 %</b>	<b>0 %</b>
<b>Fire</b>		<b>5.9 %</b>	<b>0 %</b>	<b>0 %</b>
<b>Unknown or not reported</b>		<b>7.2 %</b>	<b>1 %</b>	<b>0 %</b>
<p>* from Jonkman &amp; Kelman (2005) for selected regional case events from 1992 through 2001</p> <p>** for 1997 through 2002 – see Tables 9 and 10</p> <p>*** drowning deaths are extracted from other categories for those victims drowning during rescue associated with activities that included either in vehicle or in a building</p>				

deaths. They compiled flood disaster death data from nor'easter, tropical storms and hurricanes, as well as storms and both river and flash floods. For Texas and the Guadalupe River basin, the percentages are extracted from **Tables 9 and 10**. For the United States, physical trauma, heart attack, electrocution, fire and “unknown or not reported” ranged from approximately 5 to 10 percent of flood-related deaths. Based on reported fatalities in Texas and in the Guadalupe River basin, only electrocution and heart attack are comparable; no physical trauma, carbon monoxide poisoning or fire deaths were reported for the period 1997 through 2002.

Drowning causes 85 % of flood-related fatalities in the Guadalupe River basin and 95.8 % of flood-related fatalities in the State of Texas, compared with approximately 67 % for the United States. Similarly, drowning in vehicles is the most common cause of flood-related deaths in the Guadalupe River basin and in Texas (70 % and 49 %, respectively), compared to only 18.4 % in the United States. Maples and Tiefenbacher (2008) provide a detailed analysis of drownings associated with motor vehicles in Texas floods during the period 1950 through 2004. They suggest that roadway familiarity and time of day were important factors; however, roadway characteristics, sex and age of the drivers seemed not to be key contributing factors. Similar to a review of flash flood mortality for the period 1969 through 1981 for the United States (French, Ing, vonAllmen and Wood 1983), Maples and Tiefenbacher (2008) noted a decrease over time in flood-related mortality in Texas for the period 1950 through 2004. Maples and Tiefenbacher (2008) also noted that over half of the vehicle-related flood fatalities occurred within ten miles of the residence of the victim, suggesting the victim had a high degree of familiarity with the roads being driven and therefore the element of surprise associated

with a flash flood might have been a key factor. Drobot, Benight and Gruntfest (2007) assessed risk factors for driving into flood roads and found that respondents in Austin, Texas, were: 1) more likely to drive into flooded roads if they did not take warnings seriously; 2) aged 18 to 35; and 3) did not know that motor vehicles were involved in more than half of all flood fatalities.

Pedestrians account for approximately 45 % of flood-related deaths in the United States. In contrast, pedestrians account for no more than 2 % of flood-related fatalities in the Guadalupe River basin and in Texas (**Table 11**). Drowning in a building in the Guadalupe River basin (15 %) and in Texas (12.5 %) is approximately five to six times greater than across the United States (2.6 %). The number of victims under the age of 20 who died while playing was 6.25 % for Texas; no deaths were attributed in the Guadalupe River basin to playing. Jonkman and Kelman (2005) did not distinguish this activity. Of interest -- since this is Texas -- is the 1 % of the flood-related deaths attributed to being on horseback. While 28 % of deaths due to drowning associated with unknown or unreported activities in Texas, none were noted for the United States nor in the Guadalupe River basin. Of the flood-related fatalities that were reported to have occurred during rescue attempts associated with vehicles or being in buildings, in the Guadalupe River basin, 5 % of deaths were associated with unsuccessful rescue attempts and 15 % of deaths were associated with unsuccessful rescue attempts in the State of Texas.

It should be noted that, in reviewing the text discussions given for the various event records in the NCDC Storm Event Database for counties in the Guadalupe River basin and across the State of Texas, a number of event records contained anecdotal

mention of rescues and evacuations, including rescue of adults and very young children from vehicles (e.g., cars, pickup trucks and motor homes) that had been swept into flood waters as motorists attempted water crossings, families who had to be rescued from their flood homes, a police chief who was trapped in his home by flood waters, and families that had to be evacuated and were in need of alternate housing. In some cases, high water rescues are described as numerous and numbers of persons being evacuated are given as being in the hundreds. Rescues were conducted by truck, boat and helicopter and by public safety and emergency personnel, as well as a swift water team in a raft. However, not enough detail is provided to have confidence in delineating discrete situations and numbers of individuals of any given age. Therefore, while these anecdotal reports are indicative of situations in which persons were at risk or may have been injured, no additional analysis is possible.

#### **Assessing Completeness of the Storm Events Database for Flood-Related**

**Fatalities in Texas** - Of the available databases, the NCDC Storm Events Database appears to be the most complete. However, it does not include details on all flood-related deaths that have occurred in Texas. For example, the NCDC Storm Events Database includes details of significant damage associated with Tropical Storm Allison as it meandered across eastern and southeastern Texas, causing minor problems along coastal sections of southeast Texas, but catastrophic flooding further inland. A query of the Storm Events Database must review 'hurricane & tropical storm events' in order to retrieve an overview of the impacts of Tropical Storm Allison which includes notes that

there were 22 people who lost their lives due to flash flooding in Harris County; no injuries are reported.

A search for newspaper items through *Lexis-Nexis Academic* and *InfoTrac Newspapers* retrieved several articles posted by the *Houston Chronicle* for the period June 16 through June 23, 2001, which include discussion of the following:

- ◆ A 42 year old female who drowned in a parking garage elevator; a head injury contributed to her death.
- ◆ 22 persons drowned and 3 were electrocuted, including a female adult and her child who attempted to pull an appliance plug in a flooded building.
- ◆ A 47 year old male drowned after jumping off his sinking boat in Aransas Bay; his wife was treated at a hospital for minor injuries and released.

These flood-related deaths are confirmed in the literature. Ivey (2002) lists a total of 22 deaths in Houston related to Tropical Storm Allison, including: 12 in vehicles, 6 pedestrian, 3 electrocutions and one in an elevator. The National Weather Service (NWS 2001) also includes a man who drowned swimming in a ditch.

A news brief posted by the *New York Times* on December 21, 1997, provided clarification of the age group for two victims near Killeen: two teen-agers in a vehicle that was swept off a bridge by high waters. The Storm Event Database had identified these victims simply as two people, no age or gender given.

Further clarification is provided by Kremer and Zane (1999) and by Kremer, Zane, Underwood, Stanley and others (2000) summarizing mortality related to the October 1998 floods and storm-related tornado. They reported that 20 of 31 deaths were males, all but one were Texas residents, one was resident of Louisiana visiting the state, 24 of 31 (77 %) drowned, 3 of 31 (10 %) of cardiac origin, 1 of 31 (3 %) from multiple trauma in flood waters, and one of 31 (3 %) of hypothermia. 27 of 31 deaths (87 %)

occurred on the first two days of the storm. The victim who died of hypothermia and one cardiac origin victim were both involved in vehicular immersion in flood waters.

Another victim of cardiac origin died when phone service was out and emergency personnel could not reach him through flood waters. Two other victims died of trauma in a tornado.

The fatalities listed in the Storm Events Database were clarified with the additional information derived from the various news and literature sources and other identified fatalities were also tabulated for a total of 120 flood-related fatalities in the State of Texas for 1997 through 2002. **Table 12** lists these 120 fatalities classified following the system of Jonkman and Kelman (2005).

**Application of the Disaster-Attributed Mortality Matrix** - Since this study evaluates flood-related deaths, the disaster-attributed mortality matrix of Combs and others (1999) was adapted to focus on flood-related events and is presented as a flood-attributed mortality matrix. Further, reflecting the philosophy of flood fatalities presented by Kelman (2004), the disaster-attributed mortality matrix was modified to reflect that all fatalities associated with floods are all direct impacts. Any death which would not have occurred without the disaster even counts as a direct death if it resulted from flood waters, while awaiting rescue, during rescue, or from loss of access to services. Therefore, the flood-attributed mortality matrix presented in **Table 13** and **Table 14** categorizes fatalities as direct consequences of exposure to an environmental force (Part I), loss or disruption of services (Part II), or personal loss or lifestyle disruption (Part III).

The classification system and coding guide of Combs and others (1999) facilitated application of the flood-attributed mortality matrix to the 20 fatalities reported in the

**Table 12.** All Known Flood Deaths in Texas, 1997 through 2002. Fatalities are classified following the system of Jonkman and Kelman (2005).

Medical Cause	Number *	Activity	Timing	Gender	Age **	Lack of Judgment
<b>Drowning</b> <b>109 of 120</b> <b>= 90.1 %</b>	13 (R 1 ?)	In vehicle	Impact phase	4 M 2 F 7 ?	< 20	?
-- in vehicle 56 of 120 = 46.7 %	20 (R 2 F, 1 M)	In vehicle	Impact phase	10 M 9 F 1 ?	20 – 59	probably
-- as pedestrian 8 of 120 = 6.7 %	6 (R 1 M)	In vehicle	Impact phase	4 M 2 F	60 +	probably
-- on horseback 1 of 120 = 0.8 %	9	In vehicle	Impact phase	9 M	?	?
-- in boat /kayak 4 of 120 = 3.3 %	8	In vehicle	Impact phase	8 ?	?	?
-- in a building 12 of 120 = 10 %	8	As pedestrian	7 Impact 1 Post-impact	1 M 1 F 6 ?	20 – 59 20 – 59 ?	yes
-- while playing 6 of 120 = 5 %	1	On horseback	Impact phase	1 M	20 – 59	yes
-- swimming 1 of 120 = 0.8 %	4	In boat or kayak	Impact phase	4 M	20 – 59	probably
-- not reported 21 of 120 = 17.5 %	12 (R 9 ?)	In a building	Impact phase	12 ?	?	?
During rescue 14 of 120 = 12 %	6	While playing	Impact phase	4 M 1 F 1 ?	< 20	yes
	1	Swimming	Impact phase	1 M	20 – 59	yes
	21	Not reported	Impact phase	2 M 1 F 18 ?	3 Adult 18 ?	?
<b>Cardiac origin</b> <b>3 of 120</b> <b>= 2.5 %</b>	3 (R 1 M)	2 Unknown 1 trapped in water crossing in vehicle	Impact phase	3 M	20 - 59	?
<b>Electrocution</b> <b>4 of 120</b> <b>= 3 %</b>	4	1 M in boat; shocked by live wire then drowned 1 F & 1 Child in building	Impact phase	1 M 1 F 1 ? 1 ?	? 20 – 59 < 20 ?	? yes ? yes
<b>Physical trauma</b> <b>2 of 120 = 1.7 %</b>	2	1 F in a building 1 in flood water	Impact phase	1 F 1 ?	20 – 59 ?	Yes ?
<b>Hypothermia</b> <b>1 of 120 = 0.8 %</b>	1	Trapped in vehicle, drowned	Impact phase	1 M	20 – 59	?
<b>Unknown</b> <b>1 of 120 = 0.8 %</b>	1	?	?	?	?	?
<b>Fire or Carbon monoxide</b>	0					

\* R indicates victim died during rescue attempt.  
\*\* Reports of “adult” were interpreted as being in the 20 - 59 year age group, “young adult” or “child” as being less than 20 years of age, and “elderly” as 60 years of age or greater.

NCDC Storm Events Database for the Guadalupe River basin (**Table 13**) and the 120 flood-related fatalities across the State of Texas (**Table 14**). The flood-attributed mortality matrix provided a mechanism for reporting the death of an unborn child that was described, but not tabulated, in the NCDC Storm Events Database. With the exception of the fetal death, there was insufficient information provided in the database to attribute any other fatality any cause of death other than accidental. Where possible, for the State of Texas, the mortality data incorporated the clarification of death details and the deaths identified from other sources as discussed above; these data are denoted on **Table 13**. For the State of Texas, only one known fatality could not be incorporated into the flood-attributed mortality matrix since no details of the activity or cause of that flood-related death were reported.

The flood-attributed mortality matrix for the Guadalupe River basin is comparable to the matrix for the State of Texas. Across the State of Texas, 105 of the 120 included fatalities (87.5 %) were direct effects of the floods, including 97 (80.8 %) drowned, 4 (3.3 %) electrocution, 2 (1.6 %) acute blunt trauma, 1 (0.8 %) cardiac origin, 1 (0.8 %) hypothermia, and 1 (0.8 %) fetal due to maternal drowning.

Indirect effects due to loss or disruption of services accounted for 11 of the 120 (9.2 %) fatalities, including 9 (7.5 %) due to unsuccessful rescue attempts, 1 (0.8 %) due to loss or disruption of transportation services, and 1 (0.8 %) due to loss or disruption of telephone utilities. Three of these indirectly caused fatalities were of cardiac origin, one was due to acute blunt trauma, and 7 were due to drowning.

Indirect effects due to personal loss or lifestyle disruption accounted for 4 of the 120 (3.3 %) fatalities. These included one person who drowned attempting clean-up



**Table 14. Flood-Attributed Mortality Matrix for the State of Texas, 1997 through 2002.**

Circumstances	Cause, Manner of Death: Accidental (A), Homicide (H), Suicide (S), Fetal (F), Undetermined (U)										Other	Cause, Manner of Death: Natural (N)
	Asphyxia, drowning		Blunt, penetrating trauma		Other trauma		Exposure to elements, hypothermia	Poisoning		List cause (C = Cardiac origin)		
	Acute	Late effects	Burns	Electrocution	Carbon monoxide	Other						
<b>Part I. DIRECT EFFECTS: Environmental Forces</b>												
Flash flood water	5		1 + 1 *									
River or other flood waters	2			1 + 3 *								
Drove vehicle into flood waters	48 + 12 *						1 **			1 C ** 1 F (maternal death)		
Vehicle swept off road/bridge	11											
Fell/slipped/jumped/swim/play	11 + 7 *											
<b>Part II. DIRECT EFFECTS: Loss or Disruption of Services</b>												
Failure of rescue attempt	7		1							1 C		
Loss, disruption of transportation-related services										1 C		
Loss, disruption of public utilities										1 C *		
Exposure: industrial hazards												
Loss, disruption of usual access to medical health care												
<b>Part III. DIRECT EFFECTS: Personal Loss or Lifestyle Disruption</b>												
Evacuation or Use of temporary shelter, provisions, displacement												
Clean-up during / after disaster	1											
Return to unsafe, unhealthy structures or environment	3											
Psychological stress, anxiety												
* Fatalities reported by Ivey (2002) and National Weather Service (2001) not reported in the NDCD Storm Event Database												
** Fatalities reported by Kremer and Zane (1999) that clarified mortality data in the NDCD Storm Event Database												

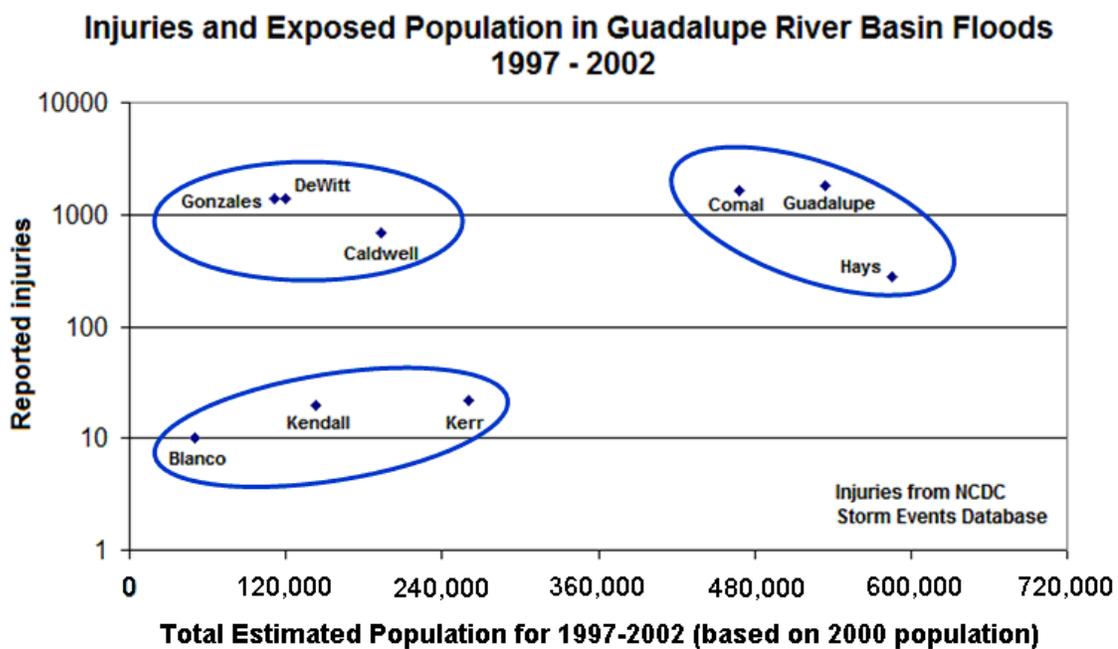
the disaster and three who exercised poor judgment in returning to unsafe conditions by re-entering flood waters.

### **Assessing Injuries in the Exposed Population in the Guadalupe River Basin -**

There is no direct relationship between the number of fatalities and number of reported injuries reported for the given counties (Table 8 and Figure 13). However, Zahran, Brody, Peacock, Vedlitz and Grover (2008) using data from the SHELDUS™ suggest that the ratio of injury to death by natural disaster is roughly 7.5 to 1. This ratio would suggest that over the period 1997 through 2002 for 20 flood-related fatalities in the Guadalupe River basin, we should expect roughly 150 injuries. Similarly, for the period 1997 through 2002 for 120 flood-related fatalities across the State of Texas, we should expect roughly 900 injuries. Flood events in Texas during 1997 through 2002 where at least one death was reported in the NDCD Storm Events Database were tabulated. There are a total of 2,791 injuries reported for 53 events, suggesting a ratio of approximately 52.5:1.

Using the population in each county in the year 2000 as proxy for the exposed population over the period 1997 through 2002 (**Table 8**), the number of reported injuries by county can be compared to the population (**Figure 18**). The resulting clustering reflects high numbers of injuries in the three counties with the largest populations and, in counties with smaller populations, few injuries were reported in three of the counties and a greater number of injuries were reported in the other three.

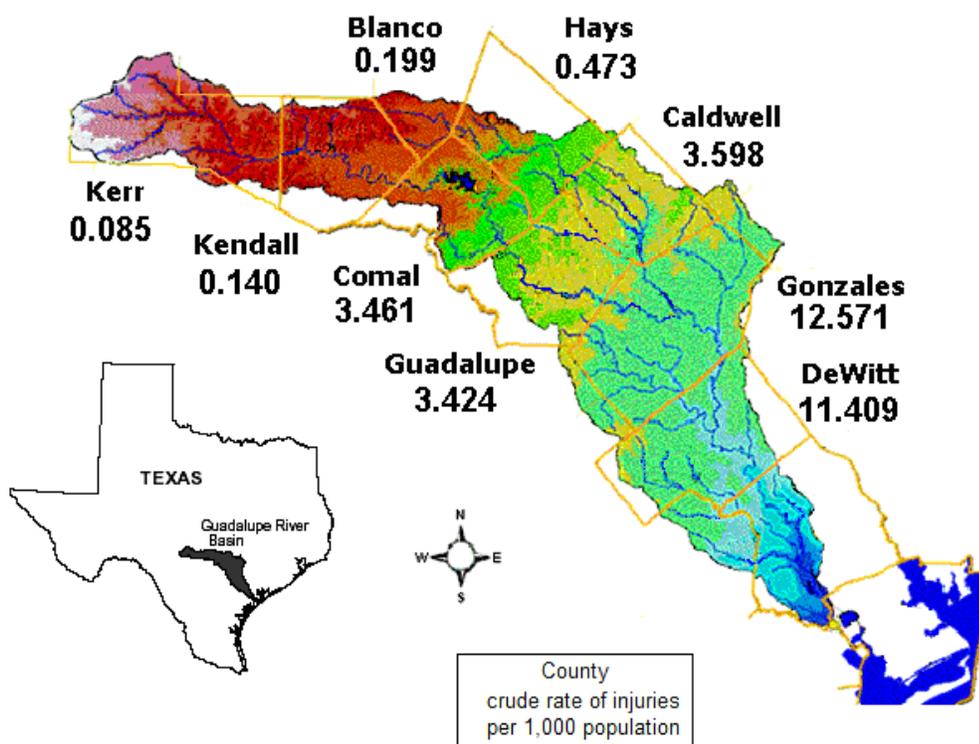
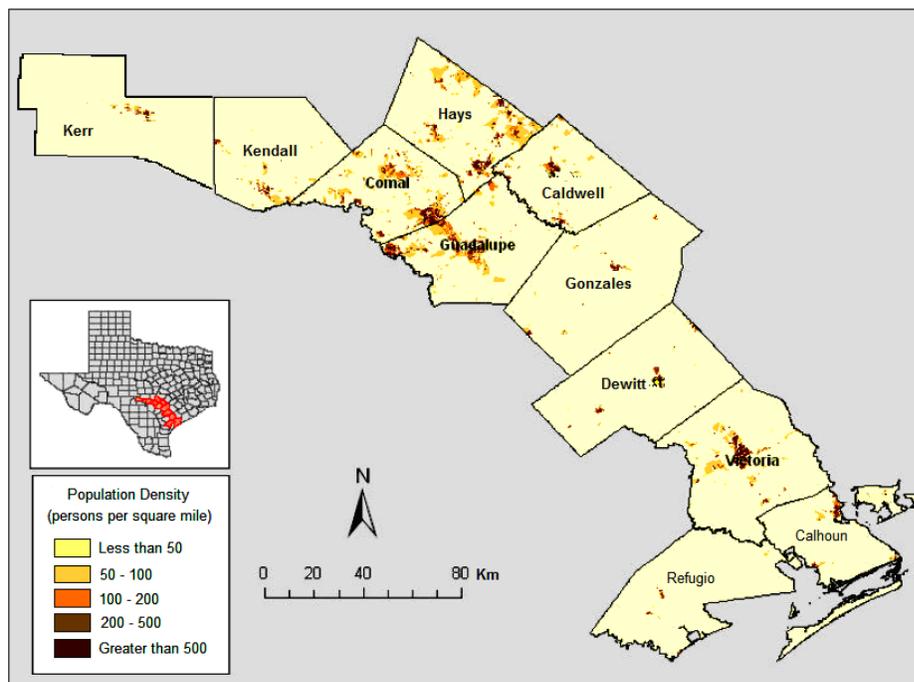
The relationship between number of injuries and size of population can also be evaluated by examining the crude rates calculated for each county (**Table 8**). Crude rates of less than one injury per 1,000 were calculated for Kerr, Kendall, Blanco and



**Figure 18.** Clustering by county of injuries in Guadalupe River Basin. Clusters are defined by exposed population and number of flood-related injuries reported for 1997 through 2002.

Hays Counties. Crude rates of approximately 3.5 injuries per 1,000 were calculated for Comal, Caldwell and Guadalupe Counties. Crude rates of 11.4 and 12.6 injuries per 1,000 were calculated for DeWitt and Gonzales Counties, respectively. These findings are not consistent with the model of flood casualties in Texas developed by Zahran and others (2008) that assessed related social vulnerability and aspects of the natural and build environment. Among the top 20 counties in the Guadalupe River basin, Zahran and others (2008) included data for eight of the counties (all but Caldwell) in terms of flood casualties for the period 1997 through 2001. Their models suggest that for every unit increase in population density, the odds of flood casualties (deaths and injuries) rise by a factor of 2.99 ( $p = < 0.10$ ); as one increases the population density in a county the odds of a resident being killed or injured increases. However, in this analysis, DeWitt and Gonzales Counties are among the lowest in population densities in the Guadalupe River basin, but residents have the highest crude rates of injuries and are among the counties reporting the fewest fatalities.

Reviewing the geographic distribution of the crude rates (**Figure 19**) reveals that crude injury rates increase downstream. These crude rates suggest that residents in the upper reaches of the Guadalupe River basin have a low risk of injury (less than 1 per 1,000), residents in the middle reaches of the river have a moderate risk (3 - 4 per 1,000), and residents in the lowermost reach of the river have the highest risk (11.5 – 12.5 per 1,000). These rates underestimate the likelihood of injury since they are averaged across six years and injuries are significantly under-reported. Further, relative risk will vary among the entire county population of any given county; those persons living within the 500-year floodplain, estimated at 29,700 (GBRA 2004) have a higher potential risk of



**Figure 19.** Geographic distribution of crude rates of flood-related injuries. Crude rates are per 1,000 population by county in the Guadalupe River basin for injuries reported for 1997 through 2002.

exposure. Sufficient data is not available to discriminate between persons with greater or lesser potential risk resulting from their geographic locale relative to flood potential. If it were possible to calculate crude rates of injury for the sector of the population living within the 500-year floodplain, as opposed to the entire county, then it is expected that the rates presented herein are indeed underestimated.

**Assessing Completeness of the Storm Events Database for Flood-Related**

**Injuries in Texas** - Review of NCDC event descriptions for floods in the Guadalupe River basin for the period 1997 through 2002 indicated no descriptors of the types or seriousness of injuries nor characteristics of the injured victims for any flood event other than the following:

- ◆ December 1997 – Two drowned, but a third person in a vehicle that was washed off a road was treated for hypothermia due to prolonged exposure to cold water temperatures.
- ◆ August 1998 – A woman and her 13 month-old son were swept into flood waters and then deposited on patch of dry land. Rescue workers found her clutching a tree and her child. They were taken to a nearby hospital, treated and released. (No injuries were tabulated for this event.)
- ◆ March 2000 – The mother of two children who drowned when their vehicle was washed off a road crossing was treated for hypothermia and released.

Review of the event descriptions from Slade and Patton (2003) of major and catastrophic storms and floods in Texas during the interval 1997 through 2002 provided very limited detail related to a few flood-related injuries, summarized as follows:

- ◆ April 1997 -- A Chevrolet Suburban and the elderly driver and wife were washed off the road into a ditch; the occupants escaped through a rear door and climbed into a mesquite tree. After 3 hours in the early morning, the woman went for help and 911 emergency personnel rescued her husband. Her husband had had open-heart surgery 2 years prior and was put into intensive care after rescue.

- ◆ June 1997 – A resort was caught in rising flood waters of the Sabinal River. Guests (a convention of psychologists, including men, women and children) climbed to the second floor. As waters deepened inside the building to 4 to 5 feet, they panicked, punched a hole in the roof and remained on the roof in the rain until all were rescued.
- ◆ October 1998 – Three boats were destroyed during rescue operations near Lavernia. One woman was rescued from the flood zone by helicopter. Unable to hang on, she fell back into water from about tree-top level. She suffered undetermined back injuries; the second rescue attempt was successful.

And an article in the *Houston Chronicle* included discussion of the following:

- ◆ June 2001 - The wife of a 47 year old male who drowned after jumping off his sinking boat in Aransas Bay was treated at a hospital for minor injuries and released.

Therefore, a more detailed analysis of the more than 7,200 reported injuries that would parallel the Jonkman and Kelman model is not feasible since detailed data on the cause, type, timing, gender or age of injured individuals is not contained in the NCDC database and, as discussed above, limited detail is known for only a few individuals. It is likely that the number of injuries may be significantly underestimated, as evidenced by the event of August 1998 and reports from sources other than the NCDC database. For example, the “Summary of Natural Hazard Statistics for 1998 in the United States” notes that 6,091 injuries occurred during a flood in south-central Texas during the period October 17 through 21, 1998 (NWS 2000); this flooding was centered upon the Guadalupe River.

### **Other Causes of Historic Flood-Related Morbidities**

Given the paucity of data from available databases on other diagnosed specific flood-related morbidities, a retrospective literature review was conducted to determine historic indications for potential diseases or injuries of concern. To optimize results, priority was given to reports encompassing the Guadalupe River, supplemented by accounts of morbidities throughout Texas and the impacts of flooding associated with Hurricanes Katrina and Rita in 2005. Two sets of search terms were utilized. Search terms for geographic location and events included: Texas, evacuation centers, hurricanes, flood, flash flood and disaster. Search terms for health-related impacts included: morbidity, mortality, disease outbreak, illness, zoonotic disease, bacterial infection, respiratory illness, emerging disease, and arbovirus. Cross-referencing was conducted as literature was reviewed. A total of 647 articles (e.g., journal articles, working papers, abstracts, special papers) were previewed and 167 articles were selected for review. Of these, information in key articles was evaluated to identify morbidity and mortality data and to assess whether the data were unique or were duplicated from other sources.

It was anticipated that there may be documented outbreaks of disease related to molds and fungi, to food-borne or water-borne contamination, to poisonous animal or insect bites, or to arboviral disease carried by endemic species of mosquitoes in Texas (Hanford and Bottoms 2009). Jones (2006) suggests that hepatitis A, tetanus, diarrheal diseases, carbon monoxide poisoning, and the potential for leptospirosis should also be expected in association with flood disasters. Ligon (2006) notes the potential challenge of wound infections with tetanus, staphylococci or other bacterial organisms. These types of health impacts might occur in residents or rescue and relief workers.

Other causes of morbidity (and mortality) associated with flood events through 2005 in Texas that were identified in the literature are listed in **Table 15**. There were no epidemic occurrences of flood-related disease reported in Texas. Outbreaks that were reported were limited to evacuation centers during the post-impact or recovery phase of the flood events. The reported outbreaks were, in general, non-life threatening and were primarily gastro-intestinal illness due to norovirus (up to 50 %), rotavirus, non-toxigenic *Vibrio cholerae*, and non-typhoid salmonella. Cases and fatalities were diagnosed as *Vibrio vulnificus* and *V. parahaemolyticus*. Other infections included MRSA (i.e., antibiotic-resistant staph infections), skin rashes of undetermined cause, and respiratory illness. Outbreaks of anthrax in the 1970s occurred in several counties in south Texas among grazing animals where heavy rains followed by hot weather coaxed the bacteria *Bacillus anthracis* to the surface (USDA – no date). Such occurrences are not common since successive episodes of necessary climatic conditions appear to be needed to concentrate the spores.

A need for mosquito control was identified in south Texas (Waring and others 2002, 2005). The presence of arboviruses such as West Nile virus (e.g., Vanlandingham, Mcgee and others 2007), St Louis encephalitis (e.g., Lillibridge Parsons Randle and others 2004), and dengue fever (e.g., Brunkard, Robles Lopez, Ramirez, Cifuentes and others 2007) is recognized in Texas. There is also a potential threat of malaria (Mundy, White, Hines and others 1996). However, no arboviral cases were reported in association with flood events in Texas through 2005. This is consistent with Nasci and Moore (1998), who note that no occurrence has been identified of increased transmission of viruses (including Eastern Equine, Western Equine and St. Louis Encephalitis) to either

TABLE 15. Other Causes of Morbidity and Mortality Associated with Flooding in Texas.

Reference	Morbidity	Mortality	Comments
Zachria & Patel 2006		<p>111 deaths over 7 days (3days before, 1 day of landfall, and 3 days following)</p> <ul style="list-style-type: none"> <li>▪ 3 from tree fall</li> <li>▪ 10 % hyperthermia during evacuation</li> <li>▪ 25.5% nursing home evacuees in bus fire</li> <li>▪ 11% from chronic health facilities</li> </ul>	Hurricane Rita 83 % of fatalities due to mass evacuation
Audin 2006, Cukor and Restuccia 2007	<p>Carbon monoxide</p> <ul style="list-style-type: none"> <li>▪ 2 transfers for hospitalization</li> <li>▪ 13 treated &amp; released</li> </ul>	<p>Carbon monoxide</p> <ul style="list-style-type: none"> <li>▪ 5 fatalities and 1 brain dead of 21 exposures</li> </ul>	Hurricane Rita during 5 days after event in 2005
Tucker, Eichhold, Lofgren, Holmes and others 2006 -- MMWR 55(9): 236-239	<p>Carbon monoxide - 41 non-fatal cases from 11 incidents</p> <ul style="list-style-type: none"> <li>▪ 8 of 51 required hyperbaric oxygen treatment</li> <li>▪ 4 of 51 hospitalized</li> <li>▪ 25 of 51 discharged from emergency department or mobile clinic</li> <li>▪ 2 of 51 treated by emergency medical services on site</li> <li>▪ 10 of 51 died</li> <li>▪ 10 of 51 – disposition unknown</li> </ul>	<p>Carbon monoxide</p> <ul style="list-style-type: none"> <li>▪ 10 fatalities associated with 4 incidents (5 females, 6 blacks, 4 whites, median age = 34 (range: 8-76)</li> </ul>	Hurricanes Katrina and Rita in 16 counties in Texas Most incidents associated with use of a portable generator
Jablecki, Norton, Keller, DeGraw and others 2005 -- MMWR 2005 54(38): 961-964	<p>MRSA (i.e., antibiotic resistant staph infections)</p> <ul style="list-style-type: none"> <li>▪ 30 pediatric &amp; adults at evacuation center in Dallas (3 confirmed by culture)</li> </ul> <p><i>V. vulnificus</i> &amp; <i>V parahaemoliticus</i></p> <ul style="list-style-type: none"> <li>▪ 24 cases wound infections</li> </ul> <p>Diarrheal disease</p> <ul style="list-style-type: none"> <li>▪ <i>Norovirus</i> detected</li> </ul>	<p><i>V. vulnificus</i> &amp; <i>V parahaemoliticus</i></p> <ul style="list-style-type: none"> <li>▪ 2 deaths</li> </ul>	Hurricane Katrina Evacuees & rescue workers No confirmed cases of <i>Shigella</i> dysentery or typhoid fever

TABLE 15 - continued.

Reference	Morbidity	Mortality	Comments
Vest and Valadez 2006	<p>Chronic &amp; acute health needs</p> <ul style="list-style-type: none"> <li>▪ 49.8% (of 4000)</li> </ul> <p>Skin rashes &amp; Diarrhea</p>		Hurricane Katrina – 4000 displaced from New Orleans to Austin TX
Ivers and Ryan 2006	<p><i>Vibrio</i> spp.</p> <ul style="list-style-type: none"> <li>▪ Wound infections, co-morbidities, wading in waters</li> <li>▪ 13 cases</li> </ul> <p>Diarrheal disease (gastroenteritis)</p> <ul style="list-style-type: none"> <li>▪ Outbreaks among 1000 evacuees &amp; relief workers at 3 facilities</li> <li>▪ ~50% <i>norovirus</i> confirmed</li> <li>▪ Non-toxic <i>V. cholerae</i> isolated from 2 individuals who presented with gastroenteritis</li> </ul>	<p><i>Vibrio</i> spp.</p> <ul style="list-style-type: none"> <li>▪ 5 deaths</li> </ul>	Hurricane Katrina Note: duplicates data from MMWR 2005 and Vest & Valadez 2006
USDA (no date)	<p>Anthrax</p> <ul style="list-style-type: none"> <li>▪ Associated with cycles of drought and excessive run-off resulting in occurrence of spores on vegetation consumed by exotic and domestic hoofed animals</li> <li>▪ Most human cases occurred in 1930, numbers decreasing until 1960, 2 cases in 1980, 1 case in 2001</li> </ul>		Reported for five counties in south Texas
Averoff, Young, Mott, Fleischauer and others 2006 -- MMWR 55(26): 727-731	<p>Reports at Evacuation Centers of individual / aggregate morbidity causes = 33 %</p> <ul style="list-style-type: none"> <li>▪ Injury and mental illness &lt;6%</li> <li>▪ Rash 16%, then declined over 2 weeks, then 20%</li> <li>▪ Respiratory 20% increased over 2 weeks to 52%</li> <li>▪ Gastrointestinal 27% with peak in second week</li> <li>▪ Chronic illness (diabetes, asthma, emphysema, cardiovascular disease)</li> </ul> <p>Reports at Health Care Facilities</p> <ul style="list-style-type: none"> <li>▪ Injury 58 % with 135 visits daily and peak of 532 at end of 1<sup>st</sup> week</li> <li>▪ Respiratory 16%</li> <li>▪ Rash, chronic &amp; mental health &lt;10% 2<sup>nd</sup> through 3<sup>rd</sup> week</li> </ul>		Texas, tracked by week through third week after event

TABLE 15 - continued.

Reference	Morbidity	Mortality	Comments
Linscott 2007	<p><i>Norovirus</i></p> <ul style="list-style-type: none"> <li>Confirmed in 18 % with gastroenteritis symptoms</li> </ul> <p><i>V. cholerae</i></p> <ul style="list-style-type: none"> <li>Confirmed among Katrina evacuees – not designated as in Texas</li> </ul> <p>Reported:</p> <ul style="list-style-type: none"> <li>Chronic health condition 42%</li> <li>Physical or mental disability 28%</li> <li>Mental health needing counseling to cope with events 20%</li> </ul>		<p>Hurricane Katrina – evacuees at Reliant Park in Houston</p> <p>No E coli confirmed</p>
Rogers, Guerra, Suchdev, Chapman and others 2006 -- MMWR 2006 55(9): 242-244	<ul style="list-style-type: none"> <li>Chronic health condition 42%</li> <li>Physical or mental disability 28%</li> <li>Mental health needing counseling to cope with events 20%</li> </ul>		<p>Hurricane Katrina -</p> <p>4 Evacuation Centers in San Antonio – Sept 3 → 16 = 12,700 → 3700 evacuees – Sept 16</p>
Waring, des Vignes-Kendrick, Arafat, Reynolds and others 2002 – MMWR 51(7): 365-569 Waring, Zakos-Feliberti, Wood, Stone and others 2005 – MMWR 2002 51(17): 365-369	<p>Significant increase in persons living in flooded homes compared to non-flooded homes:</p> <ul style="list-style-type: none"> <li>illness (OR, 5.1; 95% CI, 2.7-9.4),</li> <li>injuries (OR, 4.8; 95% CI, 1.9-12.8)</li> <li>immediate health needs (OR, 3.3; 95% CI, 1.7-6.1)</li> </ul> <p>Most commonly reported:</p> <ul style="list-style-type: none"> <li>Injuries were minor, with cuts/scrapes/scratches, animal bites, insect bites and blunt trauma/bruising</li> </ul> <p>Most common illnesses reported:</p> <ul style="list-style-type: none"> <li>diarrhea, respiratory ailments, headaches, and sleep disturbances</li> </ul> <p>Needs Assessment:</p> <ul style="list-style-type: none"> <li>4% of homes reported at least 1 person injured after onset of flooding</li> <li>Diarrhea/stomach conditions associated with residing in flooded homes</li> <li>Most common needs: mosquito control &amp; pharmacy access</li> <li>Mold was included among other needs</li> </ul>		<p>Tropical Storm Allison – Houston TX</p> <p>420 homes surveyed including 24 outside the 500-year floodplain</p> <p>Surveyed 1 week after flooding</p> <p>No reported outbreaks immediately after onset of flooding</p>
Khan and Wilson 2003	<p>Species of <i>Aspergillus</i>, <i>Penicillium</i> and <i>Ciadosporium</i></p> <ul style="list-style-type: none"> <li>Identified at levels ranging from 80% to 20X corresponding outdoor readings = airborne &amp; potentially aerosolized</li> </ul> <p>Species of <i>Stachybotrys</i> that are considered toxic upon inhalation</p>		<p>SE Texas after Tropical Storm Allison</p>

humans or domestic animals, with the exception of the 1975 flood event on the Red River in North Dakota.

Flood waters may flush out mosquito breeding areas and reduce the potential for transmission of such arboviruses, despite the potential for increased exposure to residents due to flood damage or increased outdoor activity during cleanup after the flood.

Receding flood waters may, however, provide an optimal breeding environment for mosquitoes. Other factors, such as the degree of viral concentration or life cycle phase response (Shaman and Day 2007), may play a role in whether an outbreak of arboviral disease occurs as much as one to two months after a flood. Linscott (2007) suggests that the role of drought-induced amplification of the virus in the mosquito population prior to flooding and on-going or intensified mosquito-abatement programs may play a role in determining the potential for arboviral outbreaks.

Khan and Wilson (2003) collected and analyzed air and surface (swab, tape and bulk) samples to determine mold concentrations and potential mycotoxin exposures in the Houston area over a three-month period as flood waters from Tropical Storm Allison receded in 2001. Of the most common molds that produce air-borne spores, *Aspergillus* and *Penicillium* species were considered potentially toxic at elevated levels due to their ability to produce mycotoxins that can have a wide variety of pathogenic effects. Of the heavier molds which are less likely to become airborne, *Strachybotrys* species was considered potentially toxic at elevated levels as they can cause neural damage and other health effects. Waring, des Vignes-Kendrick, Arafat, Reynolds and others (2002) reported mold among other needs of residents impacted by Tropical Storm Allison.

The greatest number of fatalities were associated with evacuations (e.g., Zachria and Patel 2006) associated with Hurricane Rita. Use of portable generators resulted in the greatest number of non-fatal cases and fatalities resulting from carbon monoxide poisoning associated with Hurricanes Katrina and Rita (e.g., Cukor and Restuccia 2007; Tucker, Eichold, Lofgren, Holmes and others 2006).

In addition, surveillance summaries for waterborne-disease outbreaks in the United States were reviewed for 1997-1998 (Barwick, Levy, Craun and others 2000), for 1999-2000 (Lee, Levy, Craun, Beach and Calderon 2002), and for 2001-2002 (Blackburn, Craun, Yoder, Hill and others 2004). An outbreak of 1400 cases of *Cryptosporidium parvum* were reported associated with a community well supply in July 1998. An outbreak of 22 cases due to *Escherichia coli* O157:H7 was reported in association with a contaminated community well supply for November 1999. A total of three cases of meningoencephalitis caused by *Naegleria fowleri* were reported for July 1998, August, 1998 and July 2000, respectively. No other outbreaks of waterborne-disease associated with water bodies, water sources or streams were reported. None of the reported outbreaks could be temporally associated with any flood event in Texas.

### **Estimated Years of Potential Life Lost**

The mortality and morbidity cost to society associated with flood-related injuries in Texas, and in particular, in the Guadalupe River basin should be based on factually tabulated numbers of cases, severity of disability, length of disability and age of the victim. Unfortunately, these data are not readily available in an extant database and, when available, are incomplete. Specific age is known for 26 of the 120 (21.7 %) known

flood-related fatalities in Texas, including two children, four teenagers, and four elderly persons.

For the State of Texas, age group can be inferred for 63 of the 120 (52.5 %) fatalities as listed in **Table 16**. Years of potential life lost (YPLL75) as a measure of the number of years not lived by each individual who died before reaching 75 years of age weights deaths at younger ages more heavily than deaths at older ages. The younger the age at death, the greater the number of years of potential life lost. The YPLL for a population is computed as the sum of all individual YPLL values for those who died during a specific time period and was calculated as follows:

$$YPLL = \sum_{DEATHS}^{0-75} (75 - X_{\text{median fatality age in years}})$$

Specific age is known for only 4 of the 20 (20 %) known flood-related fatalities in the Guadalupe River basin, including one teenager and three elderly persons; age group can also be inferred for two others. Therefore, analysis is only conducted for fatalities across the State of Texas. Median ages were calculated for each age group for those individuals of known age and a median age is used for each age group for those individuals where age was not specified. An estimated 2,576 years of potential life were lost for those flood-related fatalities where individual victim age was reported or could be inferred.

### **QALY / DALY**

Calculating and assessing quality-adjusted life years (QALY) and disability-adjusted life years (DALY) require detailed data on either groups of individuals or on

**TABLE 16.** Estimated Years Potential Life Lost for Flood-Related Fatalities in Texas, 1997 through 2002.

<b>Age Group *</b>	<b>Number of Fatalities</b>	<b>Median Age</b>	<b>Total YPLL[75] **</b>
Children & Teens (< 20 years)			
◆ ages known	6	13.5	429
◆ of uncertain age	14	10	910
Adults (20 – 59 years)			
◆ ages known	16	45.5	472
◆ of uncertain age	21	40	735
Elderly (60+ years)			
◆ ages known	4	70	20
◆ of uncertain age	2	70	10
TOTAL YPLL[75]			2576
* Age group is known or can be inferred for 63 of the 120 (52.5 %) fatalities in Texas			
** Years of Potential Life Lost calculated for age 75			

individuals who suffer specific morbidity due to flood-related injury or illness. As discussed above, cause of morbidity is known for only a few individuals and details on treatment, recovery time, or long-term disability are not known. While some victims may have injuries or exposure that can best be addressed by a treat-and-release approach, other victims such as the woman with back injury sustained during rescue when she fell from tree-top height into flood waters may require more intensive care and may sustain long-term disability. A study by Ogden, Gibbs-Scarf, Kohn and Malilay (2001) suggests that a high proportion of the flood-related injuries in Texas should also be due to musculo-skeletal injury and/or lacerations.

However, lacking adequate data, QALY or DALY cannot be estimated for the flood events in Texas during the period 1997 through 2002. The potential for significant health-related illness can only remain a concern. As noted by Howard, Brillman and Burkle (1996), the relatively low rates of infectious diseases reported in many disaster studies including floods may be a result of the fact that the natural history of those diseases requires study periods of several months to a year to document an increase.

### **Analysis**

Incidence or outbreaks of disease in Texas associated with a flood event will most likely reflect disease that was in the disaster-affected area before the flood. Therefore, we should expect what is endemic rather than the exotic. The occurrence and persons potentially impacted will depend upon the phase of the disaster and their geographic location within the Guadalupe River basin.

Most flood-related fatalities will occur during the impact phase and the victims will include residents (and visitors) directly impacted by environmental conditions, with automobile-related drownings being the most frequent cause of death. Significant risk of loss of life is also posed to emergency rescue personnel attempting to save persons from direct flood impacts. Most fatalities have occurred during the impact phase of flood events. A significant (and much greater number) of injuries will also occur during the impact phase, with the greatest risk posed to persons in the middle reaches of the Guadalupe River basin.

During the recovery phase, there is continued risk of injury and the potential for disease. The specific risks and cause of morbidity are anticipated to correlate with the duration and magnitude of the flood event. In particular, non-life-threatening illness should be expected in evacuation centers, among rescue and relief workers, and among those who suffer from pre-existing medical conditions. The changing conditions and changes in human behavior during both impact and recovery phases may include reduction in disease control activities and overcrowding which may increase the risk of disease exposure and communicability.

Since a significant number of fatalities and, likely injuries, as well as the need for rescues result from persons entering flood waters in vehicles, on foot or on horseback as people try to evacuate during flash flood and put themselves at greater risk, there is a need to determine if shelter-in-place (Hayes, Coates, Leigh, Gissing, and others 2009) may be a more viable and safer alternative to evacuation in flash flooding events in Texas. Perhaps as many as half of the fatalities related to evacuation or rescue from flood waters could have been avoided.

### **Future Actions to Meet the Need for Detailed Data**

In 1987, the American Red Cross and Centers for Disease Control and Prevention (CDC) developed a natural disaster morbidity and mortality surveillance system (Patrick, Brenner, Noji and Lee 1992). In the ensuing years, the CDC has continued to develop and refine tools for surveillance and reporting to facilitate public health assessment and surveillance after a disaster. The current mortality and morbidity surveillance forms (**Appendix E**) provide mechanisms for individual and institutional reporting of information critical to identifying public health concerns and in directing interventions and necessary resources during emergency preparedness and response.

These standardized forms for morbidity & mortality surveillance disaster reporting supplement normal patient triage and record keeping while providing protocols to ensure patient confidentiality. These forms are part of the Community Assessment for Public Health Emergency Response (CASPER) toolkit developed by the Division of Environmental Hazards and Health Effects, Health Studies Branch (DEHHE/HSB) at the CDC to assist any local, regional, state, or federal public health department or other agency in conducting a needs assessment during a disaster. While standardizing the assessment procedures for disaster response, this process will also help to ensure collection, analysis and reporting of critically needed data on the broad range of potential health impacts associated with each stage of the disaster event.

Use of these reporting forms for floods in Texas would provide a level of detail needed to conduct better analysis and assessment of health-related impacts in real-time and as a basis for retrospective analysis of the health-related impacts in flash- and river-flood-prone basins. For example, knowing the numbers of persons in various age groups

and the impacts they suffer can lead to better planning or the implementation of other assessment tools that are age-group appropriate. Dyer, Regev, Burnett, Festa and Cloyd (2008) developed SWiFT, which is a rapid triage tool for assessing the needs of vulnerable older adults lacking a social support network that would help to mitigate disaster impacts or assure timely access to needed assistance and care.

However, those implementing such reporting should be mindful of the problems identified by Wetterhall and Noji (1997), including:

- ◆ Compromise between timeliness and accuracy
- ◆ Competing priorities for information
- ◆ Logistical constraints
- ◆ Absence of baseline information
- ◆ Denominator data unavailable
- ◆ Lack of representativeness
- ◆ Resource costs of collecting and analyzing data

Since response activities and planning for relief and recovery are based on the data collected, this type of data is definitely needed and every effort should be made to ensure that the information collected is accurate and reliable. The resulting data can then be used for hazard mapping and vulnerability assessments to characterize the disaster event and for effective planning of disaster preparedness programs, evacuation plans or other response activities. As noted by Hanford and Bottoms (2009), such future events and standardized approaches to gathering critical information on flood impacts also become opportunities for:

- ◆ Education of displaced & impacted persons
- ◆ Basic hygiene practices

- ◆ Prevention & mitigation techniques
- ◆ Immunization screening
- ◆ Train public health professionals -- Direct & indirect impacts
- ◆ Emphasize surveillance & reporting as both collaborative efforts among agencies and for collecting both individual and aggregate information

The value of such surveillance, as presented in this chapter, has been shown recently during the response to flooding in southern Louisiana associated with Hurricane Katrina (Williams, Guarisco, Guillot, Wales and others 2005). Their experience recognized the value of active surveillance which also considers non-traditional sources of post-disaster information such as police, humanitarian aid agencies, religious officials, and pharmacies. They further recognized that the data gathered by active surveillance were useful in identifying injury patterns and in guiding prevention messages issued by decision makers.

The historical record developed in this chapter demonstrated that, as called for in Proposition #1, at least adequate data does exist and could be compiled from a number of sources to begin to provide measures of the health-related impacts and the flood hazard. Despite the limitations of the existing data and this historical record, chapter VII addresses the utility of this historical record as a tool to influence the levels of awareness and longitudinal shifts in perceptions of the decision makers.

## **CHAPTER VIII**

### **LEVELS OF AWARENESS AND LONGITUDINAL SHIFTS IN PERCEPTIONS**

Chapter VII addressed the tenets of Proposition #1 that called for the establishment of an historical record of epidemiology and flood hazard data due to the lack of an organized and complete presentation of such data and information in an accessible extant database. Proposition #2, or the second goal of this study, asserts that the historical record can then inform local government leaders of these concerns, who then must educate and inform their communities of health risks associated with flood occurrences; in doing so, the development of educational materials serves as a primary tool. This chapter tests such an information tool with local government leaders via a survey of local government leaders, in their capacities as health and emergency management officials, to assess whether a “Fact Sheet” can raise levels of knowledge awareness.

#### **Survey Procedure, Data Collection, and Response**

The audience for this survey encompassed decision makers who would be issuing messages to the public or providing first-line response to public health needs during a flood event in Texas. As such, the potential audience population was limited and, therefore, the sample design was limited to “purposive” or purposeful sampling as a

consequence of participant training, experience or job function. Open requests for participation in the survey process were issued.

An initial survey was to be performed in time period 1, with a “Fact Sheet” being introduced to the participants, and then a final survey given to assess whether levels of awareness, as defined by levels of knowledge, increased, or not. Analysis of completed survey instruments from participants in two time periods—initial and final survey—provided an opportunity to observe whether statistically significant longitudinal shifts occurred in levels of perception and knowledge awareness. The initial survey responses were assumed to be based on the level of experience, training, and knowledge of flood events. Responses to questions regarding flood events, fatalities and injuries reflect a level of awareness of reported data (**Table 17**). The final survey responses were assumed to be based on reading and review of information provided in the Fact Sheet: Health Consequences from Floods (**Appendix D**) that was provided to respondents with the request to complete the final survey.

A total of 43 persons completed the initial survey; of these, 12 (27.9%) declined to participate further, and 31 agreed to participate in the final survey. Initial survey packets were completed by June 13, 2007. Due to extenuating circumstances, final survey packets were not provided to participants until June of 2009. It should be noted that no significant flood events occurred in Texas during this time interval. Therefore, no potentially confounding influence of the participants having experiencing flood conditions during the survey interim is considered herein.

Completed final survey packets were returned no later than September 4, 2009. Final survey packets were mailed to 31 persons; of these, two persons were lost in

**Table 17.** Questions Used to Evaluate Level of Knowledge/Awareness of Flood Events.

<b>Question number on Survey</b>	<b>Query</b>
<b>Part I/Part II</b>	
<b>Q 14/24</b>	Considering the number of deaths that occur in the United States due to drowning in flash floods over the recent 40-year (~1960-2000) record, where does the State of Texas rank?
<b>Q-15/25</b>	How many deaths due to flash-flooding in Texas over the recent 40-year (~1960-2000) record?
<b>Q-16/26</b>	What percentage of flood deaths over the recent 40-year record (~1960 – 2000) in Texas occurred in south-central Texas within the Guadalupe River system?
<b>Q-17/27</b>	How many flood-related injuries have been reported within the Guadalupe River system in south-central Texas during flood events in the last decade of record (~1990-2000)?
<b>Q-18/28</b>	How many flood events on the Guadalupe River system have exceeded the 100-year flood level during the historic record which spans approximately 150 years in south central Texas?

follow-up and 15 persons did not return the final survey despite having originally agreed to participate in the second survey. Therefore, a total of 14 participants (14 of 31 = 45.2%) completed the initial and final surveys, with all 14 participants completing all questions on both survey instruments.

After receipt of the final surveys, responses provided on the 31 initial survey packets and the 14 final surveys were tabulated for analysis. Surveys and specific responses were identified by letter-numerical sequence to maintain anonymity of individual responders in accord with protocols approved by the IRB, while ensuring appropriate survey pairings for statistical analysis. The following designations were used:

- ◆ N - # = initial survey completed but respondent declined further participation; surveys sequentially numbered for data tabulation purposes
- ◆ D - # = initial and final surveys completed by respondent; survey pairs sequentially numbered for data tabulation purposes

### **General Analytical Approach**

Because two different time periods for two groups of participants are being tested, the Wilcoxon Matched-Pairs Signed Ranks Test was used to test the paired groups of participants to determine whether there were statistically significant changes on awareness or perception variables between groups for the two time periods in question. This version of the Wilcoxon first calculates the differences between each set of pairs and then ranks the absolute values of the differences from high to low. Summation of the ranks for the initial and final surveys were calculated and used to determine the p-value. Thus, if the Wilcoxon signed-rank z-score was positive, then rank summation for the final survey responses would be greater than the first time period, i.e., the initial survey.

Further, z-value equal to or greater than 1.0 would support the interpretation that respondents gained an increased level of awareness or perceived a greater impact. If the p-value was small, then the pairing would be interpreted as statistically significant, and thus, one might conclude that informational process was effective.

### **Assessment of Levels of Awareness of Participants**

The responses of each survey participant to questions on the number of deaths in Texas, the number deaths and injuries in the Guadalupe River basin, and the number of floods that exceeded the 100-year event in the Guadalupe River basin were used as a basis for assessing the level of awareness of data-based knowledge. Participant survey responses were grouped and compared. Of those respondents (Group N) who declined to participate further in the study, only 12% of their responses to questions Q-14 through Q-18 regarding flood events, fatalities and injuries reflect a level of awareness of reported data (**Table 17**) were consistent with the available data. Of those respondents (Group D) who agreed to participate further in the study, 13.4% of their responses to questions 14 through 18 were consistent with the available data. Of those respondents in Group D who completed both the initial and final surveys, 43.2% of their responses to questions 14 through 18 were consistent with the available data. The responses of these groups were further evaluated using the Two Independent Sample Wilcoxon Rank Sum Test to determine whether the differences were statistically significant. The Two Independent Sample Wilcoxon Rank Sum Test was used to compare the responses of two independent groups.

All persons participating in the initial survey had a low level of overall awareness of data-based knowledge of the characteristics of flood events and the number of fatalities and deaths in Texas. Among those persons who declined to participate further in the study, the level of knowledge awareness was slightly lower; however, the difference was not statistically significant.

For those persons completing both the initial and final surveys, the level of awareness was significantly improved (z-score 1.604) and that improvement in level of awareness was statistically significant at the 95% confidence level ( $p = 0.05$ ). These statistics support the assessment that the information provided in the supporting Fact Sheet significantly improved the level of awareness of the participants.

### **Shifts in Perception of Potential Health Impacts Associated with Flood Events**

Perceptions shifted regarding potential health morbidities associated with flood events (**Table 18**). Positive z-scores are noted for eating contaminated food and drinking contaminated water. Positive z-scores were also calculated for heart attacks and blunt force trauma causing strains and sprains or contusions. The z-score increase (2.073) for blunt force trauma broken bones is statistically significant (95% confidence level). The z-score (1.214) for drowning in a vehicle while driving through flood waters is positive, though not statistically significant. This result is not consistent with the “Turn Around, Don’t Drown” campaign that was instituted by the National Weather Service in 2003 (NWS 2007).

**Table 18.** Shifts in Perception of Potential Health Impacts Associated with Flooding.

<b>Health Impact</b>	<b>Z-Score</b>	<b>P-value</b>
Likelihood of Health Consequences		
in the United States	- 1.325	0.185
in Texas	- 0.255	0.799
in South-Central Texas	0.840	0.401
in Community	0.314	0.754
Drowning		
In flood waters	- 0.338	0.735
In vehicle driving thru flood	1.214 *	0.225
Blunt trauma		
Broken bone(s)	2.073 *	0.038 **
Sprains or strains	1.890 *	0.059
Contusions (scrapes & bruises)	1.481 *	0.139
Exposure to Mold & Fungi	0.314	0.753
Ingestion of Food or Water		
Eating contaminated food	1.352 *	0.176
Drinking contaminated water	1.604 *	0.109
Poisonous animal or insect bites	- 0.490	0.624
Mosquito-born		
West Nile Virus	0.000	1.000
Dengue Fever	0.845	0.398
Malaria	- 1.014	0.310
Yellow Fever	0.000	1.000
EEE encephalitis	0.630	0.529
Technological Impacts		
Exposure to Toxic Chemicals	0.314	0.753
Electric shock or electrocution	- 0.474	0.636
Other Communicable Disease	- 0.840	0.401
Heart Attack	0.943	0.345
Mental Stress	0.000	1.000
* indicative of important shift in perception toward greater awareness, though not statistically significant		
** 0.05 level of significance		

### **Shifts in Perception of Areas or Facilities Potentially Impacted During Floods**

Perceptions shifted regarding potential health morbidities associated with flood events (**Table 19**). Though not statistically significant, z-scores reflect an increased level of recognition of potential impacts in smaller communities or rural areas and on hospitals and medical facilities.

### **Shifts in Perception of Sectors of Population Impacted During Flood Events**

Perceptions shifted regarding potential health morbidities associated with flood events (**Table 20**). The z-score and a statistically significant (95% confidence level) P-value reflect increased level of recognition of potential impacts on male adults.

### **Shifts in Perception of the Occurrence of Flood Events and the Number of Injuries Associated with Floods**

Perceptions shifted regarding potential health morbidities associated with flood events (**Table 21**). The z-score reflects an increased recognition of the high ranking of Texas with respect to the occurrences of floods in the United States. The z-scores and P-values reflect statistically significant (95% confidence level) increased awareness and recognition of the number of flash flood deaths in Texas. The z-score and a statistically significant (at the 95% confidence level) P-value reflect increase in recognition and concern for the number of injuries that occurred in the Guadalupe River System associated with a major flood event in 2002. The z-score (1.784), while not statistically significant at the 95% confidence level, reflects increased awareness of the number of major (exceeding the 100-year event) floods occurring on the Guadalupe River in the 150-year recorded history.

**Table 19.** Shifts in Perception of Areas or Facilities Potentially Impacted During Floods.

<b>Areas or Facilities Potentially Impacted</b>	<b>Z-score</b>	<b>P-value</b>
Large Metro Area	- 0.296	0.767
Small to Medium City	1.183 *	0.237
Rural area outside city limits	1.268 *	0.204
Government Buildings/Facilities	0.338	0.735
Schools / Educational Facilities	0.630	0.520
Law Enforcement Facilities	0.000	1.000
Hospitals & Medical Facilities	1.050 *	0.294

\* indicative of important shift in perception toward greater awareness, though not statistically significant

**Table 20.** Shifts in Perception of Sectors of Population Potentially Impacted During Floods.

<b>Sectors of Population Potentially Impacted</b>	<b>Z-score</b>	<b>P-value</b>
Young age (less than 12 years)	0.280	0.779
Senior Citizen (> 65 years)	0.734	0.463
Disabled	- 0.405	0.686
Living alone	0.405	0.686
Living with family	0.405	0.686
Male Adults	2.030 *	0.042 **
Female Adults	- 0.405	0.686

\* indicative of important shift in perception toward greater awareness  
\*\* 0.05 level of significance

**Table 21.** Shifts in Perception of the Occurrence of Flood Events and the Number of Injuries Associated with Floods.

<b>Occurrences of Floods</b>	<b>Z-score</b>	<b>P-value</b>
Texas Ranking in US	1.400 *	0.161
Flash Flood Deaths in TX in 40 years	2.040 *	0.041 **
% TX Flash Flood Death in Guadalupe River System	- 1.066	0.286
Number of Injuries in Guadalupe River	2.935 *	0.003 **
Number of floods in 150 years on Guadalupe R exceeding 100-year event	1.784 *	0.074

\* indicative of important shift in perception toward greater awareness  
\*\* 0.05 level of significance

### **Analysis of Levels of Awareness and Longitudinal Shifts in Perceptions**

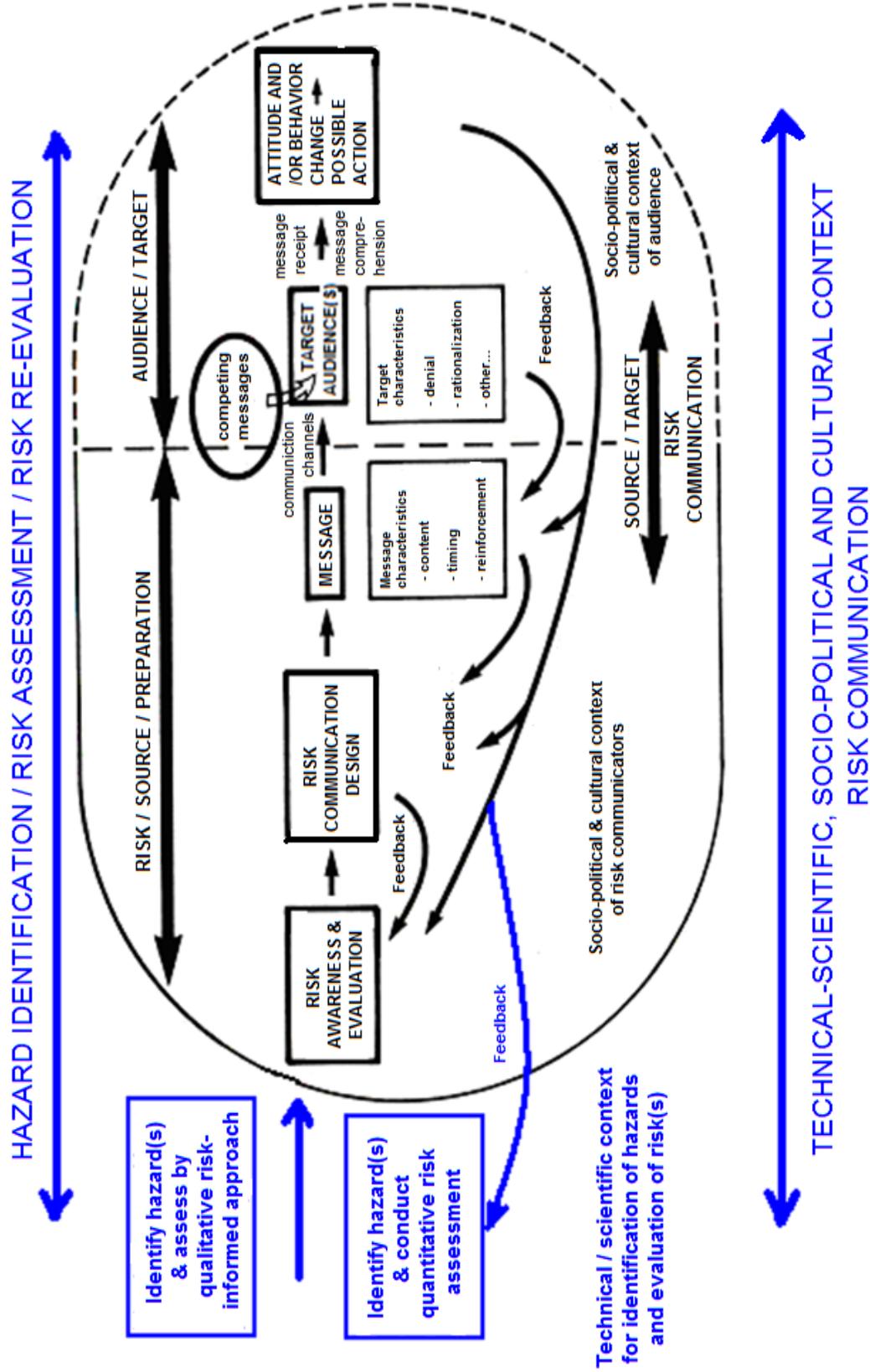
Requests for participation in the research and two-part written survey were made in person, briefly outlining the need for the study and the importance of participation by decision makers in Texas who are on the front lines of responding to flood disasters. Of the 43 persons who willingly completed the initial survey, almost 30 % declined to participate further. Of importance is the low level of awareness of all decision-makers regarding the occurrence of floods and flood-related mortality and injuries in Texas. Only 12 to 13% of the responses on pertinent questions were consistent with the available data. If decision-makers are not fully aware of actual disaster conditions and impacts, the efficacy of their directives may be significantly reduced.

Presenting the available information on the morbidity and mortality associated with flood events in the Guadalupe River basin as an informational Fact Sheet that, when presented to decision-makers, resulted in significantly influencing their level of awareness of health-related impacts, as well as significantly altering their perceptions of the potential for health-related impacts associated with a long and frequently recurring history of flood events. The approach was a passive presentation of the Fact Sheet supporting the final written questionnaire.

Reasonable efforts were made to encourage participants to complete the initial and final surveys, including postage-paid return envelopes and gentle-reminder post cards. These efforts and minimal loss of participants to follow-up resulted in a 45.2% return of final surveys. Statistical analysis of the paired survey responses indicated both a statistically significant change, as well as scientifically important shifts in levels of

awareness and perception among those decision-makers who made use of the available Fact Sheet and completed the survey process.

Therefore, it is reasonable to conclude that the informational process of providing factual data to the decision makers that was framed in a straight-forward textual and graphical format on the Fact Sheet did improve the level of awareness of the participants. Their increased level of awareness and knowledge would be expected to improve the efficacy of their directives aimed at reducing health risks associated with flood events and thereby improving the likelihood that the public would take appropriate actions in a flood event. This conclusion supports the incorporation of the technical/scientific context into defining the first stage of a risk communication model, such as that developed by Penning-Rowsell and Handmer (1990), as shown in **Figure 20**. The technical/scientific context of the model represents the research conducted in Parts I and II, giving definition to a triple-context model which incorporates hazard identification, risk assessment and risk communication. This triple-context model provides an appropriate and useful framework for identifying, assessing and responding to the health-related impacts associated with flood hazards.



**Figure 20.** Triple context model for risk communication. Modified after Penning-Rowse & Handmer (1990) to include technical / scientific context for identification of hazards and risk assessment to develop the Triple Context Model for Risk Communication.

## **Chapter IX**

### **CONCLUSIONS AND CONTRIBUTIONS OF THE STUDY**

#### **Conclusions**

Through the use of framing, this research first, identified a significant problem concerning the dearth of information and action by local leaders concerning risk communication toward risks related to health from flood occurrence. Secondly, framing diagnosing and discussing its causes by providing context and background of local government policy toward emergency management and communicating risk. The remaining steps of making assessments and/or judgments through analysis; and, suggesting remedies called for establishing an historical framework describing the magnitude and frequency of major flood events in south-central Texas, as well as some of the associated short- and longer-term epidemiological vulnerabilities. Qualification and quantification of an historical records of health risks posed by the occurrence of floods informed the development information tool—a Fact Sheet—which was empirically tested by a respondent group of local officials in two time periods, before and after reviewing the document. The results between groups and between time periods were statistically significant on a number of variables, thus indicating that the Fact Sheet might serve as an effective measure for local leaders to use in developing the first stage of a risk communication process for the general public. The results of such a process would lead to a program for facilitating preparedness, response and recovery by demonstrating the

need for proactively implementing a standardized surveillance system not only for flood-related deaths, but also for injuries and illnesses. The findings from this research, through a process of framing have defined the initial stages of a risk communication model, whereby local leaders might become informed of historical flooding and its impact on health epidemiology, and then communicate the knowledge to their citizenry. The derived triple-context risk communication model enhances the theoretical literature by incorporating the technical/scientific contribution. This model adds a third context to the Penning-Rowell and Handmer (1990) model: the technical/scientific context. The technical/scientific context includes identification of hazards and evaluation of risks by the qualitative risk-informed approach or, if sufficient data are available, by quantitative risk assessment. When considering the broad range of environmental conditions and potential health impacts, it must be emphasized that this will require the integration of a number of disciplines with experts contributing improved flood forecasting, developing early warning systems, predicting the location and frequency of health impacts and need for emergency and institutionalized medical care facilities. Use of the flood-attributed mortality matrix provides a mechanism to display relationships between specific circumstances or activities and health outcomes, to identify clustering of events that will help responsible parties to develop or modify prevention policies and public education or to prioritize policy implementation. It is an effective framework for standardized analysis to understand relationship between humans and environmental impacts of flood hazards on human health in Texas.

Further research will be needed to empirically test the effectiveness of this model for other natural hazards, the reception and response in the socio-political context of

decision makers, the reception and response in the socio-political context of the target audience, and the mechanisms through which feedback from decision makers and the audience may enhance the development of technical/scientific information and its use and benefits to facilitating hearing and responding appropriately to the message. Such research may also include both empirical and practical applications of the resulting policies to assess the effectiveness in prevention, as well as mitigation of the short- and long-term health impacts of all natural disasters. Providing and incorporating accurate and detailed information on the broad range of health impacts associated with flood events can help shift the emphasis from disaster response to risk management.

Aside from the benefits in facilitating effective risk communication, this research also provided a much needed knowledge base of flood disaster epidemiology that can be disseminated to the community at large, to State and local health departments, to federal agencies and other organizations. It provides more accurate information about the risks and dangers posed by expected flood events that, further, can be used in training emergency management officials, policy makers, the public, and others regarding the dangers of inland flooding and risk management techniques. The results are directly applicable to future research including both empirical studies and practical applications that extrapolate the findings to other regions similarly subject to flood hazards and epidemiological vulnerabilities.

A simple, right answer was not expected from this research. The theoretical framework, methods, and research questions allowed for great complexity and ambiguity. However, what has emerged is a body of research “framing” the many perspectives of health risks from flood occurrences. In addition, this work has helped to focus attention

on the paucity and lapses in available data and the need to conduct inter-disciplinary research to address the varied morbidity and mortality impacts across the social spectrum that are related to flood disasters. It is humbly hoped that this research will be an important impetus in developing an understanding of the intrinsic and extrinsic factors that affect the health risks associated with future flood events in Texas and elsewhere. Multi-disciplinary approaches that integrate research and socio-economic dimensions to determine efficient models for territorial ordering, education and environmental interventions should be employed to reflect the interactive character of the various parameters which offer future research opportunities.

### **Contributions of this Research**

The degree to which the citizenry will be prepared for and will mitigate against potential hazardous occurrences and the associated epidemiological risks depends on whether local leaders themselves have participated in the process of understanding and communicating risks from state and national leaders and the scientific community. Thus, a major contribution of this research included the development of a comprehensive theoretical construct to inform other interested researchers towards understanding the process of risk communication as well as defining the link between scientific research and members of the community, particularly at the interface between the physical environment and the consequent impacts on humans. In addition, this research produced an analysis of history of floods and reported epidemiological impacts in south-central Texas and, more specifically, in the Guadalupe-Blanco River basin. This record of deaths, injuries, and disease was essentially non-existent, and compilation of this record

served to integrate existing data and analytical and forms a foundation for future surveillance and research.

This investigation of also examined the interactions of physical, policy and socio-economic parameters to assess natural conditions and understand human responses in terms of epidemiological impacts and risks associated with flood events. The proposed empirical and systematic analysis provided a theoretical interpretation of how risk might be communicated to local leaders so that policies and programs may be developed at the local level for the citizens of a community with respect to characterizing and understanding the associated short- and longer-term epidemiological impacts on the health care system, on the individual, and on society, as well as eliciting effective mitigating response by policy-makers and the public.

### **Importance of this Research and Future Needs**

Among the critical list of empirical issues on a research agenda for disasters in the next century, Quarantelli (2003) stressed the need for intensive studies of disasters that cut across governmental and political boundaries, as well as in-depth studies of disaster topics for which the data base is very weak, or non-existent. In addition, Alaszewski and Horlick-Jones (2002) noted the need for interdisciplinary research to produce a ‘transdisciplinary’ focus on application as well as scholarly reflection with regard to important health and risk issues. Further, how technical information and scientific analyses are framed is critical to determining how society understands environmental issues and whether it will make sensible use of that information to address health and risk problems (Kaufman, Gardner and Burgess, 2003). Finally, Tapsell, Penning-Roswell, Tunstall and Wilson (2002) noted a need to record health impacts in greater detail than

has been done in the past so that a proper balance may be struck between health effects and pure monetary losses due to structural damage, as well as, to develop predictive models of the health impacts on society to plan to alleviate such impacts with future policies and plans.

This systematic historical analysis of major flood events in south-central Texas provided a much-needed conceptual model to “frame” and guide future research as well as for exploring and understanding, from a geographic perspective, the spectrum of natural and health hazards associated with flooding. Further, it emphasized that the effective communication of appropriate risk information to policy-makers and the public with respect to understanding the potential long-term epidemiological impacts on the health care system, on the individual, and on society is critical to eliciting mitigating response by policy-makers and the public. By undertaking a longitudinal investigation of floods in Texas and the Guadalupe-Blanco River system, this research identified the interactions of physical, policy and socio-economic parameters for a clearer understanding of human health risks and the epidemiological impacts associated with flood events, and to set the stage for future directions, both theoretical and applied, in developing a substantial knowledge base of hazards and epidemiological research.

## **APPENDIX A**

### **Internal Review Board (IRB) Exemption Letter**



Texas State University | SAN MARCOS

*Office of Sponsored Programs*

601 University Drive  
San Marcos, Texas 78666-4616  
office: 512.245.2102  
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February 9, 2006

EJ Hanford  
9400 Wade Blvd., #1115  
Frisco TX 75035-6532

Dear Ms. Hanford,

Based on the synopsis submitted via email on 12/2/05, the research project "Health Consequences from Major Flood Occurrences in South-Central Texas, Framing the Issues, Assessing Awareness, and Communicating Risk" was found to be exempt from full, or expedited review by the Texas State Institutional Review Board.

Sincerely,

*Becky Northcut*  
jl

Becky Northcut  
Compliance Specialist

## **Appendix B**

### **Floods and Health Survey Questionnaire - Part I:**

**Survey Announcement**

**Questionnaire - Part I**



## An Invitation to Assist in Research...

### Floods and Health Survey Questionnaire - PART I

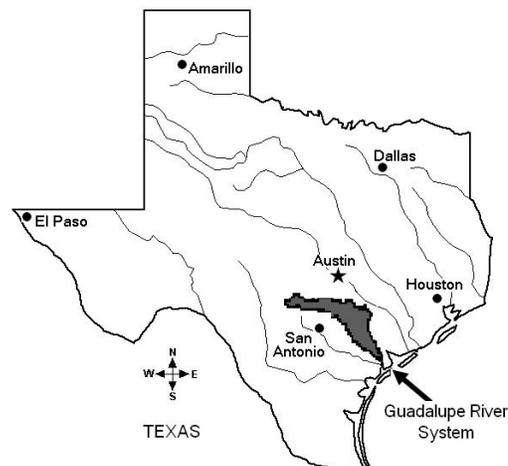
Elaine J. Hanford, Doctoral Candidate  
eh1053@txstate.edu  
Department of Geography - Texas State University  
Lovell Center for Environmental Geography and Hazards Research  
San Marcos, Texas 78666-4616

The set of questions asks for your perceptions and knowledge about floods and associated threats to human health from major future flood events. In addition, there are a few questions on the nature of flooding in south-central Texas on the Guadalupe River system.

You may be assured that your responses will remain confidential - only summary statistics of response analyses will be utilized and presented in the research report. Thank you for taking time to provide information for this project on this very important topic.

To participate in Part II of the survey, please provide your detailed mailing address on the form with the enclosed survey to facilitate receiving Part II by mail.

Please return completed Part I Survey Packets here by Noon on  
Wednesday, June 13, 2007.



## Floods and Health Survey Questionnaire - PART I

**Elaine J. Hanford, Doctoral Candidate**  
 Department of Geography  
 Texas State University  
 Lovell Center for Environmental Geography and Hazards Research  
 San Marcos, Texas 78666-4616

The following set of questions asks for your beliefs, perceptions, and knowledge about floods and any associated threats to human health from major future flood events. You may be assured that your responses will remain confidential - only summary statistics of response analyses will be utilized and presented in the research report. Thank you for taking time to provide information for this project on this very important topic.

As a token of our thanks, we would be happy to provide you with a summary report of the survey results. If you would like a summary report, please note your request at the end of this survey.

### PLEASE BEGIN THE SURVEY:

Q-1. What is your current occupation/title? \_\_\_\_\_

Q-2. How long have you been working in this occupation? \_\_\_\_\_

Q-3. Have you had any formal training on possible health consequences of floods?

\_\_\_\_\_ YES [If YES, please answer Q-4 and Q-5.]

\_\_\_\_\_ NO [If No, please proceed to Q-5.]

Q-4. What training or information have you received prior to this questionnaire? [Please write your comments on the following lines.]

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Q-5. By what other means have you become knowledgeable about floods and human health impacts? Please rank the sources by frequency of use, where: "1" = Do Not Use, "2" = Not Very Frequently Used, "3" = Somewhat Frequently Used, or "4" = Very Frequently Used. [Please circle the number to indicate your response.]

Source of knowledge	Do Not Use	Not Very Frequently	Somewhat Frequently	Very Frequently
A. Broadcast Media [TV and Radio]	1	2	3	4
B. Print Media [Newspapers, Pamphlets, Brochures]	1	2	3	4
C. Books	1	2	3	4
D. From Meetings at Work	1	2	3	4
E. From Conversations with Co-Workers	1	2	3	4
F. From Family and Friends	1	2	3	4
G. Personal Experience	1	2	3	4
H. Other source: _____	1	2	3	4



**Q-11.** Please indicate your belief as to the likelihood that the following human health impacts might be associated with flooding in south-central Texas. [Please circle your choice: "1" = Not Very Likely, "2" = Somewhat Unlikely, "3" = Somewhat Likely, or "4" = Very Likely.]

Possible Health Impact	Not Very Likely	Somewhat Unlikely	Somewhat Likely	Very Likely
<b>A. DROWNING</b>				
a) In flood waters	1	2	3	4
b) In a vehicle driving through flood waters	1	2	3	4
c) Other _____	1	2	3	4
<b>B. INJURY or BLUNT FORCE TRAUMA</b>				
a) Broken bones	1	2	3	4
b) Strains or Sprains	1	2	3	4
c) Contusions (scrapes & bruises)	1	2	3	4
<b>C. DISEASE FROM MOLD &amp; FUNGI</b>				
<b>D. DISEASE FROM EATING CONTAMINATED FOOD</b>				
<b>E. DISEASE FROM DRINKING CONTAMINATED WATER</b>				
<b>F. POISONOUS ANIMAL or INSECT BITES</b>				
<b>G. DISEASE FROM MOSQUITOES</b>				
a) West Nile Virus	1	2	3	4
b) Dengue Fever	1	2	3	4
c) Malaria	1	2	3	4
d) Yellow Fever	1	2	3	4
e) Encephalitis	1	2	3	4
<b>H. EXPOSURE TO TOXIC CHEMICALS</b>				
<b>I. ELECTRICAL SHOCK or ELECTROCUTION</b>				
<b>J. OTHER COMMUNICABLE DISEASE</b>				
<b>K. HEART ATTACK</b>				
<b>L. MENTAL STRESS</b>				
M. OTHER _____	1	2	3	4
N. OTHER _____	1	2	3	4

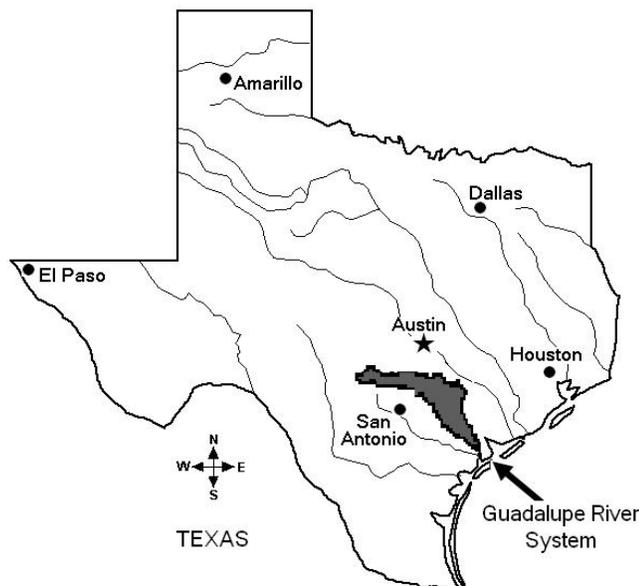
**Q-12.** Please indicate your belief as to the likelihood that certain locations or facilities might be affected by human health impacts of floods. [Please circle your choice: "1" = Not Very Likely, "2" = Somewhat Unlikely, "3" = Somewhat Likely, or "4" = Very Likely]

<b>Location or Facility</b>	<b>Not Very Likely</b>	<b>Somewhat Unlikely</b>	<b>Somewhat Likely</b>	<b>Very Likely</b>
A. Large Metropolitan Area	1	2	3	4
B. Small to Medium-Sized City	1	2	3	4
C. Rural Areas, Outside City Limits	1	2	3	4
D. Government Buildings	1	2	3	4
E. Educational Institutions / Schools	1	2	3	4
F. Law Enforcement Buildings	1	2	3	4
G. Hospitals and Medical Facilities	1	2	3	4
H. OTHER _____	1	2	3	4
I. OTHER _____	1	2	3	4

**Q-13.** Please indicate your belief as to the likelihood that certain groups of persons might be affected by human health impacts of floods. [Please circle your choice: "1" = Not Very Likely, "2" = Somewhat Unlikely, "3" = Somewhat Likely, or "4" = Very Likely]

<b>Social Group</b>	<b>Not Very Likely</b>	<b>Somewhat Unlikely</b>	<b>Somewhat Likely</b>	<b>Very Likely</b>
A. Young Age (under age 12)	1	2	3	4
B. Senior Citizens (age 65 or older)	1	2	3	4
C. Physically Disabled Persons	1	2	3	4
D. Those Living Alone	1	2	3	4
E. Those Living with Family	1	2	3	4
F. Male Adults	1	2	3	4
G. Female Adults	1	2	3	4
H. OTHER _____	1	2	3	4
I. OTHER _____	1	2	3	4

**TO ANSWER QUESTIONS Q-14 THROUGH Q-18, PLEASE BASE YOUR ANSWERS ON YOUR CURRENT KNOWLEDGE. Please place an X on the line to the left of the answer you select. For your reference, the following map of Texas highlights the Guadalupe River system.**



**Q-14.** Considering the number of deaths that occur in the United States due to drowning in flash floods over the recent 40-year (~1960-2000) record, where does the State of Texas rank?

- The state with the most deaths by drowning
- Among top 5 states having the most deaths by drowning, but not having the most deaths
- Comparable to the average number of deaths by drowning across the United States
- Among the states having the least number of deaths by drowning

**Q-15.** How many deaths due to flash-flooding occurred in Texas over the recent 40-year (~1960-2000) record?

- Less than 200**    **200 - 300**    **300 - 400**    **400 - 500**    **more than 500**

**Q-16.** What percentage of flood deaths over the recent 40-year record (~1960-2000) in Texas occurred in south-central Texas within the Guadalupe River system?

- Less than 5%**    **5-10%**    **10-15%**    **15-20%**    **more than 20%**

**Q-17.** How many flood-related injuries have been reported within the Guadalupe River system in south-central Texas during flood events in the last decade of record (~1990-2000)?

- Less than 2000**    **2000 - 4000**    **4000 - 6000**    **more than 6000**

**Q-18.** How many flood events on the Guadalupe River system have exceeded the 100-year flood level during the historic record which spans approximately 150 years in south-central Texas?

- Less than 5**    **5 - 10**    **10-20**    **20-25**    **more than 25**

**THANK YOU FOR COMPLETING PART I OF THIS SURVEY.**

**TO PARTICIPATE IN PART II OF THE SURVEY, PLEASE PROVIDE YOUR DETAILED MAILING ADDRESS BELOW TO FACILITATE RECEIVING PART II BY MAIL WITHIN 30-90 DAYS.**

**NAME:** \_\_\_\_\_

**MAILING ADDRESS:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**I WOULD LIKE TO RECEIVE A REPORT WHICH  
SUMMARIZES THE RESULTS OF PARTS I AND II  
OF THIS SURVEY:**

**YES**     **NO**

**YOUR PARTICIPATION IN THIS SURVEY PROCESS IS GREATLY APPRECIATED. MANY THANKS!**

**PLEASE RETURN YOUR COMPLETED SURVEY IN THE ENCLOSED ENVELOPE.**

## **APPENDIX C**

### **Floods and Health Survey Questionnaire - Part II:**

**Survey Announcement**

**Questionnaire - Part II**

**Survey Completion Reminder Postcard**



## Floods and Health Survey Questionnaire - PART II

Elaine J. Hanford, Doctoral Candidate  
eh1053@txstate.edu  
Department of Geography  
Texas State University – San Marcos  
Lovell Center for Environmental Geography and Hazards Research

August 1, 2009

Dear Survey Participant,

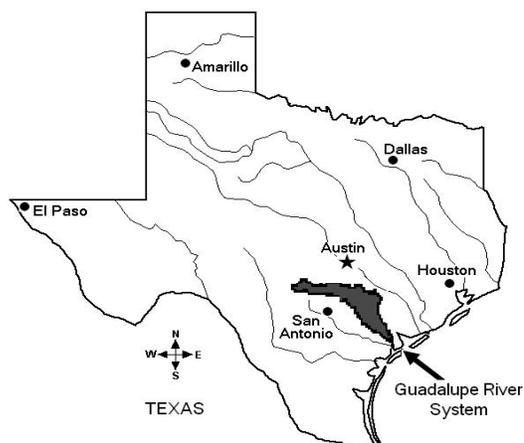
Thank you for completing Part I of this survey and indicating your willingness to continue to participate by completing the enclosed Part II. I extend my humble apology for the delay in providing this portion of the survey to you. The delay was necessitated by chronic personal health issues which now seem to be under control, hopefully allowing me with your help to complete this final portion of my research.

A Fact Sheet – Health Consequences of Flooding in South-Central Texas is enclosed for you. The set of questions asks for your perceptions and knowledge about floods and associated threats to human health from major future flood events. In addition, there are a few questions on the nature of flooding in south-central Texas on the Guadalupe River system.

You may be assured that your responses will remain confidential - only summary statistics of response analyses will be utilized and presented in the research report. Thank you for taking time to provide your responses on this very important topic.

Again, please accept my apologies for the delay in providing this final part of the Survey. Your attention and prompt return of the completed survey in the enclosed self-addressed, stamped envelope are very much appreciated!

Respectfully,





**Q-21.** Please indicate your belief as to the likelihood that the following human health impacts might be associated with flooding in south-central Texas. [Please circle your choice: "1" = Not Very Likely, "2" = Somewhat Unlikely, "3" = Somewhat Likely, or "4" = Very Likely.

Possible Health Impact	Not Very Likely	Somewhat Unlikely	Somewhat Likely	Very Likely
<b>A. DROWNING</b>				
a) In flood waters	1	2	3	4
b) In a vehicle driving through flood waters	1	2	3	4
c) Other _____	1	2	3	4
<b>B. INJURY or BLUNT FORCE TRAUMA</b>				
a) Broken bones	1	2	3	4
b) Strains or Sprains	1	2	3	4
c) Contusions (scrapes & bruises)	1	2	3	4
<b>C. DISEASE FROM MOLD &amp; FUNGI</b>	1	2	3	4
<b>D. DISEASE FROM EATING CONTAMINATED FOOD</b>	1	2	3	4
<b>E. DISEASE FROM DRINKING CONTAMINATED WATER</b>	1	2	3	4
<b>F. POISONOUS ANIMAL or INSECT BITES</b>	1	2	3	4
<b>G. DISEASE FROM MOSQUITOES</b>				
a) West Nile Virus	1	2	3	4
b) Dengue Fever	1	2	3	4
c) Malaria	1	2	3	4
d) Yellow Fever	1	2	3	4
e) Encephalitis	1	2	3	4
<b>H. EXPOSURE TO TOXIC CHEMICALS</b>	1	2	3	4
<b>I. ELECTRICAL SHOCK or ELECTROCUTION</b>	1	2	3	4
<b>J. OTHER COMMUNICABLE DISEASE</b>	1	2	3	4
<b>K. HEART ATTACK</b>	1	2	3	4
<b>L. MENTAL STRESS</b>	1	2	3	4
<b>M. OTHER _____</b>	1	2	3	4
<b>N. OTHER _____</b>	1	2	3	4

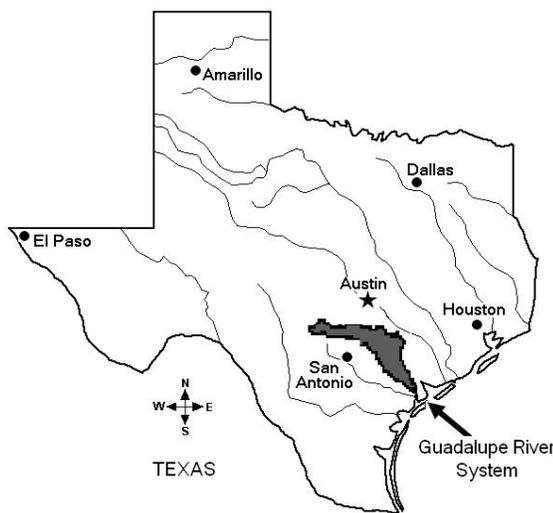
**Q-22.** Please indicate your belief as to the likelihood that certain locations or facilities might be affected by human health impacts of floods. [Please circle your choice: "1" = Not Very Likely, "2" = Somewhat Unlikely, "3" = Somewhat Likely, or "4" = Very Likely.

Location or Facility	Not Very Likely	Somewhat Unlikely	Somewhat Likely	Very Likely
A. Large Metropolitan Area	1	2	3	4
B. Small to Medium-Sized City	1	2	3	4
C. Rural Areas, Outside City Limits	1	2	3	4
D. Government Buildings	1	2	3	4
E. Educational Institutions / Schools	1	2	3	4
F. Law Enforcement Buildings	1	2	3	4
G. Hospitals and Medical Facilities	1	2	3	4
H. OTHER _____	1	2	3	4
I. OTHER _____	1	2	3	4

**Q-23** Please indicate your belief as to the likelihood that certain groups of persons might be affected by human health impacts of floods. [Please circle your choice: "1" = Not Very Likely, "2" = Somewhat Unlikely, "3" = Somewhat Likely, or "4" = Very Likely.

Social Group	Not Very Likely	Somewhat Unlikely	Somewhat Likely	Very Likely
A. Young Age (under age 12)	1	2	3	4
B. Senior Citizens (age 65 or older)	1	2	3	4
C. Physically Disabled Persons	1	2	3	4
D. Those Living Alone	1	2	3	4
E. Those Living with Family	1	2	3	4
F. Male Adults	1	2	3	4
G. Female Adults	1	2	3	4
H. OTHER _____	1	2	3	4
I. OTHER _____	1	2	3	4

**TO ANSWER QUESTIONS Q-24 THROUGH Q-28, PLEASE BASE YOUR ANSWERS ON YOUR CURRENT KNOWLEDGE. Please place an X on the line to the left of the answer you select. For your reference, the following map of Texas highlights the Guadalupe River system.**



- Q-24.** Considering the number of deaths that occur in the United States due to drowning in flash floods over the recent 40-year (~1960-2000) record, where does the State of Texas rank?
- The state with the most deaths by drowning
- Among the top 5 states having the most deaths by drowning, but not having the most deaths
- Comparable to the average number of deaths by drowning across the United States
- Among the states having the least number of deaths by drowning
- Q-25.** How many deaths due to flash-flooding occurred in Texas over the recent 40-year (~1960-2000) record?
- Less than 200     200 - 300     300 - 400     400 - 500     more than 500
- Q-26.** What percentage of flood deaths over the recent 40-year record (~1960-2000) in Texas occurred in south-central Texas within the Guadalupe River system?
- Less than 5%     5-10%     10-15%     15-20%     more than 20%
- Q-27.** How many flood-related injuries have been reported within the Guadalupe River system in south-central Texas during flood events in the last decade of record (~1990-2000)?
- Less than 2000     2000 - 4000     4000 - 6000     more than 6000
- Q-28.** How many flood events on the Guadalupe River system have exceeded the 100-year flood level during the historic record which spans approximately 100 years in south-central Texas?
- Less than 5     5 - 10     10-20     20-25     more than 25

**Q-29.** Have you ever experienced any kind of disaster(s) such as fire, earthquake, tornado, hurricane, chemical spill, etc?

\_\_\_\_\_ YES     **[If YES, please go on to Q-61]**

\_\_\_\_\_ NO     **[If NO or DON'T KNOW, please skip to Q-27 and proceed].**

\_\_\_\_\_ DON'T KNOW

**Q-30.** If YES, please indicate the disaster(s) \_\_\_\_\_

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**Q-31.** Have you ever experienced any flood disaster?

\_\_\_\_\_ YES     **[If YES, please go on to Q-32]**

\_\_\_\_\_ NO     **[If NO or DON'T KNOW, please skip to Q-33 and proceed].**

\_\_\_\_\_ DON'T KNOW

**Q-32.** If YES, please indicate the disaster(s) \_\_\_\_\_

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**Q-33.** Please indicate how prepared you believe the following entities are should a major flood occur in your community within the next year. [Please circle your choice: "1" = Not Very Prepared, "2" = Somewhat Unprepared, "3" = Somewhat Prepared" or "4" = Very Prepared.

<b>Entity</b>	<b>Not Very Prepared</b>	<b>Somewhat Unprepared</b>	<b>Somewhat Prepared</b>	<b>Very Prepared</b>
A. Local Law Enforcement	1	2	3	4
B. Local Hospital	1	2	3	4
C. Federal Emergency Agencies	1	2	3	4
D. State Government	1	2	3	4
E. Local Government	1	2	3	4
F. Educational Institutions / Schools	1	2	3	4
G. Non-Governmental Organizations [e.g., Red Cross]	1	2	3	4
F. Neighborhood Associations	1	2	3	4
G. Individual Households	1	2	3	4
H. OTHER _____	1	2	3	4

**Q-34.** Where is the location of your employment? [Please indicate your city/town and your county].

City/Town \_\_\_\_\_ County \_\_\_\_\_

**THESE FINAL QUESTIONS ARE FOR DEMOGRAPHIC PURPOSES. AGAIN, IT IS EMPHASIZED THAT YOUR INDIVIDUAL ANSWERS WILL REMAIN CONFIDENTIAL. .**

**Q-35.** How many years of school have you completed? \_\_\_\_\_(years)

**Q-36.** What is your age? \_\_\_\_\_(years)

**Q-37.** In what state (U.S.) or country were you born? \_\_\_\_\_(place)

**Q-38.** With what ethnic group do you identify? [Please check the appropriate box.]

- 1. ASIAN-AMERICAN
- 2. AFRICAN-AMERICAN
- 3. HISPANIC
- 4. NATIVE AMERICAN
- 5. PACIFIC ISLANDER
- 6. WHITE [ANGLO]
- 7. OTHER (Please Specify) \_\_\_\_\_

**THANK YOU FOR COMPLETING PART II OF THIS SURVEY.**

**PLEASE RETURN YOUR COMPLETED SURVEY IN THE ENCLOSED SELF-  
ADDRESSED, STAMPED ENVELOPE.**

**YOUR PARTICIPATION IN THIS SURVEY IS GREATLY APPRECIATED.**

## Survey Completion Reminder Postcard



### **Floods and Health Survey Questionnaire - PART II**

Dear Survey Participant,

I know that life and work keep you busy, but helping in this research by completing and returning Part II of the Survey that you received several weeks ago is very important.

If you have already completed and mailed your survey packet back in the self-addressed stamped envelope, then **THANK YOU!!**

If it is still waiting for you to finish the survey, then I hope that you kindly take some time to complete and return the Questionnaire.

Respectfully,

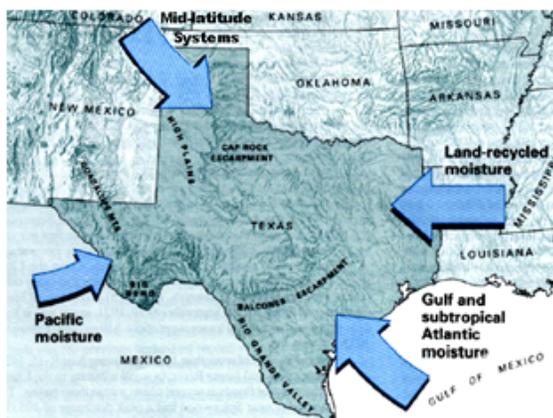
**APPENDIX D**

**Fact Sheet:  
Health Consequences of Flooding in South-Central Texas**

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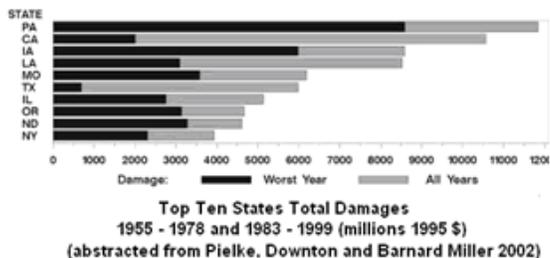
## Health Consequences from Major Flood Occurrences in the Guadalupe River System in South-Central Texas: What We Do and Don't Know

There is an old adage about everything being bigger in Texas. And historically, south-central Texas has led the nation in the frequency and magnitude of hazardous flood events. Why? Geographically, Texas is unique. The State is located at the inland confluence of oceanic storms making landfall along the Gulf of Mexico, the flow of moisture from oceanic storms along the Pacific and Atlantic Coasts, and fronts generated by mid-latitude cyclonic systems. But is bigger always better?

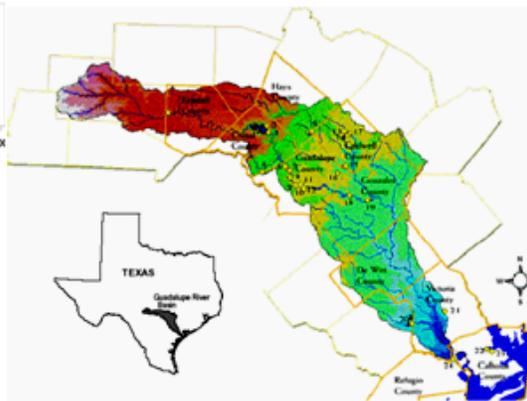


Many of the largest storms in the world with the greatest precipitation depths and durations ranging from about 1 to 48 hours have occurred in Texas. These occurrences produced a history of unexpected deaths and economic hardships, especially when maximum flood discharges significantly exceed the 100-year flood discharge.

Local and regional public policy has been directed toward reducing the most serious impacts from major flood events. Typically, these impacts are tallied in "deaths and dollars," that is the deaths that occurred during the flood and the economic costs of repairing/replacing damaged structures. Based on data from the National Climatic Data Center, from 1960 through 2002, some 715 individuals lost their lives in floods in Texas. Between 1955 and 2003, total flood damages (adjusted to 1995 dollars) in Texas were reported to exceed \$11.5 billion (Pielke, Downton and Barnard Miller 2002). When the final numbers become available for Hurricanes Katrina and Ike, these deaths and dollar values will increase, guaranteeing Texas a place in the 'top five' states.



But deaths and dollars do not reflect the totality of the impacts of flood disasters on society. Human health must be protected in the broadest sense. Policies to protect the health and well-being of an increasingly vulnerable population from the hazards posed by recurrent catastrophic floods should be based on available records to begin to characterize the hazards and identify the



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potential risks. The Guadalupe River system, a region of great cultural and socio-economic diversity in Texas, serves as a case study of flood impacts on human health.

### The Guadalupe River

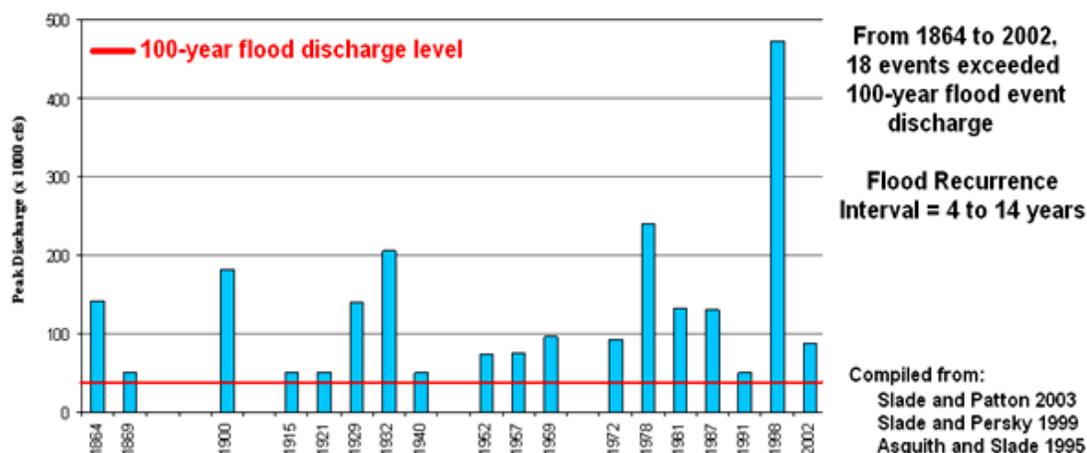
Originating in Kerr County at about 1,800 feet above mean sea level, the river flows about 410 miles to its juncture with the San Antonio River upstream from Guadalupe Bay. 30-year (1961-1991) precipitation in this 6,000 square mile drainage basin ranges from about 30 inches near the headwaters to about 40 inches near the coast.

Based on 1935 to 1997 records for the US Geological Survey streamflow-gaging station 08176500 Guadalupe River at Victoria, the annual mean discharge of the Guadalupe River into Guadalupe Bay is 1,867 cubic feet per second (Gandara, Gibbons, Andrews, Jones and Barbie, 1998). Canyon Dam was completed in 1964 to create Canyon Lake for flood control, water storage, hydroelectric power generation, and recreational uses. With the dam, the Guadalupe River became a regulated river over much of its length. Based on 1963 to 1997 records for the US Geological Survey streamflow-gaging station 08167800 Guadalupe River at Sattler Daily, the mean discharge from Canyon Dam ranges from 0.80 to 5,680 cubic feet per second, with annual mean discharge is 457 cubic feet per second (Gandara, Gibbons, Andrews, Jones and Barbie, 1998).

The San Marcos River, tributary to the Guadalupe River in Gonzales County provides the only regular input of substantial flow below Canyon Dam. The San Marcos is a spring-fed river with annual mean discharge from the springs of 170 cubic feet per second (Gandara and others, 1995). Spring-fed headwaters derived from the Edwards Aquifer are joined by surface runoff and provide high water quality that makes the river attractive to Texas residents and tourists while supporting rich and divergent ecosystems. South-central Texas experiences rapid urban and suburban population growth, with an ethnically diverse population dependent on the river for water supply, recreation, and economic support. It is this same population that is vulnerable to a wide range of impacts when the Guadalupe River floods in response to major precipitation events.

### Historical Flood Events on the Guadalupe River

Flood records dating back to the mid to late 1800s and stream gauge monitoring since the early 1900s provide a long historical record reflecting at least 18 major floods exceeding the designated 100-year event for this river system. These events include the 1998 and 2002 floods which have been described as 500-year events.



The interval between historic floods ranges from 4 to as many as 14 years (Hanford 2003). Intervening droughts may also play a role in the severity of the succeeding flood when convergent climatic conditions draw in significant moisture and produce intense precipitation events of long duration.

### Health Impacts of Floods in South-Central Texas

Mortality and morbidity data for Texas has been included in the National Climatic Data Center (NCDC) Storm Events Database. NCDC data for the period 1960 to 1996 indicates Texas contributed 619 fatalities during flash flood events, with males accounting for the majority (79%) in vehicle-related deaths. Texas has the dubious distinction of being the only state to have at least one flood fatality in each year, with an average of 17 flood-related deaths per year and at least 10 deaths in each of 25 separate years during this interval (Hanford 2003).

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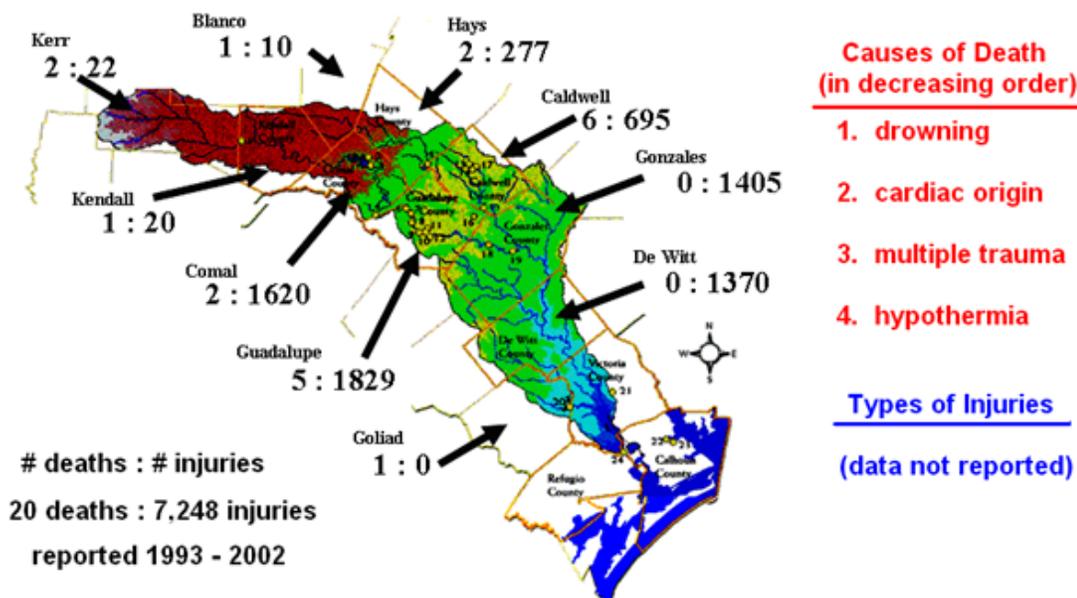
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Time interval	Deaths	Reported injuries
1960 - 1996	619	(not reported)
1997 - 2002	96	6889
1997	21	239
1998	41	6357
1999	2	7
2000	9	12
2001	9	233
2002	14	41

Reported Flood Mortality and Morbidity Data for the State of Texas Summarized from National Climatic Data Center (NCDC) Storm Events Database

Texas led the nation in five of the six years between 1997 and 2002 in flood fatalities, with almost 20 percent of the fatalities occurring within the Guadalupe River basin. Critically, more than 7200 injuries were reported for that same time interval. There is no direct relationship between the number of fatalities and number of reported injuries in any county. The numbers of injuries are likely significantly under-reported; types, causes, and/or severity of injuries was not reported and included in NCDC database.

Review of Texas State Hospital Discharge data for the third and fourth quarters of 2002 indicated no individual patient cases where flood-related IDC codes were designated as a primary or secondary diagnosis.



#### Potential for Disease Outbreaks Associated with Flooding

Review of epidemiologic surveillance data for the last three decades indicates that occasional small increases in life-threatening infectious diseases were detected among those in Texas who were impacted by both coastal and inland flooding. Dynamics of climate change, demographic patterns, prevalence of endemic disease, and emerging zoonoses warrant awareness, planning, mitigation and response to ensure appropriate measures to address the incidence of disease during the three phases of a flood disaster in Texas.

Experience with coastal flooding associated with recent hurricanes along the Gulf Coast and with regional inland flood events throughout the state suggest the diseases of potential concern. Epidemic-prone infection may be transmitted directly from contaminated water by leptospires. Flooding followed by hot weather may coax *Bacillus anthracis* to the

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soil surface leading to ingestion and infection of grazing animals, with potential for transmission to humans by improper handling of infected animals, carcasses, manure or bedding. Skin or soft-tissue injuries may become infected with MRSA, *Clostridium tetani*, *Vibrio vulnificus* (in brackish waters), or *V. parahaemolyticus*. Gastrointestinal infections may be caused by norovirus, rotavirus, *E. coli* or non-toxicogenic *V. cholerae*. Increased exposure to wild animals and host organisms may result in risk of rabies, rat-bite fever, Chagas, hantavirus, or tick-transmitted diseases.

The three-plus decade record indicates that no epidemic occurrences have been reported. Outbreaks that have been identified have been limited to evacuation centers and among relief workers during post-impact phase (recovery period). Most outbreaks were non-life threatening gastro-intestinal illness. Norovirus accounted for up to 50 % of illnesses. Skin rashes and non-specific diarrhea were common in evacuation centers. Both adult and pediatric cases of MRSA infections were also reported in evacuation centers (MMWR 2005). An increase in animal bites and respiratory illness has been reported (MMWR 2002). No outbreaks of mosquito-borne illnesses have been reported.

Cases and a limited number of fatalities have been reported from *V. vulnificus* and *V. parahaemolyticus* (Ivers & Ryan 2006, Ligon 2006) associated with wound and non-wound infections.

Cutaneous anthrax occurred in six south Texas counties in the 1970s (USDA), with approximately 12 % in traditional domestic livestock. Most human cases occurred from 1930 until the 1960s, and less than three cases since 1980.

Waring and others (2005) report a significant increase in illness in flood homes (OR 5.1 95%CI 2.7-9.4). To ensure public health protection, rapid health needs assessment should continue to be a critical part of preparedness planning, particularly for the recovery phase, to identify patterns of morbidity and possible emergence of infectious diseases related to displacement of flood victims to emergency shelters and disruption of normal public health infrastructure.

Continuing efforts are needed to ensure awareness among emergency rescue and relief workers and health care personnel to appropriately recognize and report direct and indirect mortality and morbidity associated with flood events. The critical question to ask is: "Would this illness / injury / death have occurred if there had been no flood?" A database that provides details on mortality as well as morbidity will ensure our ability to assess the full range of impacts of such flood events on our social and economic programs and costs.

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## Appendix E

### CDC Morbidity and Mortality Surveillance Forms

#### **Natural Disaster Morbidity Surveillance Individual Form** (*Interim*)

**Purpose:** To capture individual-level active surveillance of medical conditions when timely, detailed, patient-level information is needed for response efforts.

#### **Natural Disaster Morbidity Surveillance Line List** (*Interim*)

**Purpose:** This form is an abbreviated version of the Natural Disaster Morbidity Report Form. Use this form if summary or less-detailed information is sufficient or when the burden of collecting detailed, individual information is substantial.

#### **Natural Disaster Morbidity Surveillance Tally Sheet** (*Interim*)

**Purpose:** This form is an abbreviated version of the Natural Disaster Morbidity Report Form. Use this form if summary or less-detailed information is sufficient and a tally sheet is the most useful to capture morbidity data. This form captures morbidity data at the individual level, but does not separate data by individual.

#### **Natural Disaster Morbidity Surveillance Summary Report Form** (*Interim*)

**Purpose:** To collect aggregate morbidity data. This form should be used for reporting purposes and does not capture individual level data.

#### **Disaster-Related Mortality Surveillance Form**

**Purpose:** Identify the number of deaths related to the disaster and provide basic mortality information.

Natural Disaster Morbidity Surveillance Individual Form  
For Active Surveillance with Medical Staff

Form v1.9  
Rev. 09/29/2009

<b>Part I: VISIT INFORMATION</b>	Name of Facility <input type="text"/>	City <input type="text"/>	State <input type="text"/>	Date of Visit / /	Time of Visit AM PM
<b>Part II: PATIENT INFORMATION</b>	Unique Identifier/Medical Record Number <input type="text"/>	Age <input type="checkbox"/> <1yrs <input type="text"/>	Gender <input type="checkbox"/> Male <input type="checkbox"/> Female	Pregnant <input type="checkbox"/> Yes <input type="checkbox"/> No/NA	If yes, due date / /
Race/Ethnicity <input type="checkbox"/> White <input type="checkbox"/> Black/African American <input type="checkbox"/> Hispanic or Latino <input type="checkbox"/> Asian <input type="checkbox"/> Unknown					
Did reason for visit occur as a result of work (paid or volunteer) involving disaster response or rebuilding efforts? <input type="checkbox"/> Yes <input type="checkbox"/> No/NA If Yes, occupation/response role <input type="text"/> Activity at time of injury/illness <input type="text"/>					
<b>Part III: REASON FOR VISIT (Please check all categories related to patient's current reason for seeking care)</b>					
<b>TYPE OF INJURY</b> <input type="checkbox"/> Abrasion, laceration, cut <input type="checkbox"/> Avulsion, amputation <input type="checkbox"/> Concussion, head injury <input type="checkbox"/> Fracture <input type="checkbox"/> Sprain/strain  <b>MECHANISM OF INJURY</b> <input type="checkbox"/> <u>Bite/sting</u> , specify: <input type="checkbox"/> Insect <input type="checkbox"/> Snake <input type="checkbox"/> Other specify _____ <input type="checkbox"/> <u>Burn</u> , specify: <input type="checkbox"/> Chemical <input type="checkbox"/> Fire, hot object or substance <input type="checkbox"/> Sun exposure <input type="checkbox"/> <u>Cold/heat exposure</u> , specify: <input type="checkbox"/> Cold (e.g., hypothermia) <input type="checkbox"/> Heat (e.g., stress, hyperthermia) <input type="checkbox"/> Electric shock <input type="checkbox"/> <u>Fall, slip, trip</u> , specify: <input type="checkbox"/> From height <input type="checkbox"/> Same level <input type="checkbox"/> Foreign body (e.g., glass shard) <input type="checkbox"/> Hit by or against an object <input type="checkbox"/> <u>Motor vehicle crash</u> , specify: <input type="checkbox"/> Driver/occupant <input type="checkbox"/> Pedestrian/bicyclist <input type="checkbox"/> Non-fatal drowning, submersion <input type="checkbox"/> <u>Poisoning</u> , specify: <input type="checkbox"/> Carbon monoxide exposure <input type="checkbox"/> Inhalation of fumes, dust, other gas <input type="checkbox"/> Ingestion specify _____ <input type="checkbox"/> Use of machinery, tools, or equipment <input type="checkbox"/> <u>Violence/assault</u> , specify: <input type="checkbox"/> Self-inflicted injury/suicide attempt <input type="checkbox"/> Sexual assault <input type="checkbox"/> Other assault specify _____		<b>ACUTE ILLNESS/SYMPTOMS</b> <input type="checkbox"/> Conjunctivitis/eye irritation <input type="checkbox"/> Dehydration <input type="checkbox"/> <u>Dermatologic/skin</u> , specify: <input type="checkbox"/> Rash <input type="checkbox"/> Infection <input type="checkbox"/> Infestation (e.g., lice, scabies) <input type="checkbox"/> Fever ( $\geq 100^{\circ}\text{F}$ or $37.8^{\circ}\text{C}$ ) <input type="checkbox"/> <u>Gastrointestinal</u> , specify: <input type="checkbox"/> Diarrhea <input type="checkbox"/> Bloody <input type="checkbox"/> Watery <input type="checkbox"/> Nausea or vomiting <input type="checkbox"/> Jaundice <input type="checkbox"/> Meningitis/encephalitis <input type="checkbox"/> Neurological (e.g., altered mental status, confused/disoriented, syncope) <input type="checkbox"/> <u>Obstetrics/Gynecology</u> , specify: <input type="checkbox"/> GYN condition not associated with pregnancy or post-partum <input type="checkbox"/> In labor <input type="checkbox"/> Pregnancy complication (e.g., bleeding, fluid leakage) <input type="checkbox"/> Routine pregnancy check-up <input type="checkbox"/> <u>Pain</u> , specify: <input type="checkbox"/> Abdominal pain or stomachache <input type="checkbox"/> Chest pain, angina, cardiac arrest <input type="checkbox"/> Ear pain or earache <input type="checkbox"/> Headache or migraine <input type="checkbox"/> Muscle or joint pain (e.g., back, hip) <input type="checkbox"/> Oral/dental pain <input type="checkbox"/> <u>Respiratory</u> , specify: <input type="checkbox"/> Congestion, runny nose, sinusitis <input type="checkbox"/> Cough, specify: <input type="checkbox"/> Dry <input type="checkbox"/> Productive <input type="checkbox"/> With blood <input type="checkbox"/> Pneumonia, suspected <input type="checkbox"/> Shortness of breath/difficulty breathing <input type="checkbox"/> Wheezing in chest <input type="checkbox"/> Sore throat		<b>EXACERBATION OF CHRONIC DISEASE</b> <input type="checkbox"/> <u>Cardiovascular</u> , specify: <input type="checkbox"/> Hypertension <input type="checkbox"/> Congestive heart failure <input type="checkbox"/> Diabetes <input type="checkbox"/> Immunocompromised (e.g., HIV, lupus) <input type="checkbox"/> <u>Neurological</u> , specify: <input type="checkbox"/> Seizure <input type="checkbox"/> Stroke <input type="checkbox"/> <u>Respiratory</u> , specify: <input type="checkbox"/> Asthma <input type="checkbox"/> COPD  <b>MENTAL HEALTH</b> <input type="checkbox"/> Agitated behavior (i.e. violent behavior/threatening violence) <input type="checkbox"/> Anxiety or stress <input type="checkbox"/> Depressed mood <input type="checkbox"/> Drug/alcohol intoxication or withdrawal <input type="checkbox"/> Previous mental health diagnosis (i.e. PTSD) <input type="checkbox"/> Psychotic symptoms (i.e. paranoia) <input type="checkbox"/> Suicidal thoughts or ideation  <b>ROUTINE/FOLLOW-UP</b> <input type="checkbox"/> Medication refill If yes, how many medications? _____ <input type="checkbox"/> Blood sugar check <input type="checkbox"/> Vaccination <input type="checkbox"/> Blood pressure check <input type="checkbox"/> Wound care  <b>OTHER</b> <input type="text"/>	
<input type="checkbox"/> <b>Influenza-like illness (ILI)</b> – Fever (temperature of $100^{\circ}\text{F}$ [ $37.8^{\circ}\text{C}$ ] or greater) AND a cough or a sore throat in the absence of a KNOWN cause other than influenza					

Form 019  
Rev. 09/23/2009

### Natural Disaster Morbidity Surveillance Line List

For use in hospital or shelter with medical staff

Facility Name:	MVC	INJURY	ACUTE ILLNESS	CHRONIC	PREG	ACUTE ILLNESS										CHRONIC			MH			Mental health including agitated behavior, anxiety or stress, depressed mood, drug/alcohol intoxication or withdrawal, previous mental health diagnoses, psychotic symptoms, and/or suicidal thoughts/ideation									
						Race/Eth	W	B	H	A	M/C	Fall	OO	Vio	Other	Derm	Fever	GI	Pain	Resp	ILI		OB/GYN	Pain	Resp	Other	Card	Diab	Resp	Other	MH
City & State:	Fall	W	B	H	A	M/C	Fall	OO	Vio	Other	Derm	Fever	GI	Pain	Resp	ILI	OB/GYN	Pain	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER	
Date (mm/dd/yy):	Other	Yes	INJURY										CHRONIC			MH			All routine and follow-up care including medication refill, blood pressure/sugar check or assessment, wound care/dressing change, vaccination												
Report time frame (12hour clock am/pm):	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other		Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER		
PREG - Pregnancy	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER			
W-White, non-Hispanic	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER			
B-Black, non-Hispanic	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER			
H-Hispanic	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER			
A-Asian	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER			
Other	Other	Yes	Sex	Age (years)	1-17	18-64	65+	M	F	W-White, non-Hispanic	B-Black, non-Hispanic	H-Hispanic	A-Asian	Other	Card	Diab	Resp	Other	Card	Diab	Resp	Other	ROUTINE	OTHER	ROUTINE	OTHER	ROUTINE	OTHER			
TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL		
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Natural Disaster Morbidity Surveillance Tally Sheet  
For Active Surveillance with Medical Staff

Form v1.9  
Rev. 09/29/2009

Part I: GENERAL INFORMATION			Part II: PATIENT INFORMATION			
Name of Facility: _____ City _____ State _____ Date of Visit ____/____/____ Reporting Period START ____:____ AM PM Reporting Period END ____:____ AM PM			Race	White	Tally (#)	Total (#)
				Black		
				Hispanic		
				Asian		
				Unknown		
			Gender	Male		
Female						
	Tally (#)	Total (#)	Pregnant	Yes		
Patients Seen			Age Category	< 1		
Workers/Volunteers				1 to 17		
				18 to 64		
				65+		
Part III: REASON FOR VISIT (For each client, place a tick mark next to the corresponding injury or illness. A single client may have more than one condition ticked)						
	Tally (#)	Total (#)		Tally (#)	Total (#)	
TYPE OF INJURY			EXACERBATION OF CHRONIC DISEASE			
Any Injury (cut, amputation, concussion, fracture, sprain, etc.)			Cardiovascular (hypertension, congestive heart failure)			
MECHANISM OF INJURY			Diabetes			
Bite/sting (all types)			Immunocompromised			
Burn (chem., fire, sun)			Neurological (seizure, stroke)			
Cold/heat exposure			Asthma			
Electric shock			COPD			
Fall, slip, trip			<b>TOTAL Chronic Disease</b>			
Foreign body			<b>MENTAL HEALTH</b>			
Hit by or against object			Agitated behavior			
Motor vehicle crash			Anxiety or stress			
Near drowning, submersion			Depressed mood			
Poisoning – CO exposure			Drug/alcohol intoxication/withdrawal			
Poisoning – other			Previous mental health diagnosis			
Use of Machinery, tools, or equip.			Psychotic symptoms (i.e. paranoia)			
Violence/assault			Suicidal thoughts or ideation			
<b>TOTAL Mechanism of Injury</b>			<b>TOTAL Mental Health</b>			
ACUTE ILLNESS/SYMPTOMS			ROUTINE/FOLLOW-UP			
Conjunctivitis/eye irritation			Medication refill			
Dehydration			Blood sugar check			
Dermatologic/Skin (includes all dermatologic/skin conditions)			Blood pressure check			
Fever (≥100°F or 37.8°C)			Vaccination			
Gastrointestinal (nausea, vomiting, diarrhea)			Wound care			
Jaundice			<b>TOTAL Routine/Follow-up</b>			
Meningitis/encephalitis			<b>Other</b>			
Neurological (includes all neurological conditions)			All "other"			
OB/GYN (includes all OB/GYN conditions)			<b>Disposition</b>			
Pain (includes all pain symptoms/conditions)			Discharge to self care			
Respiratory (includes all respiratory conditions)			Refer to other care (e.g., clinic or physician)			
Sore throat			Admit/refer to hospital			
			Left before being seen			
			Deceased			
<b>TOTAL Acute Illness/Symptoms</b>			<b>TOTAL Disposition</b>			
<b>Influenza-Like Illness (ILI)</b> - Fever (temperature of 100°F [37.8°C] or greater) AND a cough or a sore throat in the absence of a KNOWN cause other than influenza						

<http://www.bt.cdc.gov/disasters/surveillance/word/NaturalDisasterMorbiditySurveillanceTallySheet.doc>

Natural Disaster Morbidity Surveillance Summary Report Form  
For Reporting Purposes

Form v1.9  
Rev. 09/29/2009

Submit completed form daily to \_\_\_\_\_ via email (xxxxxxx@xxxxx.xxx), phone (xxx/xxx/xxxx) or fax (xxx/xxx/xxxx)

<b>Part I FACILITY INFORMATION</b> LOCATION: STATE _____ ZIP CODE _____ NAME OF FACILITY _____ REPORTING PERSON/CONTACT: PHONE _____ NAME _____ FAX _____ EMAIL _____		<b>Part III PERSONS SEEN OR TREATED</b> TOTAL SEEN OR TREATED DURING CURRENT REPORTING PERIOD: # _____ RACE / ETHNICITY: White # _____ Black/African American # _____ Hispanic or Latino # _____ Asian # _____ Unknown # _____ AGE: ≤ 1 years # _____ ≥ 65 years # _____ Pregnant females # _____ TOTAL REFERRED TO HOSPITAL: # _____	
<b>Part II REPORTING PERIOD</b> START: _____ AM PM END: _____ AM PM MONTH DAY YEAR HOUR (CIRCLE)		TOTAL SHELTER POPULATION AT START: # _____	

**Part IV TREATED PATIENTS**  
 Use categories that best describe patients' current reasons for seeking care. Complete the Total patient tallies for each syndrome category in the column to the right. Be as specific as possible. A single patient may be counted more than once.

SYNDROME CATEGORY	TOTAL	SYNDROME CATEGORY	TOTAL
<b>WORKERS/VOLUNTEERS - TOTAL</b>	_____	<b>OTHER ILLNESS - TOTAL</b>	_____
<b>INJURY - TOTAL</b>	_____	Dehydration	_____
Fall, slip, trip (from height or same level)	_____	Fever (≥100°F or 37.8° C)	_____
Motor vehicle crash	_____	Meningitis/encephalitis, suspected	_____
Carbon monoxide exposure	_____	Neurological	_____
Violence/assault	_____	Pain	_____
Injury - not specified above	_____	Other illness – not specified above	_____
<b>DERMATOLOGIC/SKIN - TOTAL</b>	_____	<b>EXACERBATION OF CHRONIC DISEASE - TOTAL</b>	_____
Rash	_____	Cardiovascular disease (e.g., hypertension, CHF)	_____
Infection	_____	Diabetes	_____
Infestation (e.g., lice or scabies)	_____	Immunocompromised (e.g., HIV, lupus)	_____
<b>GASTROINTESTINAL ILLNESS - TOTAL</b>	_____	Neurological (e.g., seizure, stroke)	_____
Diarrhea - bloody	_____	Respiratory (e.g., Asthma, COPD)	_____
Diarrhea - watery	_____	<b>MENTAL HEALTH - TOTAL</b>	_____
Nausea or vomiting	_____	Agitated behavior	_____
<b>OB/GYN – TOTAL</b>	_____	Anxiety or stress	_____
GYN condition not associated with pregnancy or post-partum period	_____	Depressed mood	_____
In labor	_____	Drug/alcohol intoxication or withdrawal	_____
Pregnancy complication	_____	Previous mental health diagnosis	_____
Routine pregnancy check-up	_____	Psychotic symptoms (i.e. paranoia)	_____
<b>RESPIRATORY ILLNESS - TOTAL</b>	_____	Suicidal thoughts or ideation	_____
Congestion, runny nose, sinusitis	_____	<b>ROUTINE/FOLLOW-UP - TOTAL</b>	_____
Cough	_____	Medication refill	_____
Pneumonia, suspected	_____	Blood sugar check	_____
Shortness of breath or difficulty breathing	_____	Blood pressure check	_____
Wheezing in chest	_____	Vaccination	_____
<b>INFLUENZA-LIKE-ILLNESS (ILI) - TOTAL</b>	_____	Wound care	_____
		<b>OTHER REASON FOR VISIT, not listed above</b>	_____



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## VITA

Elaine J. Hanford has more than twenty-five years experience as a professional geologist working in industry and as a private consultant providing guidance and technical assistance to private and corporate clients, as well as agencies of local, state and the federal government. Beginning in the 1980s, she began investigating and directing remediation of hazardous waste sites across the nation. Thus continuing the journey that led her to seek her doctoral degree in Environmental Geography from Texas State University-San Marcos. Her research interests encompass the interactions between humans and conditions that naturally exist in the environment, as well as those resulting from human activities. Real-world experience evaluating toxicology and human health risks led her to earn a certificate in Epidemiology as part of her doctoral program. For more than a decade, she has continued to combine research with collegiate-level teaching.

This thesis was typed by Elaine J. Hanford.