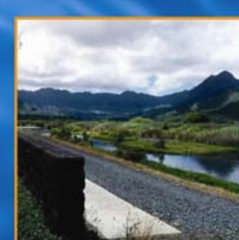
Water Resources Outlook

16 October 2007

Natural and Human-Induced Disasters and Other Factors Affecting Future Emergency Response and Hazard Management: *Trends and Outlook*

2007-R-4



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Water Resources Outlook

Water is an essential resource in the U.S. economy. It plays a crucial role in supporting many economic activities and ensuring the quality of human life and the health of ecological systems. Despite this, the value of water may not be widely appreciated because only some water resources and water uses are easily visible or noticed while others are not.

Among the Institute for Water Resources (IWR) Future Directions program activities are the identification of emerging water challenges and opportunities and the tactical engagement of U.S. Army Corps of Engineers (USACE) senior leaders on these issues. Such critical thinking is an essential prerequisite to strategy development and planning.

IWR has developed this series of Water Resources Outlook papers, commissioned utilizing outside experts, to identify emerging issues and implications for the Nation. These issues and implications will be presented in the form of "provocation sessions" with external and internal subject matter experts and stakeholders and will inform the USACE strategic planning process.

Natural and Human-Induced Disasters and Other Factors Affecting Future Emergency Response and Hazard Management: Trends and Outlook

The steady increase in losses from natural hazards over the past 46 years—both nationally and globally—challenges the effectiveness of traditional approaches to hazard mitigation and loss reduction.

While it is impossible to plan and prepare for every worst case disaster scenario, there is a common set of factors that drive catastrophic outcomes. This third in a series of Water Resources Outlook papers identifies challenges over the next 30 years to the emergency management system. Then it describes how the nation's emergency management agencies can move from a reactive to proactive posture based on developing a resilient disaster risk management system. Finally, it suggests future roles for the Corps.

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Natural and Human-Induced Disasters and Other Factors Affecting Future Emergency Response and Hazard Management: *Trends and Outlook*

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Melanie Gall
Hazards and Vulnerability Research Institute
Dept. of Geography, University of South Carolina

Susan L. Cutter
Hazards and Vulnerability Research Institute,
Dept. of Geography, University of South Carolina

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Abbreviations

ASCE	American Society of Civil Engineers
ASFPM	Association of State Floodplain Managers
CDC	Centers for Disease Control and Prevention (U.S. Army)
cfs	cubic feet per second
CI/KR	Critical infrastructure and key resources
CMA	Chemical Management Agency
cms	cubic meters per second
CSEP	Chemical Stockpile Emergency Preparedness
DHS	Department of Homeland Security
DOD	Department of Defense
DOT	Department of Transportation
DWR	Department of Water Resources (California)
EFO	Emergency Field Office
EMS	Emergency Management System
EOC	Emergency Operations Center
ERT-A	Emergency Response Teams – Advance
ESF	Emergency Support Function
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
GDP	Gross Domestic Product
GPS	Global Positioning System
GSA	General Services Administration
HAZUS	FEMAs Hazards U.S. Multi-Hazard software

HSAC	Homeland Security Advisory Council
HSPD	Homeland Security Presidential Directive
HVAC	heating, ventilation and air conditioning
IPCC	Intergovernmental Panel on Climate Change
IPET	Interagency Performance Evaluation Task Force
IT	information technology
JFO	Joint Field Office
LIDAR	Light Detection and Ranging sensor
NAFSMA	National Association of Flood and Stormwater Management Agencies
NED	National Economic Development
NFIP	National Flood Insurance Program
NID	National Inventory of Dams
NIMS	National Incident Management System
NIPP	National Infrastructure Protection Plan
NPG	National Preparedness Goal
NRC	National Research Council
NRP	National Response Plan
NSDI	National Spatial Data Infrastructure
O&M	Operation and Maintenance
P.L.	Public Law
PKRA	Post-Katrina Emergency Management Reform Act
PUD	Public Utility District
R&D	Research and Development
REPP	Radiological Emergency Preparedness Program

RFO	Recovery Field Office
RPP	Readiness Prevention and Planning
SAFCA	Sacramento Area Flood Control Agency
TCL	Target Capabilities List
TISP	The Infrastructure Security Partnership
UCEM	Umatilla County Emergency Management
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VX	Neurotoxic chemical warfare agent
WWEMD	Walla Walla County Emergency Management Division

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Executive Summary

While it is impossible to plan and prepare for every worst case disaster scenario, there is a common set of factors that drive catastrophic outcomes. By the year 2030, it is anticipated that the following factors will represent challenges to the emergency management system (EMS) and if not adequately addressed will significantly add to increased losses:

- More people will be exposed to hazards due to continued population growth.
- More people will move into hazardous areas (e.g., California, Florida, Texas) attracted by economic opportunities and coastal lifestyles.
- More people will be unfamiliar with the local hazardscape due to limited experience in their new environment.
- An increasingly diverse population will required customized approaches of risk communication or else will be reluctant to take precautionary measures.
- More people will require state and Federal assistance during and after an event given their inability to evacuate or protect themselves.
- More insurance companies will abandon risky markets and insurance premiums will either increase or not be available at all, which reduces resiliency.
- The natural system will provide less natural protection from disasters due to the destruction of wetlands, on-going land development, etc.
- The pressure on natural resources will increase and their resilience will decrease due to heightened environmental pressures (e.g., climate variability, temperature extremes) and human-induced changes in environmental systems.
- The occurrence of extreme events will increase due to a more variable climate.
- The entire U.S. coastline will experience increased damages from erosion, storm surge, severe storms, hurricanes and flooding due to sea level rise.
- The globalization of disasters will bring new and old hazards to the U.S. (e.g., malaria, avian influenza) that people, emergency professionals and procedures are unfamiliar with or unprepared for.
- A deteriorating infrastructure system (e.g., levees, dams) will expose the Nation's populations to additional risks.
- The lack of redundancies within the system of critical infrastructure enables cascading failures and catastrophic outcomes on a daily basis and not just in extreme conditions.
- Aging infrastructure will be the weakest link in effective emergency response and will slow down response and recovery efforts.

Emergency management agencies need to incorporate these anticipated changes and plan ahead to avoid escalating losses. The big question is: How does the nation move away from a reactive entitlement-driven disasters policy to a proactive policy based on the design and implementation of a resilient disaster risk management system that (1) fosters stakeholder and intergovernmental responsibility and accountability and (2) reduces the transfer of risks and risk burdens geographically or to the next generation? What should the USACE's role be in the design and implementation of such as system? Below is a summary of 15 potential avenues to improving the Nation's resilience to natural hazards:

1. Attack the national complacency towards risk reduction and half-life of concern following a disaster event by making infrastructure maintenance a national priority.
2. View infrastructure protection and maintenance as a long-term commitment and integrate it into comprehensive mitigation plans at all administrative levels.
3. Build redundancies into infrastructure and anticipate future stresses such as sea-level rise and climate change when designing and retrofitting structural and non-structural projects.
4. Align and synchronize individual flood protection projects of the U.S. Army Corps of Engineers (USACE) with the ultimate goal of reducing flood risk and increasing resilience.
5. Develop a comprehensive, national flood risk mitigation plan that fosters public-private partnerships by bringing together Federal and non-Federal infrastructure owners as well as Federal, state and local emergency management agencies.
6. Synchronize the mitigation strategies of the USACE with other Federal, state and local agencies.
7. Develop floodplain maps and incorporate future changes (e.g., subsidence, sea-level rise, etc.) and delineate floodplains accordingly.
8. Enable the public, local planners and developers to make flood-smart decisions by educating them on their true local flood risks.
9. Improve risk perception and communication by changing the standard risk nomenclature (100-year flood) to the likelihood of flooding in non-probabilistic terms (e.g., based on 30-year mortgage).
10. Establish methods and standards for assessing risk and associated societal costs from flood protection infrastructure that are not agency- or problem-dependant.
11. Prioritize the maintenance and construction of flood protection infrastructure according to these risk assessments.
12. Alter the current funding stream of USACE so that risk-wise behavior and hazard mitigation are represented in structural projects.
13. Shift USACEs administrative focus on districts to a system's perspective along watersheds and regions.
14. Expand USACEs strategic planning to include hazard mitigation and make it the driving principle behind all water resource management related decisions.
15. Ensure that social equity and social justice is the guiding principle behind increasing the Nation's resilience to hazards and disasters.

Section 1
Introduction

The steady increase in losses from natural hazards over the past 46 years—both nationally and globally (Figure 1)—challenges the effectiveness of traditional approaches to hazard mitigation and loss reduction. While the contribution of the natural system and the occurrence of more frequent and more severe events is in dispute (Landsea 2007; Landsea et al. 2006; Mann and Emanuel 2006; Pielke et al. 2005), there is no doubt about the adverse effects of natural hazards on society. Population growth and in-migration, particularly in high-risk areas such as coastal zones, along with increasing wealth and prosperity put more people, goods and properties at risk than ever before (Crossett et al. 2004; Heinz Center for Science 2002). Additionally, the destruction and/or depletion of important natural resources such as wetlands, barrier islands and floodplains due to land use changes reduces the resilience of the natural system and limits its ability to buffer the impacts of natural events on communities.

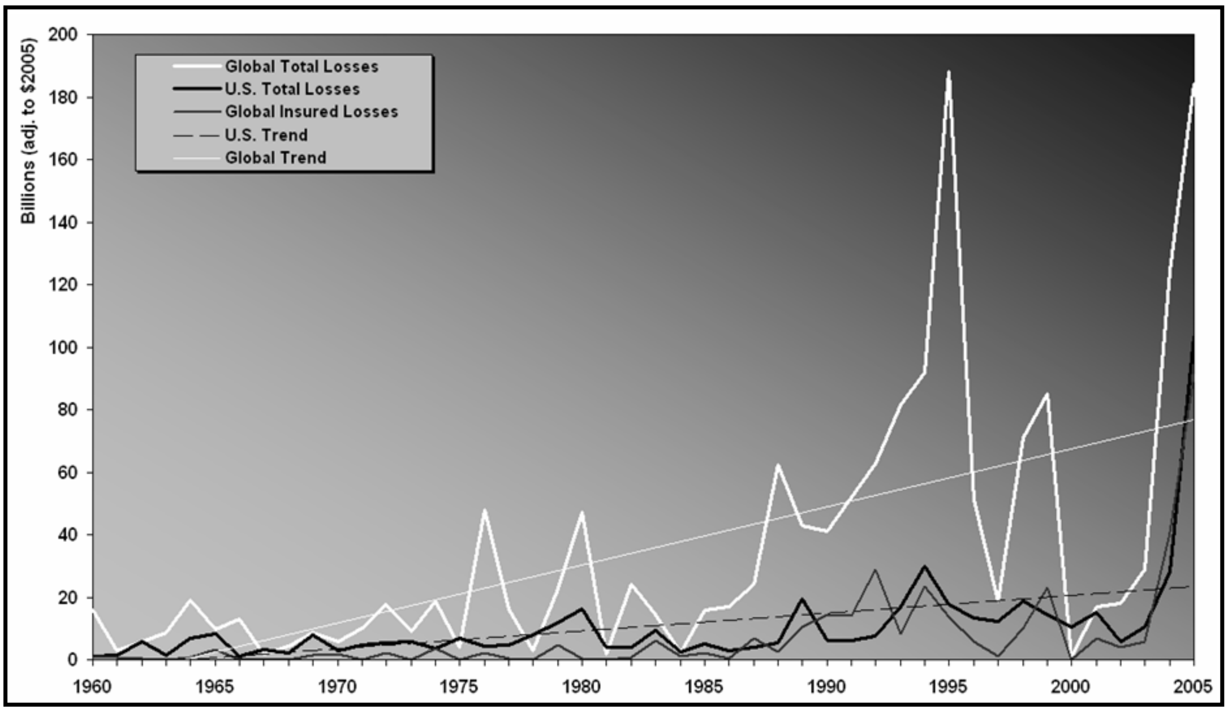

FIGURE 1
NATIONAL AND GLOBAL MONETARY LOSSES FROM NATURAL HAZARDS
Data Sources: Munich Re Geo Risks Research NatCATService (2007) and SHELDUS Version 5.1.

The impacts and losses from extreme events are no longer local. Disasters such as Hurricane Katrina (2005) or the Indian Ocean Tsunami (2004) demonstrated how large-scale catastrophic events have ripple effects that go beyond their immediate and localized areas of impact (Alexander 2006). The short-term effects of Hurricane Katrina—shortages in refined gas and price hikes at gas pumps—were tangible for everyone, regardless of where they lived. The storm also caused unprecedented long-term effects. Never before has a natural disaster in the

U.S. caused the displacement of large populations that subsequently failed to return to their homes and instead resettled in communities across the country. Thus, the disaster resulted not only in local human and economic losses but also in regional and national long-term demographic and economic changes. The connectedness and economic interdependencies of today's world globalize disasters, not only in terms of the hazard itself (e.g., global climate), but also in its impact and especially the media coverage of the event.

Hurricane Katrina, the most expensive disaster in U.S. history and globally the costliest in terms of insured losses, is considered a worst-case event (Clarke 2006). The disaster exceeded the imagination and initiative of so many and in particular of officials in charge (Select Bipartisan Committee 2006). But as Clarke (2006) and others point out the catastrophe was predictable and the precipitating event was just a matter of when, not if it was going to happen (Tidwell 2006). In fact, Laska (2004) speculated on the impacts of Hurricane Ivan on New Orleans, had the Category 3 storm made landfall there rather than in eastern Alabama. A table-top exercise called Hurricane Pam had Louisiana emergency officials responding to a fictitious hurricane Category 3 in 2004, a scenario that was almost identical to the real Hurricane Katrina. The bottom line is that Hurricane Katrina revealed the weaknesses of today's emergency management system (EMS) and the Nation's flood protection infrastructure.

This outlook paper examines the social, environmental and organizational drivers that contribute to skyrocketing flood losses. Projecting these drivers and their outcomes into the future raises important questions on the mission and role of U.S. Army Corps of Engineers (USACE) as part of the national EMS. This critical analysis considers future challenges such as sea-level rise, population growth, climate change, infrastructure deterioration and more. The purpose is to identify crucial shortcomings of USACEs current and future abilities to mitigate and respond to natural hazards. The goal is to "evaluate and improve (USACEs) capabilities to perform their assigned missions and tasks in major events" (DHS 2005: 6) and better align its responsibilities with its resources to increase the Nation's resilience to major events and protect the Nation's citizen from future harm.

Imagining the impossible is a necessary exercise to increase the resilience and adaptation of the Nation and the EMS in particular (Flynn 2007). Learning lessons from virtual worst cases[1], what-if scenarios and table-top exercises ensure that contemporary threats such as natural disasters or terrorist attacks and future threats such as sea level rise and global climate change will not overwhelm the EMS. Under Section 112(r) of the Clean Air Act as amended in 1990, toxic chemical facilities are required to develop risk management plans that consider worst case scenarios of accidental chemical release and its potential impact on surrounding populations (so called off-site consequence analysis). Following this logic in a post-9/11 era, the Department of Homeland Security (DHS) has taken the first steps towards a similar catastrophe thinking by generating National Planning Scenarios (Homeland Security Council 2005).

Some of these scenarios serve as references for this outlook paper and three worst case scenarios discussed below. Since the National Planning Scenarios are not exhaustive and are oriented towards terrorist activities (e.g., chemical, biological, radiological attacks), this paper tailors

[1] There are two types of virtual worst cases: (a) worst cases that almost happened (e.g. Three Mile Island accident) and (b) worst cases that might happen (e.g. attack on a liquefied natural gas tanker in Boston harbor) (Clarke 2005).

scenarios that are more oriented towards USACE mission and capabilities. Some scenarios are reflective of ongoing discussions surrounding critical infrastructure safety and maintenance (e.g., levee safety, dam rehabilitation). The objective of the scenarios is to delineate mitigation and response problems pertinent to USACE and the Federal EMS in general and suggest avenues for improvement. The results are 15 suggestions that are essential to reduce the Nation's vulnerability to natural forces, to boost societal resilience and to improve USACEs effectiveness in hazard management.

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Section 2
U.S. Army Corps of Engineers Missions and Hazards

2.1 U.S. Army Corps of Engineers: Trends and Uncertainties

The USACEs traditional focus resides with the management of water resources and civil works projects for recreational, public, military and defense purposes. This includes, for example, flood and storm surge protection; the construction and maintenance of crucial water transportation infrastructure (e.g., locks, dams, ports and shipping); hydroelectric power facilities; and water supply reservoirs (USACE 2007d). In recent decades, the agency's mission was expanded to include environmental stewardship (compliance, restoration, prevention and conservation) and clean-up of hazardous materials (USACE 2007b).

Today, USACE serves as one of the Nation's lead water resources management agency. The agency has to balance traditional constituencies (e.g., navigation, water supply, flood protection) and project operations with citizens' engagement and ecological restoration while operating on shrinking financial and human resources and under a plethora of environmental laws and authorities that often result in conflicting goals (NRC 2004). Given the competing visions and interpretations of environmental stewardship and water resources management, it is not surprising to find the agency's mission fulfillment and performance questioned by the U.S. Congress and others. The USACE has been widely criticized for (a) the lack of a peer review process of its flood control projects, (b) diminishing in-house engineering expertise and research and development (R&D) capacity, (c) the disconnect between flood control and environmental planning and (d) the weak coordination with state and local authorities (Carter 2005; Carter et al. 2005; Farber 2006; Mittal et al. 2005a; Mittal et al. 2005b; Mittal et al. 2006; NRC 2004).

At the organization level, USACE faces two major impediments to advancing its effectiveness in hazard mitigation. The first is the widening gap between USACE planning and construction budgets and unmet funding needs to maintain and/or rehabilitate flood risk infrastructure, wetlands and shore protection (Lane 2007; NRC 2004). The Nation's aging flood protection infrastructures and society's increasing dependence on it along with wetland destruction, floodplain encroachment and development form a fatal mixture that is far from providing human security and safety—especially under conditions of global climate change.

The second issue challenging USACE is the organizational culture and operational environment that is not as receptive to innovations in contemporary resource (Rayner et al. 2005) and hazards management practices such as adaptive management, watershed-based approaches or risk-based planning. Part of this is historic inertia within the agency, but some of it is based in diminishing R&D capacity within USACE itself as previously mentioned (NRC 2004). Examples include USACEs organizational structure that focuses on districts rather than regions or watersheds. This adversely effects emergency response during large scale disasters but most importantly limits the implementation of regional mitigation strategies. Another problem is the application of Federally mandated National Economic Development (NED) policies that are inadequate for capturing societal benefits of mitigation projects. As a result, structural projects at the lowest possible design standards are often times (economically) favored over comprehensive mitigation projects that could effectively reduce future flood losses (Larson 2007).

2.2 Natural Disaster and Emergency Response Activities

Emergency response and recovery represent long-standing tasks among USACEs Civil Works responsibilities. The Mississippi River Flood of 1882 marked the first formal emergency response assignment (USACE 2007d). Today, emergency assistance is among USACEs top priority missions: the agency responds to more than 30 declared disasters on average per year, in addition to state and local emergencies (USACE 2007a). This is reflective of USACEs significantly evolved responsibilities in the areas of emergency response and recovery compared to 1882.

At present, the Homeland Security Office of USACE (established in 2002) and its Civil Emergency Management division operate under two statutory authorities: the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law [P.L.] 93-288) and Flood Control and Coastal Emergency Act (P.L. 84-99). The National Response Plan (NRP) (formerly called the Federal Response Plan) reflects the policies established in the Stafford Act; the Homeland Security Act of 2002 Section 502(6) and Homeland Security Presidential Directive (HSPD)-5 consolidates Federal emergency response to domestic incidents. The USACE receives funding for NRP-related activities through DHS and the Federal Emergency Management Agency (FEMA) and/or supplemental appropriations legislation (Carter and Hughes 2006; USACE 2007b). In 2005, for instance, FEMA assigned about $4.4 billion to USACE for response efforts for Hurricanes Dennis, Katrina, Rita and Wilma (USACE 2007a).

Under the NRP, USACE provides support to DHS, FEMA and the Department of Defense (DOD) to prepare for, respond to and recover from terrorist attacks, natural and human-caused disasters and other emergencies. More specifically, USACE is the primary and coordinating agency for activities related to public works and engineering (Emergency Support Function [ESF] #3) including infrastructure protection, emergency repairs (e.g., power, roofing, housing), debris removal, urban search and rescue, ice and water distribution, restoration, construction management, engineering services and critical infrastructure liaison. The USACE also provides additional assistance to other ESFs (non-ESF #3) for which it is not the lead agency (Table 1).

The National Incident Management System (NIMS) represents the structure and mechanism through which the NRP is implemented. This system is a consistent nationwide approach that specifies actors and lines of command to ensure a coordinated response by Federal, state and local governments. The NIMS ultimately determines how preparedness, response and recovery activities are orchestrated across and between multiple administrative levels (DHS 2004).

Outside the NRP context, USACE can deliver emergency response and disaster preparedness activities under the Flood Control and Coastal Emergency Act. In the case of a life- and property-threatening disaster, USACE is authorized to rehabilitate flood controls, conduct flood-related rescue operations and protect/repair public facilities. The funding for such activities originates either in the annual Energy and Water Development Appropriations or is supplemented with emergency appropriations (Carter and Hughes 2006; USACE 2007b). For post-Katrina rehabilitation measures, USACE received about $7 billion dollars (including rescissions) in supplemental emergency appropriations (P.L. 109-62, P.L. 109-148, P.L. 109-234) in addition to FEMA funding through the Disaster Relief Fund (Copeland et al. 2005; Murray and Bea 2007).

TABLE 1
OTHER (NON-ESF #3) EMERGENCY SUPPORT FUNCTIONS BY U.S. ARMY CORPS OF ENGINEERS ACCORDING TO THE NATIONAL RESPONSE PLAN

Emergency Support Function	Support
Transportation (ESF #1)	Support to DOD in the restoration of transportation infrastructure, inland waterways, ports and harbors.
Firefighting (ESF #4)	Provision of contracting services through ESF #3 (Public works and engineering) to firefighting forces to obtain heavy equipment and demolition services.
Emergency Management (ESF #5)	Provision of logistics support and staffing of mobilization centers in accordance with the NIMS.
Mass Care, Housing and Human Services (ESF #6)	Provision of ice and water for mass care facilities; inspection of mass care shelter sites to ensure facility suitability; assistance in construction of temporary shelters, housing and other temporary structures; expedited repair of damaged homes (e.g., temporary roofing, etc.).
Public Health and Medical Services (ESF #8)	Provision of technical assistance, equipment and supplies to temporarily restore damaged public utilities affecting public health (through ESF #3).
Urban Search and Rescue (ESF #9)	Provision of pre-incident training for structure specialist; deployment of structure specialists and technical search specialist teams to supplement Urban Search and Rescue task forces and Joint Management Teams; assistance to the Joint Management Engineering Cell and Task Forces with Urban Search and Rescue efforts; provision of building stability monitoring and structural engineering analysis whether buildings are safe to enter.
Oil and Hazardous Materials Response (ESF #10)	Response and recovery assistance to incidents involving radiological dispersal devices and improvised nuclear devices.
Agriculture and Natural Resources (ESF #11)	Provision of expertise and resources to assist in the removal and disposal of contaminated and non-contaminated debris (including animal carcasses and debris affecting natural and cultural resources and historic properties).
Energy (ESF #12)	Coordination of Emergency Power team missions with power-system restoration activities to establish priorities and efficiently provide support to a facility having power restored.
Public Safety and Security (ESF #13)	Provision of physical and electronic security systems assistance and expertise.
Long-Term Community Recovery (ESF #14)	Provision of technical assistance in community planning and civil engineering and natural hazard risk assessment expertise; support the development of national strategies and plans related to housing and permanent housing, debris management and the restoration of public facilities and infrastructure.
Source: DHS (2004)	

2.3 Status of the National Preparedness System

In addition to the HSPD-5, which resulted in the development of the NRP and NIMS, President Bush passed HSPD-8 in late 2003. This directive was designed to establish a national system for preparedness and response based on linked responsibilities and interconnected capabilities across all governmental and non-governmental entities.

To implement this directive along with the NRP, NIMS, Interim National Infrastructure Plan and expand regional collaboration, DHS specified a National Preparedness Goal (NPG) applicable to catastrophes regardless of their cause. An interim NPG was released in March 2005 that establishes mechanisms for ensuring adequate Federal response in case of an emergency (DHS 2005). The vision of the interim NPG is "to engage Federal, state, local and tribal entities, their private and non-governmental partners and the general public to achieve and sustain risk-based target levels of capability to prevent, protect against, respond to and recover from major events in order to minimize the impact on lives, property and the economy" (DHS 2005: 3). Furthermore, the NPG prioritizes strengthening of the following capabilities: information sharing and collaboration; interoperable communications; medical surge and mass prophylaxis; as well as chemical, biological, radiation, nuclear and explosive weapons detection, response and decontamination (DHS 2005).

A list of 36 fundamental preparedness capabilities, called the Target Capabilities List (TCL), was developed. The list is largely based on the 15 National Planning Scenarios of which 12 scenarios are terrorist related and the remaining 3 focusing on hurricanes, earthquakes and influenza pandemics. To help guide the process of improving the Nation's preparedness, the TCL also includes readiness metrics and a universal task list so that measuring progress towards the National Preparedness Goal can be monitored (see Table 2).

In response to the administrative failures during Hurricane Katrina, DHS extended the review process of the final NPG to include lessons learned. The review caused DHS to revise and update several target capabilities and prioritize the strengthening of emergency operations planning and citizen protection capabilities, including planning, mass care sheltering/feeding, evacuation and in-place protection (DHS 2007a). As of September 2007, the NPG has not been finalized yet.

Following Hurricane Katrina the U.S. Congress called for a review of the status of catastrophic and evacuation planning in all states and 75 of the Nation's largest urban areas. In response, the DHS in coordination with the Department of Transportation (DOT) initiated the Nationwide Plan Review. This review revealed the need for improved catastrophic planning and highlighted preparedness weaknesses that originate in outdated planning processes, assessment methodologies, products and tools (DHS/DOT 2006). Consequently, the NRP is currently under review to ensure the incorporation of lessons learned from Hurricane Katrina.

The passage of the Post-Katrina Emergency Management Reform Act (PKRA) in October 2006 (P.L. 109-295) mandated additional evaluation of the National Preparedness System. The act also stipulated new missions and roles within FEMA as well as between FEMA and DHS to improve leadership, capabilities and accountability systems that foster fast and flexible responses during catastrophic events. More specifically, the PKRA enhanced FEMAs responsibilities and autonomy within DHS and designated FEMA the lead agency for a

TABLE 2
LIST OF TARGET CAPABILITIES AS SPECIFIED IN THE INTERIM NATIONAL PREPAREDNESS GOAL

Target Capability List	
Animal Health Emergency Support	Chemical, Biological, Radiation, Nuclear and Explosive Weapons Detection
Citizen Preparedness and Participation	Citizen Protection (evacuation and/or in-place protection)
Critical Infrastructure Protection	Critical Resource Logistics and Distribution
Economic and Community Recovery	Emergency Operations Center Management
Emergency Public Information and Warning	Environmental Health and Vector Control
Explosive Device Response Operations	Fatality Management
Firefighting Operations/Support	Food and Agriculture Safety and Defense
Information Collection and Threat Recognition	Information Sharing and Collaboration
Intelligence Fusion and Analysis	Interoperable Communications
Isolation and Quarantine	Mass Care (sheltering, feeding and related services)
Mass Prophylaxis	Medical Supplies Management and Distribution
Medical Surge	On-Site Incident Management
Planning	Public Health Epidemiological Investigation and Laboratory Testing
Public Safety and Security Response	Restoration of Lifelines
Risk Analysis	Search and Rescue
Structural Damage Assessment and Mitigation	Terrorism Investigation and Intervention
Triage and Pre-Hospital Treatment	Volunteer Management and Donations
WMD/Hazardous Materials Response and Decontamination	Worker Health and Safety
Source: DHS (2005)	

National, comprehensive emergency management agency. To support FEMA in this quest, the statute establishes 10 regional offices and a National Integration Center for the management of the NIMS and NRP (among other organizational changes). Furthermore, the PKRA transferred many functions and offices of DHSs Preparedness Directorate (back) to FEMA such as contingency planning, exercise coordination and evaluation, emergency management training and hazard mitigation with respect to the Chemical Stockpile Emergency Preparedness (CSEP) and Radiological Emergency Preparedness Program (REPP). The division for Readiness, Prevention and Planning (RPP) is designed to be FEMAs central office for preparedness policy and other planning functions. Overall, the provisions of the PKRA address currently deficient areas such as impact assessment, logistics, emergency communication, evacuation, mass care, sheltering and search and rescue—issues that have not been resolved since Hurricane Andrew or 9/11 (Bea et al. 2006).

While the PKRA restored core elements of emergency management under FEMAs authority hugely important functions—at least with respect to USACE—remained within the larger DHS: critical infrastructure protection, risk management and analysis and emergency communication among others. Despite the lessons from Katrina, critical functions and capabilities remain divided between agencies leaving the Nation with a piecemeal approach to emergency management rather than an integrated and comprehensive response system.

2.4 Emergency Responsibilities

In case of a declared disaster, numerous USACE administrative levels are activated to assign staff and ensure mission support under the NRP. The USACE headquarters responsibilities are to: (a) provide staff for the National Response Coordination Center; (b) liaise with FEMA headquarters; (c) determine and assign national assets, teams (e.g., ESF #3 management cell) and equipment to respective USACE divisions; and (d) recruit personnel (see Figure 2).

The Regional USACE Division where the event occurs assigns (a) a response field office

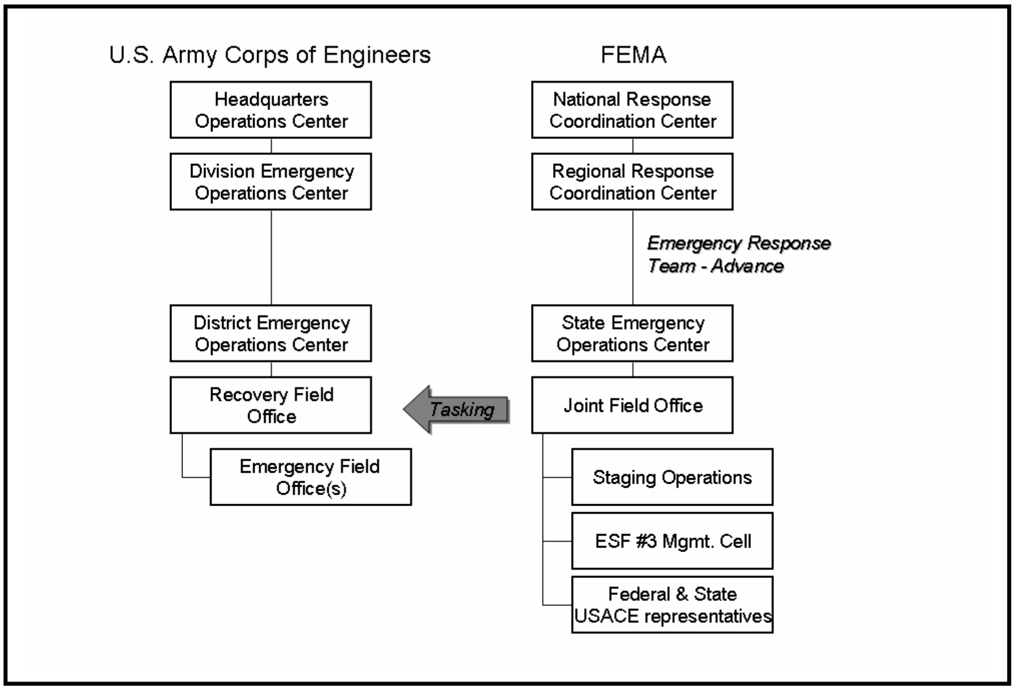

FIGURE 2
CONCEPT OF OPERATIONS ACCORDING TO THE NATIONAL RESPONSE PLAN

Source: Adapted from Morse (2005)

commander, (b) a FEMA liaison person for the Regional Response Coordination Center and (c) an ESF #3 staff person for the regional operations center and Emergency Response Teams - Advance (ERT-A). Depending on the scale of the event, there is generally one ERT-A team per state (Morse 2005).

The main responsibilities, in terms of response and recovery, fall to the local USACE District Emergency Operations Center (EOC). It is the focal point for information exchange and command and control. The District EOC generally manages all emergency response efforts under the Stafford Act (NRP) and the Flood Control and Coastal Emergencies Act. It also provides key support to (temporary) Recovery Field Offices (RFOs). Typical RFO functions are mission execution, reporting, accounting, emergency contracting, reporting, logistics management, physical and financial mission close out (see Figure 3). The RFO also manages and coordinates Emergency Field Offices (EFOs) during large scale events. During Hurricane Andrew, for example, six EFOs were responsible for debris removal, temporary housing and roofing (Morse 2005).

The Joint Field Office (JFO), located close to the actual event and established by FEMA, coordinates the Federal response. An essential part of the JFO operations is the warehousing of

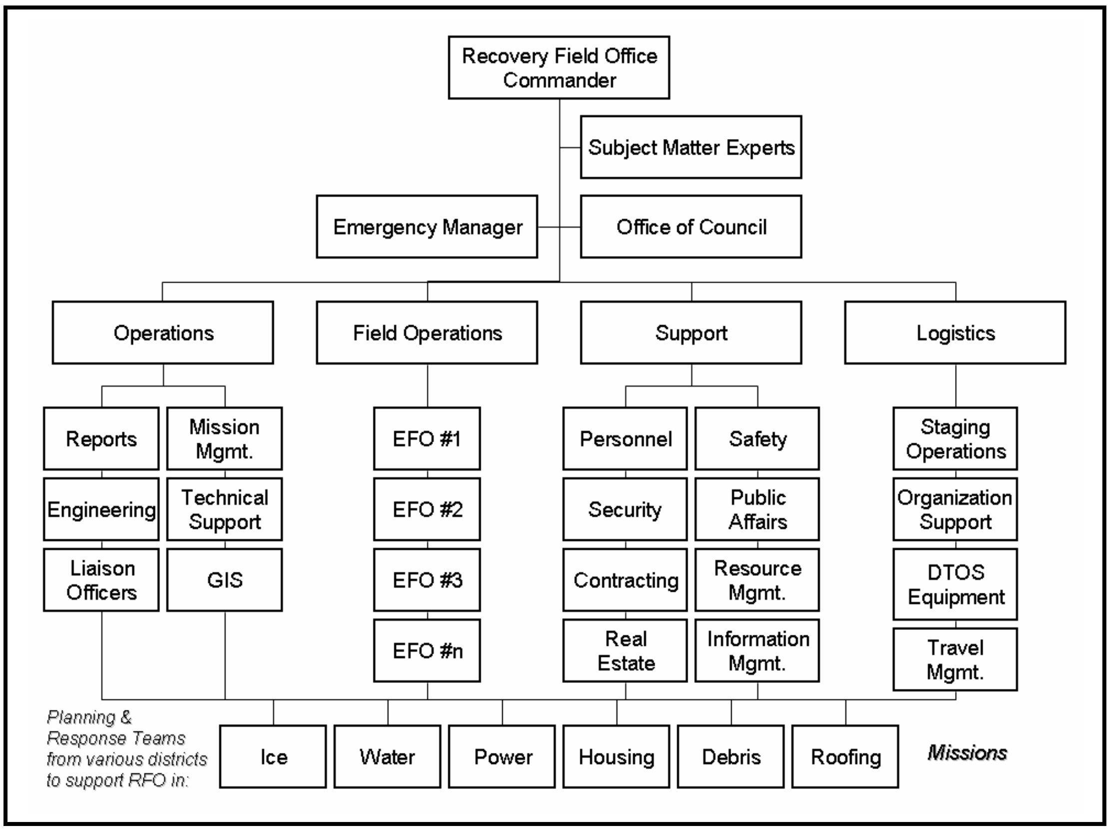

FIGURE 3
ORGANIZATIONAL CHART OF USACES RECOVERY FIELD OFFICE

Source: Adapted from Morse (2005)

disaster relief supplies (ice, water, generators and roofing materials). A team consisting of members from the U.S. Forest Service (USFS), U.S. General Services Administration (GSA), FEMA and USACE generally manages it. The JFO also houses the ESF #3 management cell, which reports to USACE headquarters, forms the primary point of contact for FEMA and assigns the tasks (mission formulation) to the RFO, which then executes the mission (Morse 2005).

Again, it is USACE local districts that execute and perform disaster response and recovery in the field with the support from districts outside the region and their staff. The degree to which USACE Districts will face more preparedness, mitigation, response and recovery responsibilities in the future depends largely on shifts in the local hazardscape and the populations at risk. The local hazardscape will vary based on the impacts of interdecadal climate variability and global climate changes (IPCC 2007b; IPCC 2007a). Populations at risk will certainly change in terms of total numbers, composition as well as spatial distribution. Hence, USACE needs to anticipate and prepare for these upcoming changes in both the physical and social systems.

2.5 Federal Flood Mitigation

The principal national documents for anything emergency related are the NPG, the NRP and the NIMS. The NPG, in particular, has tremendous significance for defining and shaping the Nation's mitigation, preparedness and response and recovery capabilities. As mentioned previously, the NPG bases the target capabilities on the National Planning Scenarios—of which none envision flood-related catastrophes. Most target capabilities that apply to USACE such as Structural Damage and Mitigation Assessment or Restoration of Lifelines are derived from the earthquake scenario.

The management and mitigation of floods should receive equal attention as earthquakes and hurricanes. Floods caused $76 billion dollars between 1960 and 2005. About 27 percent of the Nation's losses since 1960 are flood-related[2] compared to 11 percent from earthquakes (Hazards Research Lab 2007). More presidential disaster declarations have been issued for floods than any other hazard event (Sylves 2007). This underscores the Nation's need for flood mitigation. However, the Nation's current system for flood mitigation, i.e., legislation, insurance and executive authorities—is ill-suited for the problem at hand. In fact, FEMAs and USACEs authorities, responsibilities and procedures intersect as well as they contradict each other. This leaves the Nation with a fragmented approach in flood mitigation.

Today's concerns in flood risk management center on:

- Infrastructure failure—especially of levees and dams;
- Inadequate operation and maintenance (O&M) of flood infrastructure—particularly by non-Federal owners;
- Lack of information on infrastructure safety (levee locations, quality and status of O&M, populations at risk, etc.);
- The sustainability of the National Flood Insurance Program (NFIP);
- The misperception of flood risks by the public, developers and officials;
- The absence of accountability and public responsibility;

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[2] This includes losses from storm surge.

- The narrow scope of the NED categories, which is unsuited for mitigation projects; and
- The lack of coordinated policies and watershed planning between the local, state and Federal levels.

  (ASFPM 2006; ASFPM and NAFSMA 2007; HSAC 2006; Lane 2007; Larson 2007; TISP 2006; USACE-Sacramento 2007)

Root causes for many of the above listed issues are the lack of incentives and disincentives for state and local administrations as well as the public to reduce their flood risks. Apathy in flood mitigation is facilitated by the Federal (top-down) administration of important flood policies such as the NFIP, dam safety program or P.L. 84-99. USACEs responsibility to assist state, local and private authorities in flood emergencies under P.L. 84-99, practically enables non-Federal and private flood infrastructure owners to defer and ultimately transfer maintenance costs to taxpayers instead of investing in O&M and avoiding flood damages in the first place (Larson 2007). Also, NED policies in combination with the NFIP inadvertently established an informal "standard" for flood protection (100-year flood risk), which is irrespective of local as well as future risks. Homeowners outside of 100-year floodplains that actually face high potential flood risks such as residents in proximity to levees are not required to carry flood insurance, i.e., they are neither properly protected, insured, educated about their flood risk nor accountable (e.g., Paterno vs. State of California case).

Thus, all non-Federal stakeholders are practically absent in today's flood mitigation programs and the problem is aggravated by Federal programs that cannot compensate for this absenteeism. Instead, poorly coordinated Federal policies facilitated risky behavior and have generated a slew of unintended consequences. After the disaster years of 2004 and 2005, the NFIP is theoretically bankrupt and increasingly uninsured people outside of the 100-year floodplain suffer damages from flooding. Still, more people are permitted to settle in high risk flood areas without being educated or adequately protected.

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Section 3 Identification of Trends and Impacts (2006 to 2030)

3.1 Infrastructure

3.1.1 Aging Infrastructure

The levee failures during Hurricane Katrina in 2005 highlighted four significant weaknesses in the current state of national flood protection and other critical infrastructure.[3] First, many of the dams and levees are operating beyond their planned life cycles. In the NID, more than 30 percent of the listed dams exceed their designed lifespan of 50 years with many more reaching it throughout the next 25 years (Lane 2007). The American Society of Civil Engineers (ASCE) estimates that about $10 billion are necessary to address critical deficiencies in *non-Federal* dams over the next 12 years (ASCE 2005).

Second, flawed designs and/or construction make it impossible for some elements of the infrastructure to perform according to their design levels. For instance, USACE used an outdated (and weaker) hypothetical hurricane scenario (1965 Standard Project Hurricane) for designing the Lake Pontchartrain outfall canals (IPET 2007). Third, unforeseen or unaccounted environmental changes can modify and weaken the original design level. The channeling of the Mississippi River caused subsidence and destroyed wetlands along the Louisiana coast (Tidwell 2006). In the New Orleans area the amount of subsidence was underestimated and the loss of elevation left the Inner Harbor Navigation Channel more than 2 feet below the expected elevation (IPET 2007). The loss of wetlands stripped the coastal region entirely of its natural hurricane protection systems.

Finally, flood protection infrastructure falls behind its initial design level when aging and deterioration are not countered by adequate maintenance (IPET 2007). About 95 percent of the Nation's dams fall under the responsibility of states whose dam safety programs are chronically under-funded. Alabama has yet to develop a dam safety regulatory program (FEMA 2006). Less than 5 percent of NID dams fall under Federal responsibility (FEMA 2006). These dams tend to have a significant size and function. They also have a tremendous hazard potential. Out of the 608 USACE-owned dams, the NID classifies 470 dams as having the highest hazard potential. In other words, the majority of USACE-dams has the capacity to inflict catastrophic harm in case of failure (Lane 2007).

Aside from USACE-owned and operated dams and levees, USACE—under the Dam Safety Assurance Program—is also responsible for dams built by USACE but currently under different ownership. Given the substantial pool of infrastructure for which the maintenance responsibility resides with the agency, USACE has to prioritize rehabilitation needs to account for dwindling funds (Lane 2007).

[3] "Critical infrastructure and key resources (CI/KR) include the assets, systems, networks and functions that provide vital services to the Nation. Terrorist attacks on and other manmade or natural disaster could significantly disrupt the functioning of government and business alike and produce cascading effects far beyond the affected CI/KR and physical location of the incident," (DHS 2006: 7).

TABLE 3
REPORT CARD FOR AMERICA'S INFRASTRUCTURE

Infrastructure	Grade	Infrastructure	Grade
Aviation	D+	Rail	C-
Bridge	C	Roads	D
Dams	D	Schools	D
Drinking Water	D-	Security	I
National Power Grid	D	Solid Waste	C+
Hazardous Waste	D	Transit	D+
Navigable Waterways	D-	Wastewater	D-
Public Parks & Recreation	C-	Infrastructure GPA	D

Source: ASCE (2005)

The deterioration of the Nation's infrastructure is a well-known fact (Table 3). Aging infrastructure is a national problem, not one that is unique to USACE or flood infrastructure. To restore the Nation's infrastructure to good conditions, $1.6 trillion are necessary over a 5-year period according to the ASCE (ASCE 2005). However, infrastructure maintenance and upgrading compete with other issues on the national agenda with the consequence that only fractions of authorized funds get appropriated (Carter and Hughes 2006; Tidwell 2006). This creates an ever-increasing backlog of deficient infrastructure. The dilemma for USACE and society as a whole is: Can the Nation sustain its infrastructure and how sustainable is its infrastructure for purposes of disaster management? More importantly, will the current infrastructure protect the Nation from effects of global climate change especially along its coastlines?

3.1.2 Interdependent Infrastructure

Over the past century, advancements in infrastructure and technology greatly improved the effectiveness and efficiency of emergency preparedness and disaster management. Innovations in the information technology (IT) area most notably improved the collection, maintenance, analysis and communication of relevant data. The establishment of clearinghouses, data portals and the National Spatial Data Infrastructure (NSDI) have significantly improved access to and sharing of information (NRC 2007). For instance, the launch of satellites enabled advanced hurricane tracking and forecasting. With the advent of computer technology, it became possible to model natural hazards such as flooding. Today, these models are so sophisticated that they are used to track hazards in real-time and serve as early warning systems. The internet, personal computers, wireless communication and geospatial technology (e.g., GPS [Global Positioning System], spatial decision support systems) allow today's emergency manager to access an abundance of information virtually anywhere, anytime.

Successfully accessing information though requires infrastructure that technocratic societies heavily depend on: electricity, deep-sea fiber optic cables, data servers, cell phone towers and satellites. Lessons from Hurricane Andrew and Katrina as well as from 9/11 repeatedly highlighted the need for interoperable and interchangeable (redundant) systems (Select Bipartisan Committee 2006; Walker 2006). Data, software and documents are crucial for a functioning EOC. However, they need to be mirrored and backed up in different locations and accessible by a multitude of people and devices.

While touching only on issues of emergency communication, the logistics of emergency rescue and response itself presume the functioning of a wider array of infrastructure: energy (gas, electricity, etc.), transportation (airports, roads, bridges, ports, etc.) and health care (e.g., vaccines, antidotes, etc.)—infrastructure essential to effectively provide supplies, shelter and care. In a modern society such as the United States, the continuity of this infrastructure is essential during a crisis. Otherwise, infrastructure failure aggravates the misery of affected populations as seen during Hurricane Katrina.

The United States is particularly vulnerable to such disruptions given an economy that is based on Just-In-Time production and a culture where almost everything is available 24/7. Stockpiling of emergency supplies is not sufficiently practiced at the personal, organizational and institutional level. Surge capacities and redundancies are limited—especially in crucial sectors of health care (e.g., vaccines, personnel), emergency response (e.g., trained emergency personnel, search and rescue teams) or water treatment and water supply.

Overall, society benefits vastly from technology and sophisticated infrastructure. However, a deteriorating infrastructure turns an asset into a hazard. Dams and levees are “good” examples. Added benefits from hydroelectric power generation, provision of irrigation water, flood control and recreation are counteracted by the increased likelihood of dam failure and their potential for catastrophic destruction downstream. Failure of one infrastructure component can trigger cascading failures of other components due to the interdependencies that exist within and among infrastructure sectors (DHS 2006). Such cascading and complex failures can amplify damages exponentially. Generally, these problems receive little attention in hazard planning and mitigation especially at the local level.

3.1.3 Managing Risks

The U.S. Government and DHS recognized the importance of critical infrastructure, their interdependencies and the risk they pose should they fail. Shortly after the inception of DHS, the agency developed the National Asset Database (Moteff 2007a). In 2006, DHS put forward a National Infrastructure Protection Plan (NIPP) that proposed a strategy for assessing and managing risks to ultimately prioritize critical infrastructure (DHS 2006). This strategy tends to focus on specific events (mostly terrorism) and issues of physical protection and security rather than aspects of infrastructure maintenance and upgrading (HSAC 2006).

To improve the protection level of critical infrastructure, the NIPP proposed a new risk management framework (Figure 4) (DHS 2006). According to DHS, this framework outlines the necessary procedures to develop a “comprehensive, systematic and rational assessment of national or sector-specific risk that drives critical infrastructure and key resources (CI/KR) protection activities” (DHS 2006: 29). The framework is designed to incorporate and account for dependencies, interdependencies, shared vulnerabilities and multi-purpose mitigation strategies. It goes beyond the standard approach of assessing each hazard profile separately as was done in the past. It also is the basis for allocating resources depending on an infrastructure’s vulnerability and consequence potential (Moteff 2007b).

The DHS risk management framework determines risk as a function of consequences, vulnerabilities and threats where consequences represent direct and indirect losses; vulnerabilities reflect the likelihood of infrastructure failure; and threats equal the probability of occurrence of a natural or human-induced hazard. While the NIPP attempts to incorporate cross-sector interdependencies, the framework retreats to traditional approaches of assessing risk by using linear and probabilistic models. Probabilistic risk assessments (e.g., fault trees

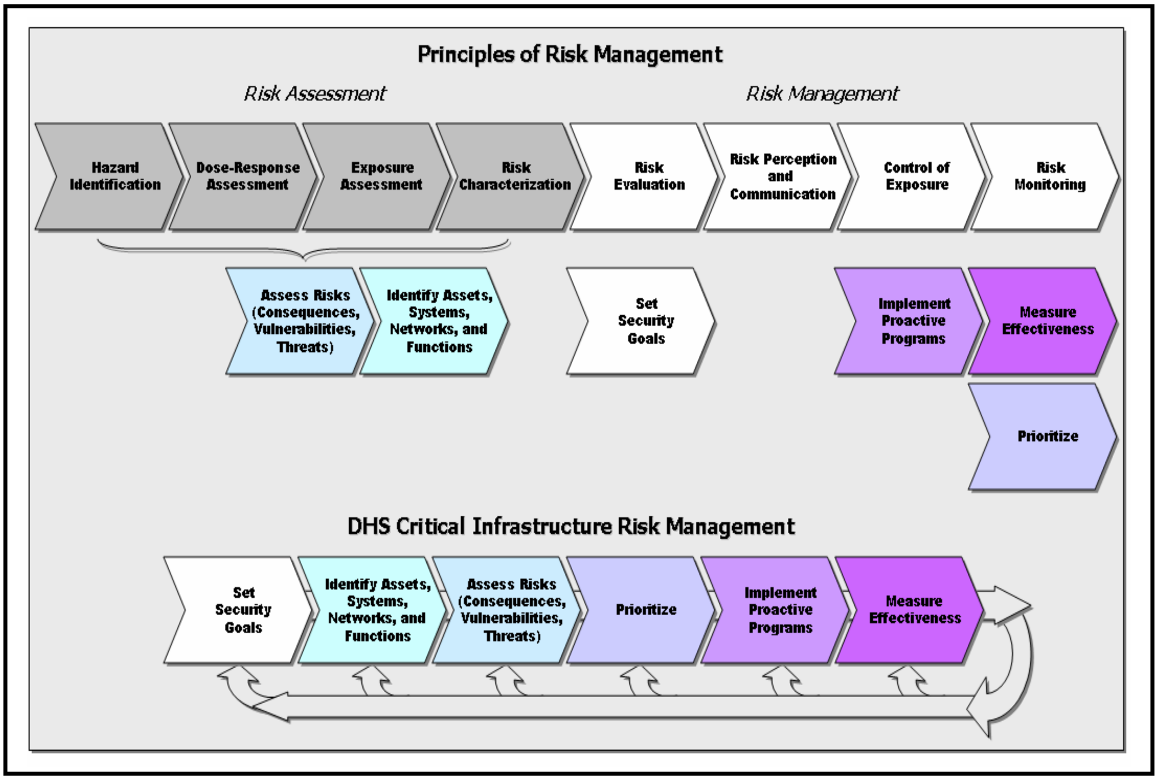

FIGURE 4
COMPARISON OF TRADITIONAL RISK MANAGEMENT FRAMEWORK AND NIPP FRAMEWORK

Source: Yassi et al. (2001)

used by the Nuclear Regulatory Commission) are the preferred tools in engineering and technocentric applications as they try to simultaneously maximize scarce resources (e.g., funding, staff, etc.) and minimize risks (IPET 2007). These tools are inadequate for catastrophic planning and preventing worst case disasters (Clarke 2005). Although catastrophic events produce high consequences, their low probability of occurrence generally does not justify excessive expenditures for their prevention in the public and political eye. Instead, catastrophic emergency planning competes on a daily basis with planning for more prevalent and frequent events. With the exception of terrorism prevention, little or no funding is currently allocated to catastrophic events arising from natural hazards. Thus catastrophic planning has not yet entered emergency management in any meaningful way. The same is true for mitigation efforts to combat global climate change or minimize its affects.

While the NIPP risk management framework reflects traditional probabilistic thinking, the framework can be criticized for its omission of existing risk knowledge and management frameworks. Figure 4 shows a widely accepted framework that is applied in the fields of risk analysis, public safety and environmental health (Yassi et al. 2001). When compared to the NIPP framework, it shows that the starting point of the NIPP framework is security-oriented rather than hazards-oriented. Additionally, the NIPP framework lacks a crucial risk communication and perception component, suggesting an unawareness of societal aspects and the absence of public participation in risk management and the EMS.

In addition to these issues, Moteff (2007b) highlights further points of criticism such as: (a) limited effectiveness of DHS in determining high priority assets; (b) small number of assets for which coherent vulnerability and risk assessments as well as buffer ozone protection plans have been developed, (c) contested allocations of resources to some states and localities, (d) reluctant or non-existing exchange of information between all stakeholders (Federal, public, etc.) and (e) non-uniform regulation of information sharing between operators of critical infrastructure. For instance, public drinking water systems must perform vulnerability assessments and submit the findings to EPA (Moteff 2007b), whereas private dam and levee owners are not subjected to such scrutiny.

With respect to all-hazards emergency management, we suggest that the NIPP not only disregards existing knowledge and risk communication but that it also lacks coordination and integration with Federally mandated (state, local and tribal) mitigation plans under the Disaster Mitigation Act of 2000. This can be attributed to the fairly recent inception of the NIPP as well as to a programmatic separation between DHS and FEMA. Under the Post-Katrina Emergency Management Reform Act, the newly established National Integration Center (FEMA) maintains the NIMS and the NRP whereas the Office of Infrastructure Protection (DHS) administers the NIPP (among others). To assess vulnerabilities, risks, impacts and mitigation strategies, DHS follows principles outlined in the NIPP risk management structure (Figure 4). FEMA procedures, however, comply with the Multi-Hazard Mitigation Planning Guidance under the Disaster Mitigation Act of 2000—called the Blue Book (FEMA 2007). Although the Blue Book considers infrastructure risks there is no reference to critical infrastructure per se. From an emergency management point of view, issues of infrastructure deterioration and interdependencies find little recognition in state, local and tribal emergency and mitigation plans.

Ultimately, the different emphases and procedures between FEMA and DHS hamper a synchronization of efforts to address hazards from ***all*** sources. Natural, technological and human-induced hazards are still treated independently from each other. Their impacts, whether on the environment, people or property, are routinely evaluated as unrelated phenomena without considering a combination of events or cascading failures (FEMA 2006). Facing a future of increased vulnerabilities, it is suggested that DHSs preoccupation with terrorism hazards and their threat to critical infrastructure needs to shift towards more imminent threats—most notably natural hazards and global climate change (see Section 3.2). As seen during Hurricane Katrina, the threat from natural hazards goes beyond their direct impact on lives and properties. The specialization of today's economy and society's dependency on crucial infrastructure (e.g., power) makes modern societies like the United States more vulnerable to natural hazards—despite all investments and technological developments devoted to emergency preparedness and mitigation. Nowadays, natural disasters can trigger a cascade of economic, social, environmental losses depending on where and when they strike. To move to a comprehensive emergency management approach and develop integrated all-hazards mitigation strategies, "parochialism must be put aside and cooperation must prevail before and after an emergency event" (Jenkins 2007: 2).

Guidance could be gleaned from The Infrastructure Security Partnership (TISP), which formulated "a much-needed strategy to develop the level of preparedness necessary for communities to adequately deal with major disasters in today's complex and interdependent world" (TISP 2006: 1). This strategy entails recommendations to overcome the stove-piped management of terrorism, cyber threats, as well as technological and natural hazards separately. The goal of said action plan is to establish regional disaster resilience across all administrative levels of government, private stakeholders and the public.

3.2 Environmental Changes

Why is the consideration of environmental changes important? Global environmental change will modify the spatial distribution of certain types of hazards such as droughts and floods as well as their magnitude and severity. The USACE should anticipate more extreme events with catastrophic outcomes and subsequently more frequent calls to assist in emergency situations.

3.2.1 Today's Hazardscape

The United States suffers the majority of direct economic losses (property and crop losses) from meteorological events such as severe storms, hurricanes, flooding, coastal storm surge, drought and tornadoes (Figure 5). Between 1960 and 2005, the U.S. absorbed more than $467 billion in direct losses (Figure 6). This averages more than $10 billion per year. Hurricane Katrina alone accounted for more than $100 billion in losses. Indirect losses such as declines in tax revenues and productivity, increased unemployment or temporary facility closures are not included in these figures. Throughout the same time period, the human toll from natural hazards is conservatively estimated at about 17,000 casualties and 160,000 injuries. On average, natural hazards kill nearly 400 people and injure about 3,500 annually (Hazards Research Lab 2007).

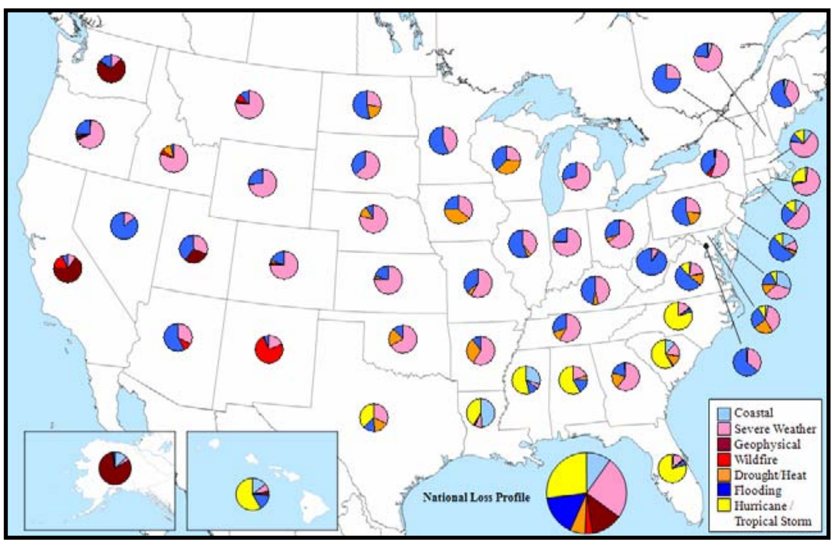

FIGURE 5
DISTRIBUTION OF MONETARY LOSSES BY HAZARD TYPE AND STATE

Data Source: SHELDUS Version 5.1

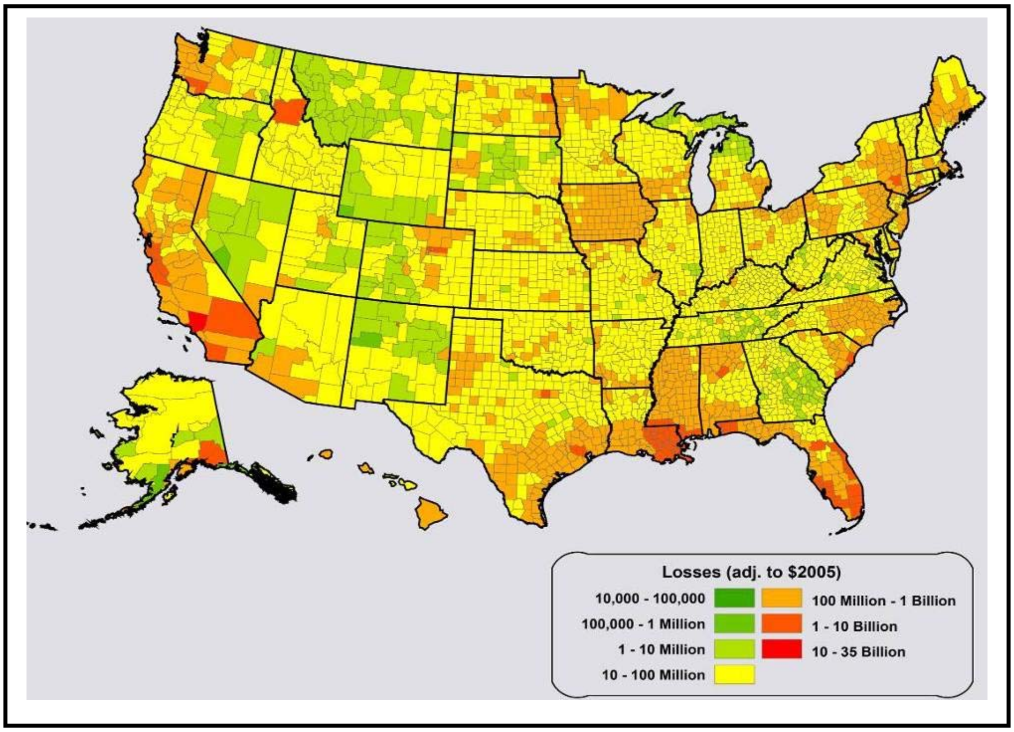

FIGURE 6
CUMULATIVE LOSSES FROM NATURAL HAZARDS, 1960-2005

Data Source: SHELDUS Version 5.1

The spatial distribution of these losses is not uniform across the country. Coastal counties, in particular along the Gulf and Atlantic coast, bear the brunt of losses from hurricanes (Figure 5 and 6). The West coast accumulates damages from earthquakes, landslides, wildfires and rare volcanic activities. The Northeast coast consistently faces large losses from severe winter weather events while the interior U.S. struggles with tornadoes and (largely underreported) droughts. All regions experience flooding and severe storms.

Spatial pockets of extreme losses tend to indicate large catastrophic events such as Hurricane Katrina (Louisiana and Mississippi coast); Mount St. Helens eruption in Skamania County, Washington in 1980; the Loma Prieta Earthquake in the greater San Francisco Bay area in 1989; the great Mississippi flood of 1993; Hurricane Hugo (South and North Carolina) in 1989; or the Northridge earthquake in Los Angeles in 1994. Florida's loss burden stems largely from hurricanes, which hit the state repeatedly during the 1990s and 2000s.

3.2.2 Tomorrow's Hazardscape

It is expected that global climate change will modify the spatial distribution of U.S. hazards as well as their intensity and frequency of occurrence. In the 12 years between 1995 and 2006, 11 of them ranked among the warmest years since the beginning of instrumental temperature recording (IPCC 2007a). The Intergovernmental Panel on Climate Change (IPCC) predicts that the United States will suffer from high temperature extremes and heat waves, increases in droughts (in both intensity and geographic extent) and higher precipitation in the Eastern parts of the country (IPCC 2007a). The IPCC report additionally hints at the possibility of more intense hurricanes but other research disagrees and finds no evidence for an intensification of hurricane activities in the Atlantic Basin (Landsea et al. 2006). In general though, it seems likely to assume an increase in severe weather due to more intense and prolonged precipitation, heat, flood and drought events (Nicholls 2004).

Given their proneness to sea level rise [estimated between 0.18 and 0.59 meters by 2100 (IPCC 2007b)] and in combination with larger future populations, coastal counties are most likely to suffer higher losses from natural hazards than interior counties. Furthermore, their natural protection mechanisms are disappearing with increasing wetland destruction and land development for residential and/or economic purposes (Nicholls 2004). Coastal counties will experience escalating losses as a result of global climate change, deficient resource management and an unrestrained desire by the American population to live along coastlines.

Nature is not always the trigger for catastrophic disasters. In times of terrorism, every element of critical infrastructure (e.g., power grid, dams) represents a potential target for terrorist activities (Cutter et al. 2003b; Flynn 2007). For instance, an attack on a dam or levee could result in catastrophic flooding. Poisoning of water supplies or other elements of the food chain with biological or chemical disease agents could cause unprecedented challenges for the health care system and socioeconomic disruptions (Chalk 2001).

3.2.3 Implications for Emergency Management

With the terrorist attacks on 9/11, the U.S. EMS has been significantly restructured and many resources have been directed towards raising the Nation's resilience to terrorism. Law enforcement and first responder capabilities received improvements. Simultaneously, resilience to natural hazards has been neglected and neither FEMAs capacities nor those of state or local emergency agencies have been strengthened. Instead the opposite happened and FEMA lost much of its operational strength through loss of personnel (institutional brain drain) and organizational restructuring (Harrald 2007).

The disastrous response to Hurricane Katrina forced a reevaluation of the current system and its priorities (Gall and Cutter 2007). Some policies put in place post-9/11 (e.g., Homeland Security Act of 2002) have been subsequently modified or reversed. Statutes enacted by the 109th Congress re-organized FEMA and DHS and clarified their missions and authorities (Bea et al. 2006). The Post-Katrina Emergency Reform Act of 2006 urged DHS to transfer the Preparedness Directorate back to FEMA though with the exclusion of several offices such as the Office of Cyber Security and Communication. The latter became part of the National Protection and Programs Directorate under DHS, which among others also includes the Office of Infrastructure Protection and the Office of Risk Management and Analysis. These changes occurred on March 31, 2007 (DHS 2007b).

Presently, the Nation's capacity to respond to and recover from terrorist attacks or natural hazards is inadequate (Flynn 2007). Preparedness and response capacities differ between administrative levels (local versus Federal) and authorities (FEMA versus U.S. Coast Guard). The tendency to mitigate terrorism through law enforcement and military efforts thwarts the civilian response to natural hazards orchestrated by FEMA. This is likely to hamper a future response to complex emergencies such as a terrorist attack on a dam with subsequent extreme flood damage to lives and properties.

The effective implementation of the NRP as an all-hazards approach where the elements of the emergency management cycle—mitigation, preparedness, response and recovery—receive equal importance, funding and institutional representation has not been achieved. This is of particular importance for USACE, which is one of the few agencies that operate across the boundaries of terrorism and natural hazards. The USACE is responsible for maintaining and protecting critical infrastructure as well as repairing that infrastructure after an event (along other ESFs).

However, the dilemma USACE faces is that it must maintain and operate a deteriorating critical infrastructure with limited resources. At the same time, USACE is responsible for the impacts of that failed infrastructure and must work in tandem with other Federal response agencies to rescue hurricane and flood victims. If this is not corrected in the future, USACE will resemble a reactive rather than a (historically) protective agency. To further explore the implications of U.S. disaster management and assigned USACE responsibilities, we discuss worst-case scenarios in Section 4. These scenarios point to organizational bottlenecks that could be incurred in the future given USACEs current policies, funding and administration.

While environmental changes and structural soundness of essential flood infrastructure are important, future demographic shifts in populations and their implications for future losses from hazards are equally relevant. In fact, many researchers predict human factors to be ***the*** leading contributor to increasing disaster losses (Cutter et al. 2006; Landsea et al. 2006; Nicholls 2004).

3.3 Demographic Shifts

Why is the consideration of future demographics and societal changes important? Because “research shows that societal vulnerability is the single most important factor in the growing damage related to extreme events” (Pielke and Sarewitz 2005: 258). In other words, it is the size, composition and behavior of a population that are the driving factors behind increasing losses. The more people live in hazardous areas, the more extensive planning and response efforts are required by USACE and other emergency management agencies.

Next to the sheer size of a population, socioeconomic and cultural aspects of a population are extremely important. These characteristics directly influence risk behavior and risk perception. For instance, affluent populations tend to be better prepared and recover faster than people living in poverty. With an increasingly diverse population and other major societal changes ahead, emergency management tactics need to acknowledge and reflect diverse socioeconomic conditions in order to provide adequate and effective support before, during and after an event.

3.3.1 Risk-Wise Behavior

According to the projections by the U.S. Census Bureau (2004), the U.S. population will reach 365 million people in 2030, up from 282 million in 2000. More than 50 percent of this population growth will occur in the South, especially Florida and Texas (Table 4). For Florida, this will equal a population increase of more than 12 million people. It is anticipated that Florida will pass New York as the third most populous state (28.7 million people) with a projected 80 percent increase from 2000 to 2030. California and Texas will remain the most populous states in the nation with 46.4 million people and 33.3 million people, respectively (see Table 5).

TABLE 4
PROJECTED REGIONAL CHANGES IN POPULATION NUMBERS FROM 2000 TO 2030

Region	2000 Population Census (in million)	2030 Population Projection (in million)	Percent Change
Northeast	53.59	57.67	5.0
New England	13.92	15.62	2.1
Middle Atlantic	39.67	42.05	2.9
Midwest	64.39	70.50	7.4
East North Central	45.16	48.64	4.2
West North Central	19.24	21.86	3.2
South	100.24	143.27	52.4
South Atlantic	51.77	78.09	32.0
East South Central	17.02	19.90	3.5
West South Central	31.44	45.27	16.8
West	63.20	92.15	35.2
Mountain	18.17	29.91	14.3
Pacific	45.03	62.24	20.9

New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont. Middle Atlantic: New Jersey, New York, Pennsylvania. East North Central: Illinois, Indiana, Michigan, Ohio, Wisconsin. West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota. South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia. East South Central: Alabama, Kentucky, Mississippi, Tennessee. West South Central: Arkansas, Louisiana, Oklahoma, Texas; Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming. Pacific: Alaska, California, Hawaii, Oregon, Washington

Not only will Florida, California and Texas experience significant population growth, these three states will also be home to nearly half of the Nation's total population. Consequently, many more people will be in the path of hurricanes, tornadoes, flooding, earthquakes, landslides and other hazards, independent of—and potentially in addition to—adverse effects from global climate change. This significantly increases the potential for loss no matter what the level of preparedness at the Federal, state and local administration.

TABLE 5
STATE POPULATIONS ACCORDING TO 2000 CENSUS AND 2030 PROJECTIONS

State	2000 Census (in million)	2030 Projection (in million)	2030 Projection Rank	Change 2000 to 2030 (in percent)
Alabama	4.45	4.87	24	9.6
Alaska	0.63	0.87	46	38.4
Arizona	5.13	10.71	10	108.8
Arkansas	2.67	3.24	32	21.2
California	33.87	46.44	1	37.1
Colorado	4.30	5.79	22	34.7
Connecticut	3.41	3.69	30	8.3
Delaware	0.78	1.01	45	29.2
District of Columbia	0.57	0.43	51	-24.2
Florida	15.98	28.69	3	79.5
Georgia	8.19	12.02	8	46.8
Hawaii	1.21	1.47	41	21.0
Idaho	1.29	1.97	37	52.2
Illinois	12.42	13.43	5	8.2
Indiana	6.08	6.81	18	12.0
Iowa	2.93	2.96	34	1.0
Kansas	2.69	2.94	35	9.4
Kentucky	4.04	4.55	27	12.7
Louisiana	4.47	4.80	26	7.5
Maine	1.27	1.41	42	10.7
Maryland	5.30	7.02	16	32.6
Massachusetts	6.35	7.01	17	10.4
Michigan	9.94	10.69	11	7.6
Minnesota	4.92	6.31	20	28.2
Mississippi	2.84	3.09	33	8.7
Missouri	5.60	6.43	19	14.9
Montana	0.90	1.04	44	15.8
Nebraska	1.71	1.82	38	6.4
Nevada	1.20	4.28	28	114.3
New Hampshire	1.24	1.65	40	33.2
New Jersey	8.41	9.80	13	16.5
New Mexico	1.82	2.10	36	15.4
New York	18.98	19.48	4	2.6
North Carolina	8.05	12.23	7	51.9
North Dakota	0.64	0.61	49	-5.5
Ohio	11.35	11.55	9	1.7
Oklahoma	3.45	3.91	29	13.4
Oregon	3.42	4.83	25	41.3
Pennsylvania	12.28	12.77	6	4.0

TABLE 5 (continued)
STATE POPULATIONS ACCORDING TO 2000 CENSUS AND 2030 PROJECTIONS

State	2000 Census (in million)	2030 Projection (in million)	2030 Projection Rank	Change 2000 to 2030 (in percent)
Rhode Island	1.05	1.15	43	10.0
South Carolina	4.01	5.15	23	28.3
South Dakota	0.75	0.80	47	6.0
Tennessee	5.69	7.38	15	29.7
Texas	20.85	33.32	2	59.8
Utah	2.23	3.49	31	56.1
Vermont	0.61	0.71	48	16.9
Virginia	7.08	9.83	12	38.8
Washington	5.89	8.63	14	46.3
West Virginia	1.81	1.72	39	-4.9
Wisconsin	5.36	6.15	21	14.7
Wyoming	0.49	0.52	50	5.9
United States	**281.42**	**363.58**		**29.2**

Source: U.S. Census Bureau (2005)
(available from http://www.census.gov/population/www/projections/ popproj.html).

The continued development of floodplains, coastal areas, as well as increasing urbanization, increases the population exposure to natural as well as technological disasters. Extrapolating today's risk-taking behavior into the future means not only more Americans but more Americans in harm's way. This will expedite human and economic losses from disasters.

These population trends combined with anticipated climate changes—i.e., more frequent extreme events, sea-level rise, etc.—makes for a sure recipe of escalating losses and events of catastrophic dimensions. Therefore, a well-orchestrated and effective EMS will be even more relevant than today. To counteract this development and to keep losses at bay, USACE as well as other emergency management partners will have to increase the effectiveness and efficiency of their emergency management operations. Without expanding agency capacities, the strain on agency resources (e.g., missions, personnel, funding, equipment, mitigation projects, etc.) will significantly increase in comparison to today's level of USACEs involvement.

Expanded response and recovery efforts alone will not suffice. Population gains in high-risk states as well as in high-risk areas such as urban places heighten the pressure on already stressed resources. And this is not only the case in highly populated places. States such as Nevada and Arizona are estimated to experience dramatic changes. Both are scheduled to double their population by 2030 (see Table 4), which will require significant administrative efforts to keep up with natural resource demand (water supply, energy, land) and infrastructure needs (irrigation, roads, schools, hospitals).

This has serious implications for the Nation's ability to respond to emergencies. Today, the Nation's infrastructure seems to operate at a breaking point with virtually no surge capacity or redundancies. To keep up with population growth, maintain quality of life, ensure safe living conditions and to facilitate emergency response rather than complicating it, the Nation's infrastructure system and its elements crucial for emergency management require significant maintenance and improvement efforts. New Orleans's levee failures were a prominent example of what is to come if infrastructure issues are neglected and how they can dramatically aggravate emergency situations or actually create them. To mend the Nation's infrastructure, engineering standards will have to be reinstated and enforced (e.g., dams, building codes). In other areas (e.g., levees), new standards will have to be developed. In regard to EMS and infrastructures, well-known deficiencies (e.g., lack of interoperable communications systems, unfamiliarity with NIMS, etc.) need to be eliminated to improve effectiveness and increase emergency management capacities. If the Nation's critical infrastructure and EMS cannot keep up with population growth, the country's response capacity will decline and be accompanied by catastrophic consequences.

However, it is not the responsibility of the Federal government to completely shoulder the burden of emergency response due to the antecedent risk taking behavior on the part of individuals and state and local governments. Reducing the dependency of private and local authorities on Federal aid by promoting hazard mitigation must become a priority for the Nation. More importantly, individuals and local governments should be held responsible for their risky decisions that put people and infrastructure in hazardous locations. USACE, FEMA, DHS and other Federal emergency management agencies cannot undo Federally sponsored risk behavior (e.g., development of floodplains) but the agencies could do their best to redraft important Federal programs (e.g., NFIP, disaster declarations, etc.) to enhance personal responsibility of at-risk populations and to promote and reward risk-wise behavior.

3.3.2 Risk Perception

Not every segment of the population will be able or capable to assume such responsibilities. Vulnerable groups of the population—e.g., low-income groups, female headed households, minorities and the elderly—will not be able to mitigate risk. Many will have to accept risks in order to find affordable housing, employment and more. The size of these vulnerable groups is anticipated to increase in the future and much of this increase will happen in states like California, Texas and Florida. Hence, there will be significantly more vulnerable people in highly hazardous areas.

Contributing factors to this trend are the rapid growth in Hispanic populations[4] and in the elderly. In 2030, one-fifth of the Nation's population will be Hispanic in contrast to today's one-eighth (Figure 7). More significantly, every other person added between 2000 and 2030 (total increase: 83 million) will have Hispanic roots. As a proportion of the total, non-Hispanic Whites will decline from 68.7 percent in 2000 to 57.5 percent in 2030 while all other ethnic and racial groups increase their demographic share.

[4] Three factors contribute to proportional shifts in the demographic make-up of the United States: differential fertility, net immigration and age distributions among the racial and ethnic groups (Day 1996; Shrestha 2006). Higher fertility rates and net immigration levels boost the proportion of people of, for example, Hispanic or Asian origin whereas an increase in mortality and lower fertility rates slows the growth of the non-Hispanic White population. According to Day (1996), the Asian and Pacific Islander population is likely to be the fastest-growing race/ethnic group exceeding 2.5 percent per year. By 2030 the Asian population will have nearly doubled in size.

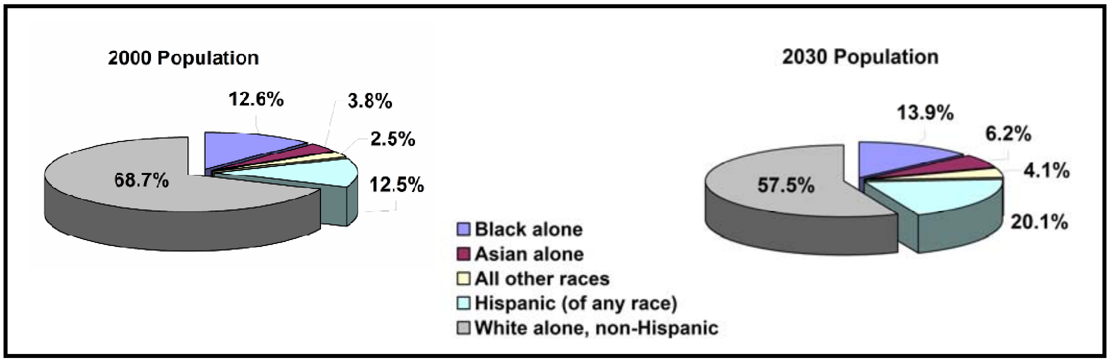

FIGURE 7
POPULATION BY RACE AND ETHNICITY

Source: U.S. Census Bureau (2005)
(available from http://www.census.gov/population/www/projections/popproj.html).

This has tremendous implications for USACE and other emergency responders: In the past, many immigrants settled in gateway cities such as New York, Miami, Los Angeles and Chicago or other places where peer communities exist that can help the newcomer with housing and employment. Today, many move to suburbia and small cities in the mid West and the South (Hirschman and Massey forthcoming). Lack of social networks, limited access to preparedness information (e.g., language barrier, internet illiteracy) and an unfamiliarity with locally prevalent hazards cause minorities and other social less integrated groups to underestimate their risk and level of exposure. This problem is aggravated by the fact that at the same time these groups overestimate their ability to cope with the event (Tierney et al. 2001).

The elderly tend to exhibit patterns of risk underestimation as well. Often times they move into retirement communities where they are not accustomed to local hazards and standard preparedness procedures. This leaves many retirees unaware and unprepared towards the risk they are facing. The retirement of the Baby Boomers over the next 25 years will significantly increase this segment of the population. The percent of people 65 and older will rise from 12.4 percent of the total population in 2000 to 19.7 percent in 2030. States that will triple their elderly population include: Alaska, Arizona and Nevada. Many other states such as California, Florida and Texas will more than double their elderly population. Florida will continue as the preferred state for elderly retirement (Florida: 4.96 million, California: 4.69 million, Texas: 3.11 million) (U.S. Census Bureau 2005). Thus, Florida and its emergency management personnel will face an ever increasing elderly population that is underestimating the threat and overestimating their ability to cope. This development should be reflected in the design of preparedness and risk communication strategies to increase the resilience of vulnerable groups.

The degree of vulnerability depends not only on age or race/ethnicity. It is also driven by other factors such as level of education, income, socioeconomic status (e.g., political power), gender, homeownership, occupation, family structure[5] (e.g., number of dependants, marital status), dependence on social services, special needs and more (Cutter et al. 2003a; Cutter et al. 2006). What it comes down to is availability and access to resources that buffer the impact of hazardous events and enable speedy recovery. As stated previously, many segments of the population lack such resources leaving people ignorant to the threat and/or unable to take precautionary steps.

The introduction of personal responsibilities into the management of hazards could adversely affect these populations and even further increase their vulnerability by removing Federal assistance, limiting eligibility and so forth. Under Executive Order 12898, USACE and all other emergency management agencies have to ensure that minorities and low-income groups will not be disproportionately affected by shifting responsibilities, reformulated Federal policies or the re-distribution of emergency management and mitigation funds. To avoid transferring emergency management costs to the most vulnerable groups, USACE and its partners need to proactively plan for the upcoming environmental and social changes. Simply shifting the burden of loss is not a sustainable strategy. Instead USACE should foster the development of mitigation programs that counteract the misperception of risks and design tailored preparedness strategies that account for different needs and capabilities within the Nation's population.

3.3.3 Risk Communication

Communicating risk is a first step towards counteracting misconceptions of local hazards, their occurrence frequencies and potential impacts. It is a common fallacy though to assume that information will automatically lead to action (Pielke 1999). It is not the lack of information that – in the eye of emergency management personnel—leads to "wrong" decisions. Preparedness decisions are influenced by a variety of factors such as message content, message source, sociodemographic characteristics of message recipient and so forth. Preparedness decisions rarely follow the simple principles of rational choice where perfect knowledge, logic and foresight guide the decision-making process. Years of research support the fact that decision makers at all levels (personal to Federal) choose actions based on limited knowledge, competing demands and use a short planning horizons(Lindell et al. 1997; Lindell and Perry 2004).

To effectively communicate risk and trigger precautionary measures the following five stages are crucial on the receiver side: attention, comprehension, acceptance, retention and action (Lindell and Perry 1992). Communicating risk does not equate to understanding risk. For example, the widely used term of 100-year flood risk is not understood by the general public. The probabilistic concept of this term is lost on most people, who actually interpret this risk statement as being exposed to floods once within 100 years (Lindell et al. 1997; Lindell and Perry 2004).

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[5] The growth in numbers and the increasing proportion of elderly influences the dependency ratio, i.e., how many children (0 to 17 years) and elderly (65 years and over) there are for every 100 people of working age (18 to 64 years). The dependency ratio will rise from 61.6 in 2000 to 76.1 in 2030. With the children dependency ratio remaining at a constant level (41.5 in 2000, 41.5 in 2030), all of the increase in the total dependency ratio is from increasing elderly. An increased dependency ratio means that the combined income of the existing work force has to maintain more people than before (e.g., those already retired and on social security and Medicare), which means smaller paychecks (more social security withheld) at present and no guarantee of the same level of social security support when the present workforce reaches retirement age.

The acceptance of issued information depends on the information source and the sociodemographic characteristics of the target group. Marginalized groups tend to rely and trust their peer community rather than local officials. Local emergency officials have to reach out to these communities and understand their language, risk culture and coping capacities to effectively mobilize these groups in case of an emergency. The lack of resources (e.g., transportation, money, access of information, knowledge of shelters, adequate response behavior, etc.) in combination with care-taking responsibilities (e.g., of grandchildren, sick relatives, pets, etc.) or other restrictions (e.g., probation, criminal prosecution, etc.) significantly reduce the ability to heed warnings and take proactive steps. As seen during Hurricane Katrina, many residents had no option but to stay at home and ride out the storm or relocate to shelters of last resort (the Superdome).

To achieve acceptance, retention and ultimately action depends also on the message itself (e.g., repetition, information channels, specificity). Research indicates that messages that include clear and concise information on the severity of the event, its impact and instructions on what to do (e.g., evacuate, shelter location, etc.) are most effective (Tierney et al. 2001).

3.3.4 Evacuation Behavior

Households, businesses, public officials—every decision-maker "favor easy and inexpensive mitigation measures" (Mileti 1999: 148). As a result, there are many constraints that impede the mitigation of risk. In the case of an emergency, for example, the elderly tend to be more reluctant to evacuate than other age cohorts. Out of the (at least) 727 fatalities in the larger New Orleans area, 70 percent were elderly (70 years and older) (IPET 2007). Reluctance to leave can stem from poor health conditions (e.g., disabilities, care of sick spouse), dependence on public transportation, underestimation of risk, limited financial resources, pet ownership, dependence on social security and other factors. Furthermore, many elderly live in retirement homes or care facilities. This externalizes their evacuation decision and makes them dependent on evacuation assistance and adequately equipped shelter facilities that are able to care for patients and maintain satisfactory levels of care throughout the disaster period.

The same reluctance or inability to evacuate occurs in other groups as well and is largely driven by the lack of resources and alternatives. To overcome the impediments of individual socioeconomic conditions, the Nation's evacuation system needs to be adjusted. Currently, the system is based on evacuation by car and seeking shelter in hotels or at friends and relatives. The system relies heavily on personal responsibility and personal resources. Hurricane Katrina exposed the necessity to plan and care for the old, the sick, the immobile, the poor and pet owners. Although the issue of transporting and evacuating pets has been addressed in the Post-Katrina Emergency Reform Act, more important issues such as the evacuation and sheltering of disadvantaged groups remain unresolved and continue to be a source for catastrophic human losses and suffering.

As seen after Hurricane Katrina, catastrophic events combined with a lack of large-scale evacuation, sheltering and recovery policies can initiate long-term demographic shifts. Many of Hurricane Katrina victims, especially those who were African American and poor have permanently relocated (not all of their own free will), creating the largest diaspora in U.S. history (Frey and Singer 2006).

Section 4
Scenarios

The three scenarios that follow exemplify the interplay of the natural, technological and human systems. The scenarios range in character from very likely events that have not yet happened (e.g., Sacramento levee failures, New York City hurricane) to events that could happen but are less probable (e.g., dam failure in the Columbia Basin). All scenarios share the fact that catastrophic outcomes are a result of shortcomings in the social and technological systems without being driven by record-setting natural events. Thus, societal choices and developments set the backdrop for the selected scenarios and the potential disasters waiting to happen.

4.1 Hurricane in New York Metropolitan Area[6]

Following New Orleans and Miami, New York is perhaps the next most vulnerable American city to hurricanes. A Category 1 hurricane with wind speeds from 75 to 95 miles per hour could cause considerable damage to the region's high-rise buildings, bridges and power infrastructure. Storm surge from a Category 1 storm would inundate most of the south shore of Long Island and the northern shore of Great South Bay, lower Manhattan and portions of Jersey City and Bayonne. All three of the region's major airports, La Guardia, Kennedy and Newark Liberty would be underwater. There would be more than 8 feet of water at the entrance to the Lincoln Tunnel during a Category 1 storm, cutting off vehicular traffic, isolating Manhattan. The underground subway and rail tunnels would be flooded indefinitely causing transportation disruptions not seen before in the city's history. For a Category 3 storm, the surge would rise to 13 feet or more (Figure 8). All of the water in the tunnels and subway would need to be pumped out once the power is restored.

The storm surge would create an environmental nightmare in Newark Bay and along the Kill Van Kull submerging oil storage and chemical facilities. Contaminated water (from both chemicals and saltwater intrusion), sewage leaking directly into New York Bay and hazardous debris would litter the landscape. Dysentery and potential cholera outbreaks would not be far behind. The Staten Island landfill, once touted as the world's largest, would not be able to handle all the debris from the clean-up of the hurricane-affected area.

Medical facilities within the region would be stressed and unable to handle any additional mass casualties. In addition to flood and/or wind damage to the buildings, the inability of staff to get to work and the loss of power as back-up generators stop because of lack of fuel would impede the provision of medical care. The inability of the Port Authority of New York-New Jersey to maintain functionality and the severe damage to roads and bridges would limit any deliver of fuel oil to these critical care facilities for days, if not weeks. Most of the public and private buildings within the storm surge areas would be flooded and their mechanical systems (normally located in basements) would have to be replaced. Losses would be in the hundreds of billions of dollars.

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[6] Based on U.S. House of Representatives Armed Services Committee Briefing by Susan L. Cutter, "Preparing for and Responding to Natural Disasters," November 1, 2005.

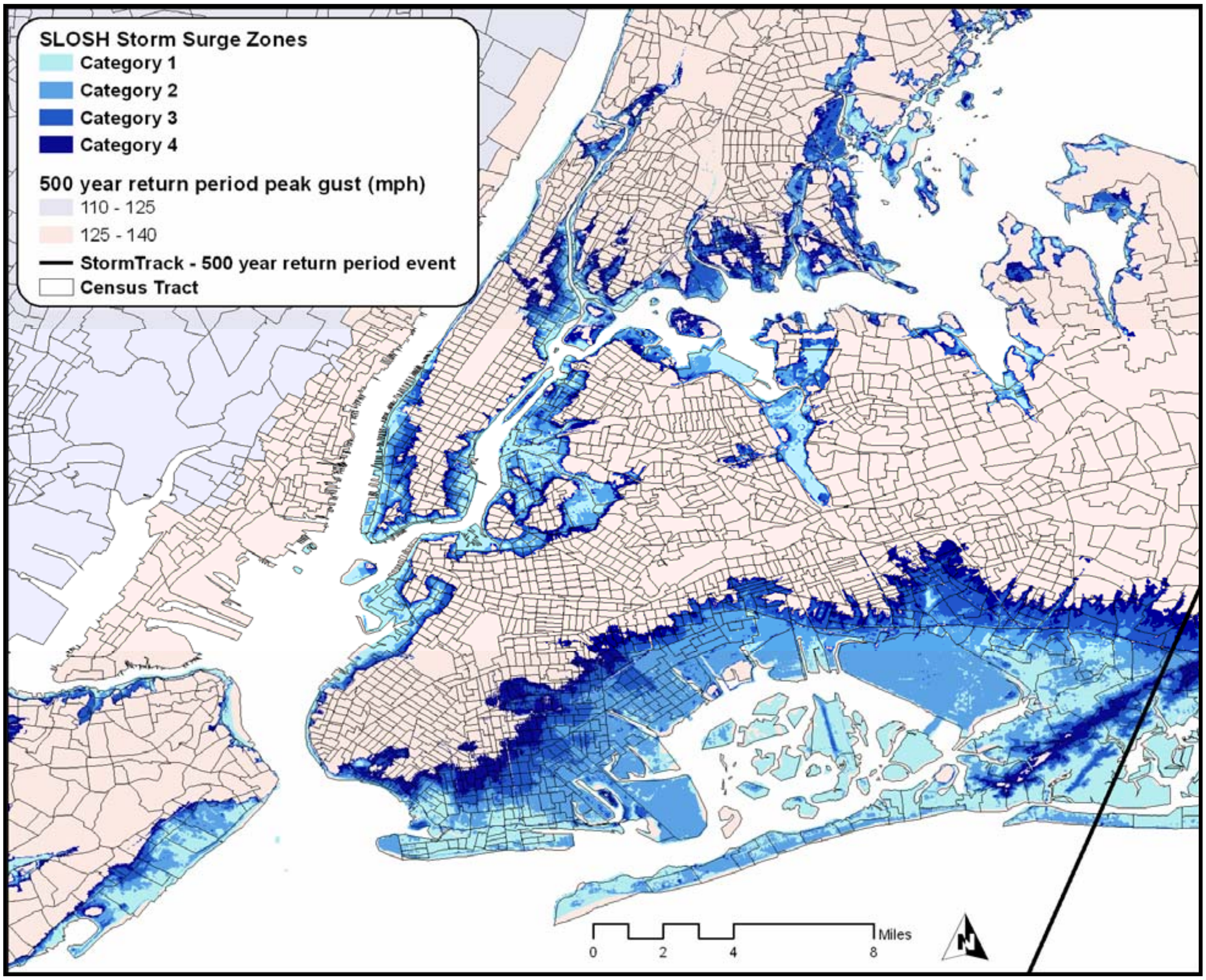

FIGURE 8
ANTICIPATED SURGE EXTENT DEPENDING ON STORM STRENGTH

Source: NOAA (2006)

(available from http://www.nysgis.state.ny.us/gisdata/).

4.1.1 Sensitive Populations

More than 11.5 million people live in the New York metropolitan area and in New York City alone, emergency management officials predict that in a Category 4 hurricane, more than one million people will have to evacuate their homes due to the flooding potential and of these, nearly one-fourth will seek public shelters placing strains on emergency services, public transportation and roadways (NRC 2007).

Even before the storm, evacuation nightmares will occur as residents of Long Island try to flee with major traffic snarls on the Long Island Expressway, on the bridges and tunnels off of the island. New York City has over 2,000 bridges and tunnel connecting the four island boroughs (Jacob et al. 2007) many of which would have to be closed before the arrival of the storm due to high winds and danger of flooding. The Long Island Railroad would be packed with commuters going into Manhattan, but then where? The evacuation of low-lying areas could take days. The sheltering in place (an alternative to evacuation) would require that people not be in top floors of tall buildings (subject to wind damage), but high enough to be out of the storm surge. More than half of the residents of Queens, the Bronx and Hudson County in New Jersey do not speak English at home, so warning messages and guidance to residents would need to reflect the multi-ethnic, multi-racial society. Warnings would have to be broadcast widely in at least a dozen languages. Providing transportation for evacuees without cars to safer locations would use all the available public transportation, school buses and taxis in the entire metro region. Long-term sheltering needs for more than a million people would trigger a "not in my backyard" reaction among the least affected communities. Since many New Yorkers do not drive or own automobiles, the suburban landscape would be difficult to navigate for basic needs—food, water, medicine, employment.

Elderly residents could be trapped in their high rises with little food or water and no power for days if not weeks after the hurricane passed. In the Bronx and Kings County more than one-fourth of the residents have disabilities. With the power grid affected, heat exhaustion (in the late summer) could add to the casualty rate especially among the poor and elderly. If the hurricane was a late season storm, the onset of cold weather (and lack of heat) could result in hypothermia among elderly residents.

4.1.2 Response and Recovery

The response to the hurricane would require heroic coordination among three states—New York, New Jersey and Connecticut—at least eight counties and countless cities and towns. Despite mutual aid agreements most places would be on their own and unable to communicate with one another. This is especially true for people on Manhattan Island and Long Island. In fact, in a Category 2 storm Manhattan Island itself could be split into two islands along Canal Street (Jacob 2000). Local, state and Federal response would be compromised by the inaccessibility of the affected area—at least in the short run (several weeks).

The September 21, 1938 hurricane decimated many Long Island communities and changed the physical landscape of the island itself creating Shinnecock Inlet and enlarging Moriches Inlet (Mandia 2007). Modeled impacts of the 1938 hurricane track onto today's environment suggests property losses of about $76 billion and business interruption losses of about $10 billion for the selected study area[7] (Figure 9). According to the model about 50,000 people would require temporary shelter and more than 215,000 households would be displaced out of the study area's population of almost 25 million. Global warming and sea level rise have made this scenario more plausible and with the increased density and vulnerability of the region's residents, a major tropical storm hitting New York becomes more realistic every hurricane season. Utilizing the same study area as for the 1938 hurricane but with landfall moved to western Long Island produces devastating outcomes (Figure 10). For this study area, the model estimates about $347 billion in property losses and an additional $41 billion in business interruption losses. Debris removal would require more than 1.4 million truckloads (at 25 tons per truck). The severity of the destruction would diminish the availability of hospital beds to 14 percent (13,254 beds out of 92,270). About a third of essential facilities (EOCs, fire stations, hospitals, police stations and schools) would sustain at least moderate damage of more than 50 percent. Overall more than

[7] The study area comprises 21 counties in New Jersey, 14 counties in New York and the entire state of Connecticut.

330,000 people would require sheltering and a staggering 1.3 million households would be displaced.

Ultimately, a major hurricane affecting the New York City metro area would create record-setting devastation. Rescue, response and recovery personnel would face extreme challenges stemming from an unprecedented combination of physical devastation, infrastructure break-downs and environmental contamination affecting a densely populated urban setting.

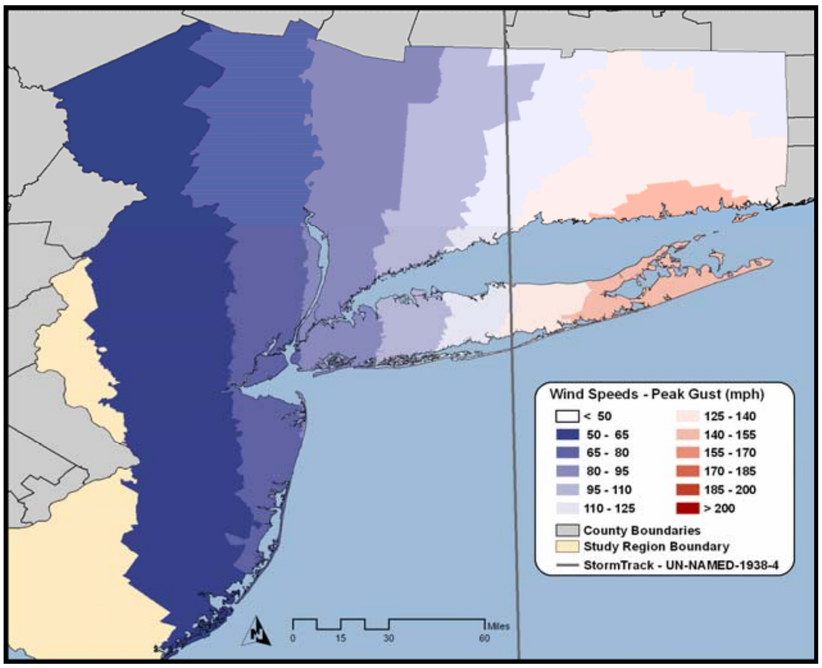

FIGURE 9
WINDFIELD MODEL OF 1938 HURRICANE
Source: HAZUS-MH MR2

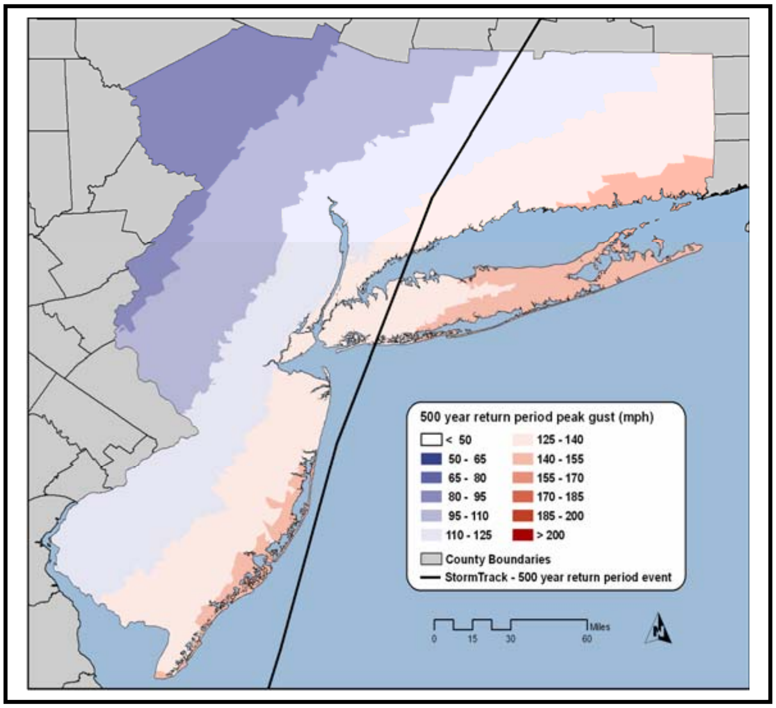

FIGURE 10
MODEL OF 500-YEAR STORM EVENT
Source: HAZUS-MH MR2

Discussion questions:

1. The existence of bottlenecks within the transportation networks and the dependence of large segments of the population on public transportation have strong implications for the design of evacuation plans for the larger New York metropolitan area. It is therefore important to ask when and how will evacuation decisions be made?

2. The importance of infrastructure (e.g., water, ice, transportation, etc.) to facilitate response and recovery is undisputable. How will USACE coordinate the restoration of infrastructure and its involvement in the restoration process itself?

3. The hotel infrastructure will not be able to house all evacuees. When and where will the remaining evacuees and evacuees without the financial resources obtain shelter?

4. The impact of an approaching storm can be mitigated through advanced preparedness efforts. What resources will be requested prior to landfall and how will the resources be coordinated?

5. The NIMS outlines the Nation's unified approach to incident management but it is not yet fully implemented at many level of the EMS. How will USACE coordinate its mission assignments with various Federal, state and local governments as well as the Red Cross and other volunteer organizations?

6. Continuity of operations plans is crucial to maintain the functionality and responsiveness of the agency. How many of USACE and other agency staff will be affected by the hurricane? What USACE resources will be affected by the event?

7. Given that much of DHS funding has been channeled into terrorism and maritime preparedness, what is the current preparedness level of New York City, New York State, USACE and other Federal agencies to respond to a hurricane?

8. The events of 9/11 highlighted the importance of ferries and boats in evacuating people from Manhattan. In the aftermath of a hurricane could boat and barge capabilities be used to ship supplies to Manhattan and Long Island?

9. The size of New York's population requires the quick and orchestrated influx of huge quantities of commodities to ensure the survival of the affected population. How can the USACE help restore the major airport and ports infrastructure to facilitate response and recovery operations?

10. Given the density of the built environment in the region, what are the short and longer-term implications of the debris removal and disposal? What are the environmental consequences and the social consequences for communities that provide disposal sites?

4.2 Levee Failures in the Sacramento-San Joaquin Delta Region, California

It does not take much to flood the Sacramento-San Joaquin Delta and the odds are high that it will happen in the future, just as it has in the past (Figure 11). The City of Sacramento, located at the confluence of the American and the Sacramento Rivers, has the lowest flood protection level compared to other river cities such as New Orleans (250-years), Omaha (250-years), St. Louis (500-years) or Kansas City (500-years). Current infrastructure protects residents only for 85-years of flood events (DWR et al. 2006).

Some of the levees date back to the early 1900s when levees were first constructed to increase stream flow and flush mining sediments. Today in the absence of these sediments, many levees suffer from severe erosion problems along with damage from animal burrowing, settling, cracking, degradation of natural berms and vegetation growth (Harder 2006). Many newer levees have design deficiencies and were constructed based on inadequate techniques and standards thus making them prone to under-seepage and other foundation weaknesses. Perhaps more importantly, not all the levees in the region were designed, constructed or maintained by USACE. The result is a system of levees (some public, some private) in varying states of disrepair, which sets the stage for a potential failure at any moment (Figure 12).

Riverine flooding is common for the Delta region between November through March and intensified by saturated soils after prolonged rainfalls or snowmelt (AMEC Earth & Environmental Inc. and The Hazard Mitigation Technical Assistance Partnership Inc. 2004). In addition, local surface run-off is high because of the area's level of urbanization and the low permeability of predominant peat soil (Harder 2006).

For the City of Sacramento a 200-year flood event is among its worst-case scenarios. It would overwhelm the flood control system entirely and numerous levee breaches along the approximately 1,600 miles of project levees and 700 miles of local Delta levees would be inevitable. The California Department of Water Resources has recently developed flood maps based on a hypothetical 200-year flood scenario. The floodwaters would presumably cause three levees to fail—one north along the Sacramento River close to the international airport, another further south close to the Garcia Bend in the Pocket Area and a third east of the city along the American River. Vast areas of Sacramento would be flooded including downtown Sacramento, the State Capitol and the campus of California State University-Sacramento. Neighborhoods such as the residential Pocket Area would experience 6 to 15 feet of flooding and in some areas even more.

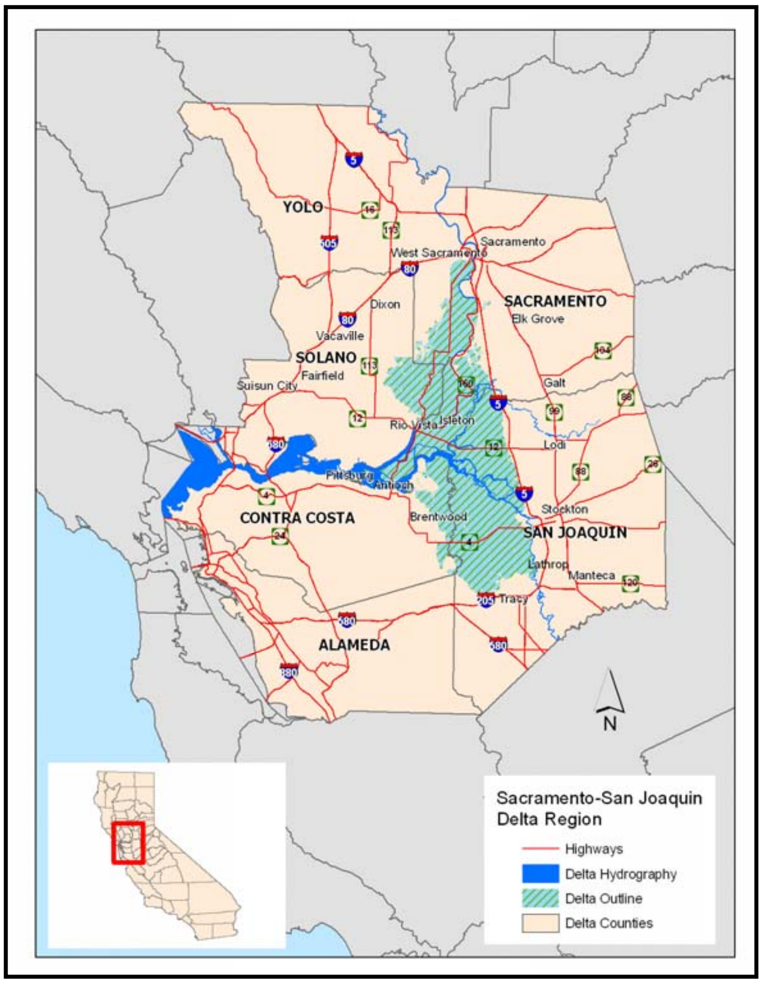

FIGURE 11
OVERVIEW OF STUDY AREA

Source: Burton and Cutter (2007)

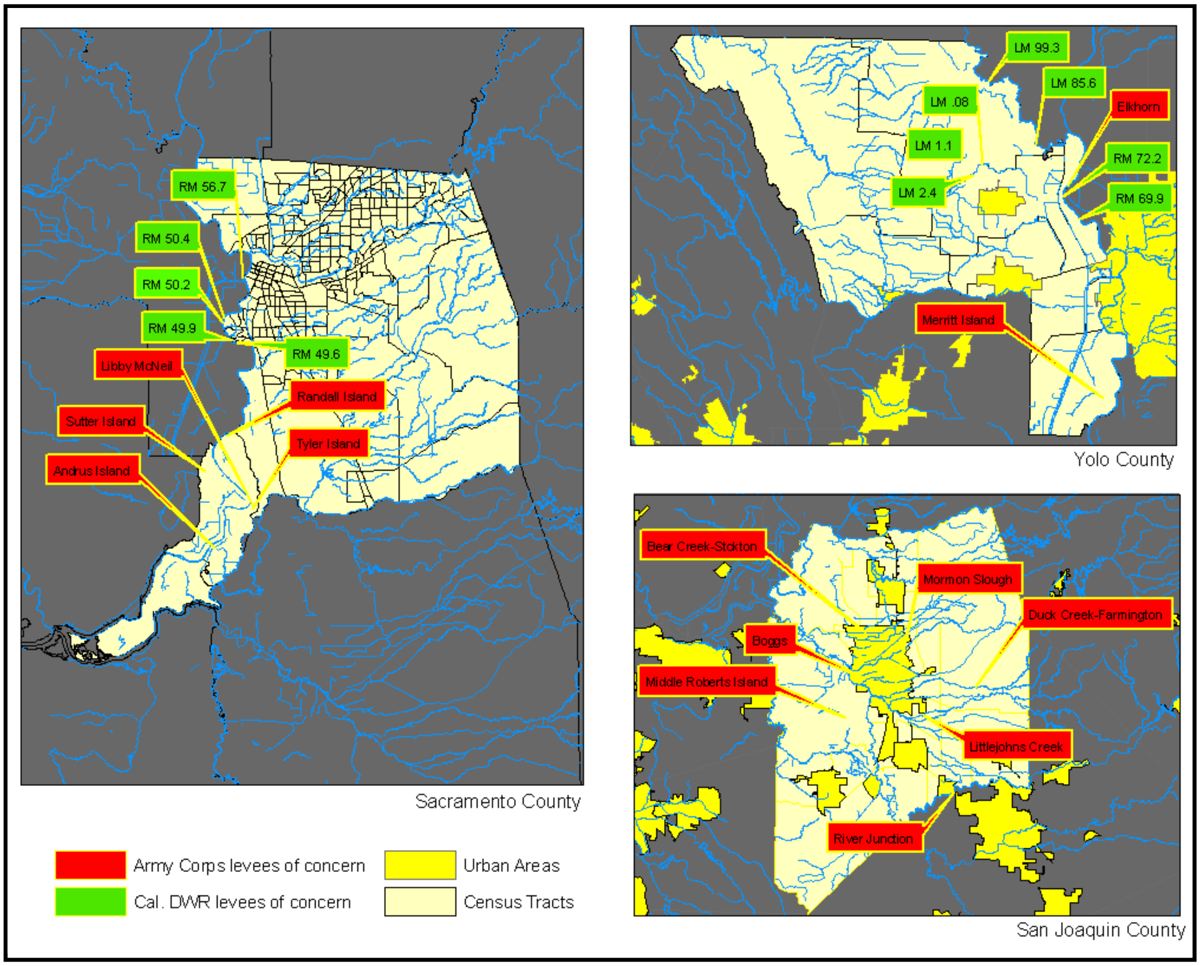

FIGURE 12
LEVEES OF CONCERN IN DELTA AREA

Source: Burton and Cutter (2007)

4.2.1 Response and Recovery

It is anticipated that 9 fire stations would be inundated by 4 feet of water or more. Also, 38 power substations including 3 high voltage substations, 16 wastewater pump stations, 1 water plant and 2 airports would be under water. The Sacramento International Airport would potentially see 13 feet of water. The direct losses are estimated at $13 billion and the net fiscal impact at $15 billion. Much of Sacramento's critical infrastructure would be effected (DWR et al. 2006). Thus, much of the city would be without power and first-responder capabilities.

Evacuation routes can become impassable within 30 minutes to a few hours making it impossible to evacuate by car (Beckner 2005). In many areas, the only alternative is escaping to higher grounds such as rooftops. Many residents could get trapped in their attics if they do not have hatches or pre-positioned tools to cut through the roofs. Based on lessons from Hurricane Katrina, casualties would likely exceed 1,000 given flood depths of 15 feet and more.

According to floodplain population modeling by AMEC Inc. (2004) more than half of the city's population lives in flood-protected zones or floodplains (235,000 out of 450,000 people). These people can only get out if they receive evacuation orders in time, comply immediately or receive timely assistance. Night-time levee failures would pose the greatest threat since many residents would be asleep and would not receive evacuation orders and details by radio and television. The city's reverse 911 system can only reach 10,000 landlines in 10 minutes (Beckner 2005). It would take almost two hours to reach half of the city's residents at risk.

It is assumed that city officials would close and brace the city's floodgate on Northgate Road. The residents of nearly all mobile-home parks would most likely receive mandatory evacuation orders. However, many residents of the North Sacramento Mobile Home Park are 55 years and older—some with serious medical conditions and limited mobility. Thus, the concerted evacuation of the elderly and the ill through regional transit buses and buses outfitted for the disabled is a similarly daunting task as it was for New Orleans. Only advanced evacuations would make it feasible to rescue these highly vulnerable populations. Such advance notice may not be possible, especially if the levee failures are due to seismic shocks rather than excessive stream flow.

Burton and Cutter (2007) developed a levee breach scenario for the region south of Sacramento. They assumed breaches along USACE as well as California Department of Water Resources levees of concerns (Figure 13). Their results show the most significant inundation along the Delta corridor south of Sacramento and westward of Isleton with an average flood depth of 13 feet. It is important to note that the majority of flooding is predicted to occur within the 500-year floodplain.

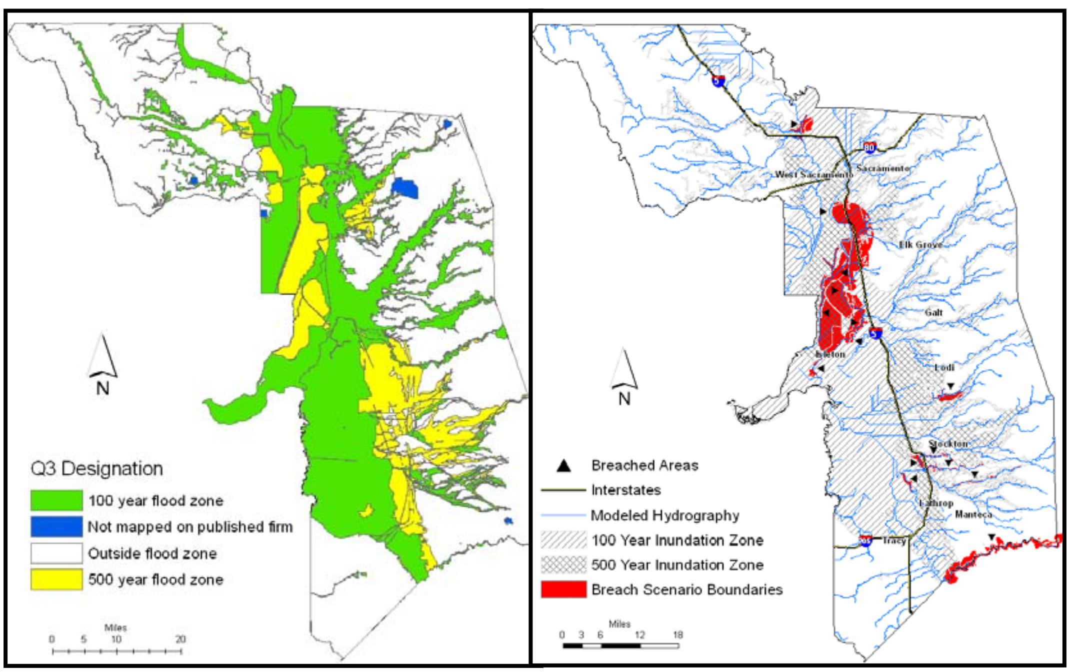

FIGURE 13
FLOODPLAIN DESIGNATIONS AND MODELED LEVEE INUNDATION

Source: Burton and Cutter (2007)

What is most interesting in regard to the scenario by Burton and Cutter is the fact that much of the inundation affects vulnerable populations (Figure 14). Although, it is difficult to predict human losses given the timing of levee failures and evacuation orders, the comparison of pre-existing socioeconomic conditions with a failure scenario provides helpful cues on the potential impact and recovery needs. It also highlights the need for tailored response strategies that differentiate between the Delta islands west of Interstate 5 dominated by Hispanic residents employed in the agricultural sector versus the urban areas such as downtown Stockton where social vulnerability is driven by age and low socioeconomic status.

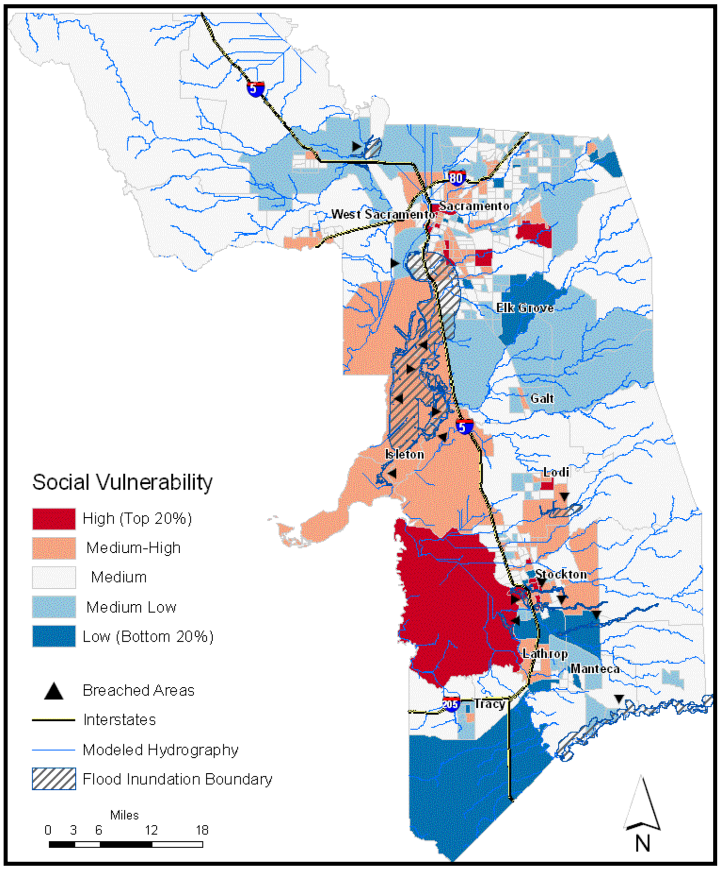

FIGURE 14
SOCIAL VULNERABILITY AND MODELED INUNDATION

Source: Burton and Cutter (2007)

4.2.2 Smart Decisions

The conversion of agricultural land into residential developments in combination with insufficient levee maintenance has put the lives of 450,000 residents, about 200,000 structures with an estimated value of $47 billion and 2 million acres of cultivated land at stake (Harder 2006). Today, the Central Valley's growing population literally lives in the shadows of levees

(Table 6). A combination of bad or uninformed decisions by land use planners, engineers and politicians left Sacramento with a disaster waiting to happen. However, these developments are not entirely the fault of state and local officials, although recent court rulings put the liability for flood damages on the state. Generally speaking, people purchasing flood-prone property possess a false sense of protection fueled by the certification of levee and the non-requirement to purchase flood insurance (Pielke 1999; Tobin 1995). The USACE has continuously reclassified areas from 100-year floodplain areas to areas protected by flood controls, which eliminated the need for residents to purchase flood insurance. It also erased the need to comply with building codes. In this rapidly urbanizing area, levee failures in Sacramento-San Joaquin delta region are just a matter of time.

TABLE 6
POPULATION CHANGE FROM 2000 TO 2005

City	2000	2005	% Change
Antioch	90,532	101,049	12%
Brentwood	23,302	40,912	76%
Dixon	16, 103	17,179	7%
Elk Grove	70,000	121,609	74%
Fairfield	96, 178	105, 026	9%
Galt	19,472	22,955	18%
Isleton	828	820	-1%
Lathrop	10, 445	12,565	20%
Lodi	57, 011	62,467	10%
Manteca	49,255	61,927	26%
Pittsburg	56, 769	62,605	10%
Rio Vista	4,571	6,837	50%
Sacramento	407, 018	452, 959	11%
Stockton	243, 771	279, 513	15%
Suisun City	26, 118	27, 716	6%
Tracy	56,929	78,307	38%
Vacaville	88, 642	96, 735	9%
West Sacramento	31, 615	40, 206	27%

Source: Eisenstein et al. (2006)

Discussion questions:

1. The FEMA is currently in the process of modernization of the Flood Insurance Rate Maps but future risks are not considered in this process. Would it be feasible to modernize FEMA flood maps using futuristic risks rather than historic ones?

2. As USACE identifies system vulnerabilities and risks, who should be responsible for rehabilitation and recapitalization? Should USACE certify levees that it did not construct or maintain in the first place?

3. Assuming that the process of decertifying levees continues and that the responsibilities remain unclear who is to rehabilitate the levee or carry the burden of losses in case of failure, what are the social and economic repercussions of decertifying levees? Should every home in Sacramento be required to have some form of flood insurance regardless of the level of protection?

4. The response to Hurricane Katrina was hampered by a limited understanding of the extent of damage and the number of affected. Are there geospatial data and technologies that can assist in detection, monitoring and impact assessment during a flood event?

5. Only the extension of the borrowing capacity of the NFIP made it possible to respond to the claims of insured customers. Are Federal and statewide insurance programs as planned in California a long-term and sustainable solution to manage flood losses?

6. How does USACE reconcile the conflicted mission of water provision and flood protection especially in rapidly urbanizing regions that are expanding beyond their sustainable limits?

4.3 Priest Rapids Dam Failure

While the probability is low, the potential of failure of one or more of the major dams along the Columbia River would be catastrophic.[8] Major cities such as Portland, Oregon (population: 539,000) or the Tri-Cities (Kennewick, Pasco and Richland) (population: 140,000) are directly in the pathway of floodwaters along with Superfund sites (e.g., Hanford Plant) and nuclear power plants (e.g., Columbia Generating Station). Dam failure and subsequent flooding could trigger a cascade of collateral hazards mainly due to loss of power and the loss of heating, ventilation and air conditioning (HVAC). Facilities such as the Hanford Plant or the Umatilla Chemical Depot are especially at risk from such failures. Given its potential for a combined natural and technological disaster, dam failure along the Columbia River could mean responding to a flood event along with radioactive and chemical contamination of water, air and soil. Such catastrophic conditions would not only generate mayhem in the vicinity of the Columbia River but also adversely affect regions and states farther away, especially those that depend on hydroelectric power, irrigation waters and transportation routes such as the Columbia-Snake River System.

4.3.1 Scenario

In mid-May, seasonal snowmelt accompanied by heavy rains cause water levels in many of the Columbia River tributaries to rise. Soils are saturated and many tributaries of the Columbia River are at flood stage. At about 2:30 pm on a workday, an earthquake shakes local residents

[8] The Columbia River is the largest hydroelectric power-producing river in North America. The river drains about 258,500 square miles and has an average annual flow of about 275,000 cubic feet per second [cfs] (7,787 cfs) (FCRPS 2001). Today 29 Federally built, hydroelectric dams and dozens of large non-Federal projects regulate water flows and support economic development in areas that, 60 years ago, were dry, remote and sparsely populated (FCRPS 2001). With the construction of dams and levees along the Columbia River, chronic seasonal flooding became virtually eliminated during winter and spring, although not necessarily along its tributaries.

and sends a reminder that not only the western part of Washington State is susceptible to earthquakes. The local shallow crustal earthquake with an intensity of MM=VIII occurs on the Rattlensnake Wallula Alignment.

The Priest Rapids Dam[9] (Figure 15), located just upstream from the Hanford Nuclear Reservation and 47 miles northeast of the town of Richland, shows some cracking from moderate ground shaking but the structure (gravity rockfill concrete) does not fail. Two landslides though occur along the Umtanum Ridge directly to the west of the dam. One landslide breaches the western concrete section of the dam. The other triggers a 20-foot wave (seiche) overtopping the remainder of the dam crumbling sections of it. Three hours after of the initial earthquake, the dam is 50 percent breached. The dam failure creates a downstream flood crest of more than 1.4 million cfs (40,000 cubic meters per second [cms]). This volume equals the probable maximum flood for the Columbia River below Priest Rapids Dam according to Campbell (1998) and exceeds the 500-year flood.[10]

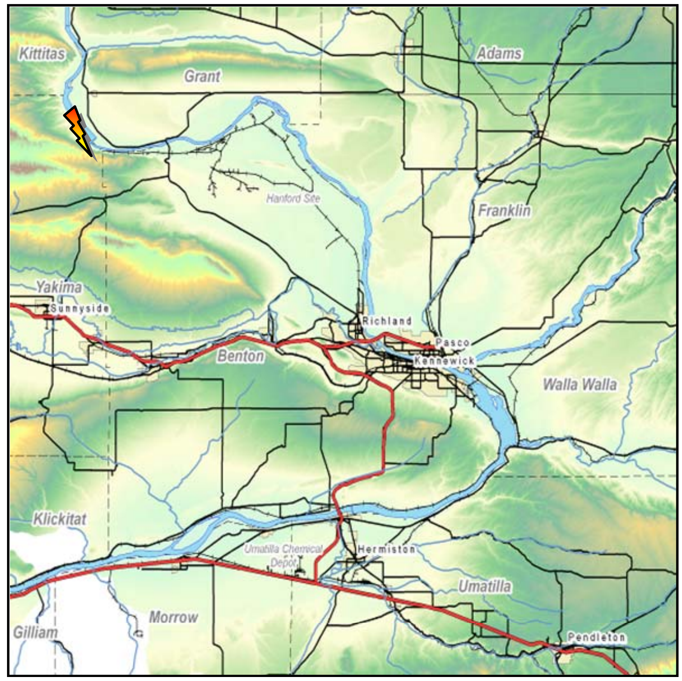

FIGURE 15
OVERVIEW MAP OF SCENARIO AREA

4.3.2 Anticipated Impact, Response and Recovery

The Hanford Reach, downriver of Priest Rapids Dam, is the only free-flowing, non-tidal stretch of the Columbia River. Situated along this stretch or in close proximity are the Hanford Nuclear Site, the Columbia Generating Station, the Umatilla Chemical Depot, a waste water management plant, a fuel storage tank facility and the Tri-Cities areas along with hospitals, schools, nursing homes, highways and other critical infrastructure. All of these areas are impacted either directly or indirectly from both the earthquake and the dam-break flooding (Figure 16). Property losses[11] are estimated between $1 billion and $5 billion. Economic losses from agricultural damages could be equally high. Almost 40,000 people will be temporarily displaced and hundreds of deaths can be anticipated given the quick rising flood waters and lack of warnings. Thousands of people will be injured and/or suffer from contact with toxic

[9] While many hydroelectric facilities along the Columbia River are owned and operated by the Federal Columbia River Power System (FCRPS), the Priest Rapids Dam is owned and operated by Grant County, Washington Public Utility District (PUD). The Priest Rapids Dam was completed in 1961 and has a rated capacity of 955,600 kilowatts. The size of the reservoir is 13 square miles with a drainage area of 95,500 square miles.

[10] There are no Federal floodplain maps for the Hanford Reach of the Columbia River.

[11] All loss figures are based on modeled outputs using HAZUS-MH MR3 (Beta).

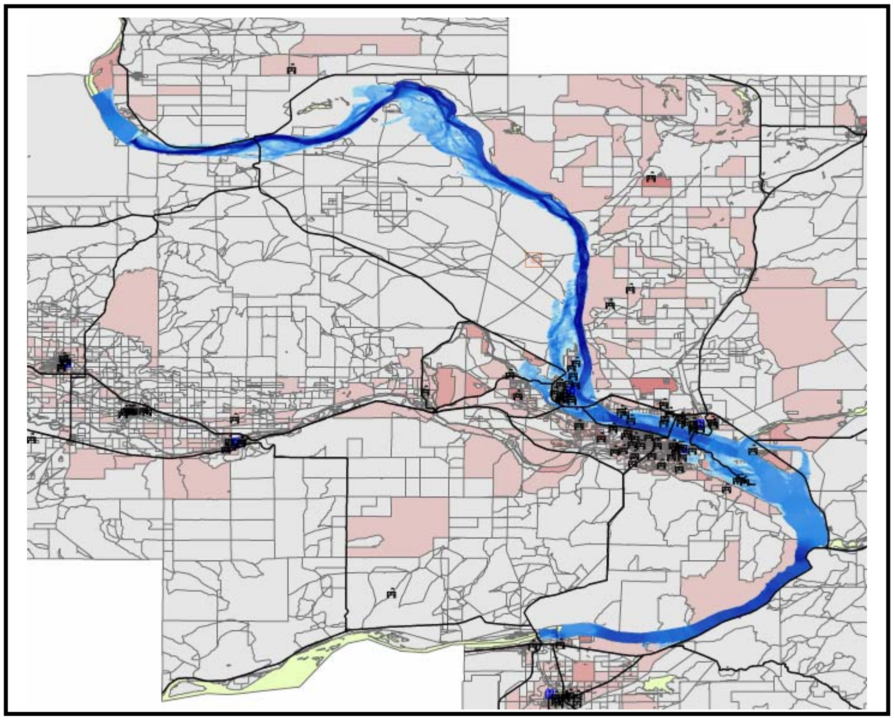

FIGURE 16
MODELED IMPACT ZONE AND CRITICAL INFRASTRUCTURE

water. Many people, especially vulnerable populations, will be trapped in their residences, schools, nursing homes and require assistance to evacuate the impacted area.

Direct damages from the earthquake will be mostly cracked road surfaces, burst pipes and the collapsing of structurally weak buildings. In combination with the rushing floodwaters, many roads, railroad lines and bridges will be impassable (e.g., I-182 South of Richland, SR 240 South, U.S. 395, U.S. 12, U.S. 730, railroad between Richland and Umatilla). The hardest hit area will be the Tri-Cities area and in particular Richland, Washington. In Richland, many escape routes will be completely cut off leaving only SR 240 North as evacuation route, but depending on the flood stage of the Cold Creek, this route might not be an option. Richland could be cut off entirely from any response and recovery during the initial stages of the emergency. Airlifts will be the only option for evacuation, response and recovery and this is totally dependent on the nature of the seismic damage to road surfaces including airport runways. Although catastrophic flooding occurs, the communities of Pasco, Kennewick and Burbank will maintain some land access routes.

Downriver dams such as the McNary Dam will immediately start releasing water to lower the levels. Still, it is anticipated that the McNary pool will rise from its initial 343 feet to 380 feet above sea level (WWEMD 2003). This will intensify the flooding and aggravate the situation for the communities of Richland, Pasco, Kennewick, Burbank and others directly below the Priest Rapids Dam. Flood levels will increase from the accumulation of debris at bridges, diversion structures, islands, drainage ditches and culverts. Furthermore, water will back up along the

TABLE 7
SOCIAL AND DAMAGE PROFILES OF ALL SIX COUNTIES WITHIN THE SCENARIO AREA

	Grant	Yakima	Benton	Franklin	Walla Walla	Umatilla, OR
Debris (in tons)**	3,500	1	1,440,000	440,000	6,600	900
Displace people**	103	0	28,134	11,441	236	26
Utility damage (in $)**	830,000	1,560,000	1,370,000	880,000	150,000	990,000
Social Vulnerability Index score*	1.16	5.03	-2.42	4.51	0.07	1.52
Social Vulnerability Index (national percentile ranking)*	59.1	91.7	12.7	89.7	44.6	64.4
Area (in sqmi)	2,791	4,311	1,760	1,265	1,299	3,231
Population (2006 est.)	82,612	233,105	159,463	66,570	57,721	72,928
Population increase since 2000	10.6%	4.7%	11.9%	34.9%	4.6%	3.4%
Population (< 18 yrs.)	29.8%	30.2%	26.3%	31.9%	22.3%	26.5%
Population (≥ 65 yrs.)	11.5%	11.2%	10.6%	7.3%	14.7%	12.0%
Non-Hispanic, white population	62.5%	53.3%	79.6%	47.2%	77.9%	76.0%
Hispanic Population	33.8%	39.3%	14.6%	48.3%	16.9%	18.2%
Primary language spoken at home other than English	28.3%	31.8%	14.2%	44.6%	16.2%	16.2%
Median Household Income (2004)	37,580	35,787,	52,922	42,029	38,419	38,388
Population in poverty	16.2%	18.6%	10.7%	15.2%	14.7%	14.9%

*Source: U.S. Census Bureau State and County QuickFacts, *Hazards and Vulnerability Research Institute, **HAZUS-MH MR3 (Beta).*

Walla Walla River and the Snake River all the way to Ice Harbor Dam and impact communities along these Columbia River tributaries as well.

The flood crest will wash away houses or push them off their foundation. Many people will be stuck in their damaged homes. Others, commuting back home after the earthquake, might get trapped in their cars. With a lead-time of less than three hours and no warning between the initial earthquake and dam failure, there is insufficient time to evacuate nursing homes, hospitals or schools. Families will become separated with children still at school or day-care and parents at work or on their way home. As the Benton County Mitigation Plan points out, there will be delayed responses by local residents due to lack of public unawareness of flood hazard, limited knowledge about flood hazards, limited flood warning for floodplain residents and overall inadequate flood hazard management for this region (HDR Engineering Inc. 2004). Thus, the inexperience of emergency officials and the lack of preparedness of residents will slow down rescue and response efforts.

The Tri-Cities area is the heart of southeastern Washington. Most of the first responder capacity and facilities are located here. In case of a dam failure, much of its infrastructure will withstand rushing floodwaters but it will be impossible to access them, complicating the response for emergency personnel. The area will need immediate assistance from neighboring counties. For instance, the Kadlec Medical Center will have to be evacuated. As stated in the Benton County Mitigation Plan, Kadlec Medical Center as well as other hospitals, medical centers, nursing homes, hospices, assisted care facilities, are not fully prepared for complete evacuation (HDR Engineering Inc. 2004).

Such special needs populations along with children and minorities will depend strongly on external assistance for rescue and relief operations. Assistance will be required in the form of transportation, evacuation, sheltering and protective behavior. The presence of large Hispanic communities in counties dominated by agricultural production will require that advisories and announcements are issued in Spanish.

The risk of radioactive and chemical contamination from the Hanford Site will be large with its countless units of hazardous radioactive and/or chemical waste as well as other non-radioactive, non-hazardous solid waste. Contaminated onsite soils and sediments (e.g., strontium, cesium) from numerous flooded areas (shutdown production reactors, waste storing area, shutdown fuel fabrication facility, etc.) will be washed into the river (Campbell 1998; Conrads 1998). Given past experiences in large technological catastrophes (Mileti 1999; Tierney et al. 2001), Hanford officials will be expected to hesitate declaring a general (off-site) emergency. They will likely opt to declare a “Site Area” emergency to protect workers and the public within the facility’s boundaries. No protective distance and zoning will be implemented. Contaminated soils and water will get far beyond the Hanford boundaries. This will pose a significant long-term threat to people’s health, agricultural products and livestock in the watershed.

At the Umatilla Chemical Depot, a U.S. Army facility three miles south of the Columbia River in Umatilla and Morrow Counties, Oregon, floodwater will mix with chemical warfare agents. The earthquake will cause storage bunkers to crack and floodwater from breached levees and irrigation canals can seep in. Water contaminated with mustard, so-called “blister” agents and nerve agents (Sarin and VX) will seep out. This puts everybody at risk that comes in direct contact with this liquid and toxic mix. Exposure is usually not fatal but the mustard agent causes skin and eyes to redden, blister or swell. Sinus pain, coughing and throat irritation are other symptoms. Symptoms from exposure to nerve gas will appear immediately (e.g., blurred vision, shortness of breath, muscle weakness) (UCEM 2005). The nerve agent VX is the most potent nerve gas and can be lethal. It has no smell. Therefore, many people will not realize that they are exposed. Antidotes are available for VX but immediate medical care in a hospital is crucial (CDC 2003).

Since chemical agents cannot be contained within the site, Umatilla officials will declare a community emergency. The general emergency response is to shelter in place (UCEM 2005). In the communities of Irrigon, Umatilla and Boardman this is impossible due to the Priest Rapids dam failure and associated flooding. Thus, people will leave their homes and get into contact with toxic waters. In addition to radioactive and chemical warfare agents, the floodwater might also carry a mix of oil products (e.g., from Chevron tank facility in and near Pasco), pesticides, herbicides and insecticides. While most toxins might be water-borne, anhydrous ammonia poses an airborne risk. Anhydrous ammonia is used for fertilizers and given the agricultural focus of this region, there are many tanks storing this substance. Depending on the prevalent wind direction, it can be anticipated that areas northwest of leaking tanks are at risk.

In such a complex event, the role of public health authorities will be extremely important as well as the ability of nearby hospitals to care for vast numbers of injured and exposed people. Health officials have to assess and monitor contamination levels during and after the event. Instantly, public health and agricultural advisories will need to be issued advising people to refrain from eating or drinking contaminated food, milk and water. After the event, it is likely that all poultry, dairy and meat animals from pastures will have to be destroyed. The same is true for all locally produced milk, eggs and crops. Almost 2 million tons in debris (circa 76,000 truckloads) will accumulate solely from residential damages. It is anticipated that the long-term recovery of the agricultural sector from this event will be slow and extend far beyond the immediate impact area.

4.3.3 Conclusions

The clean-up process will be tedious. For instance, VX can last on objects for days, under very cold conditions even up to months (CDC 2003). Overall, environmental contamination will be widespread; toxic exposure of large populations will be excessive and reach unforeseen and unprecedented levels. First responders, state and local emergency management officials will be totally overwhelmed by such a complex disaster.

Although there is emergency preparation, response planning and full-scale scenarios performances at the Hanford Site and Umatilla Chemical Depot, there is little effort, to date, to integrate county and facility response especially when it comes to off-site emergencies. No response and evacuation plan exists for complex disasters in this region. All emergency planning is conducted focusing on a single hazard alone. As a result, no county risk assessment or mitigation plan considers a multi-hazard event. Shelter in place, the common response strategy during chemical or radioactive hazards, is not an option when earthquakes or flooding occur simultaneously. Thus, comprehensive emergency strategies have yet to be designed to protect people and places in emergencies that go beyond the "normal."

It is important to note that the above scenario is not necessarily a worst-case scenario for this region. The authors refrained from assuming dam failure of the Grand Coulee Dam, the largest dam along the Columbia River. A 50 percent breach scenario of Grand Coulee Dam predicts a floodwave of 600,000 cms (21 million cfs), which would flood the entirety of the Hanford Site and nearly all of Richland, Washington (Campbell 1998). Furthermore, the authors did not assume melting of nuclear fuel or radioactive fallout in either the Hanford Site and/or the Columbia Generation Station, which could result from volcanic events.

Discussion questions:

1. Most mitigation, preparedness, response and recovery plans are oriented towards a single hazard. How can these strategies be better linked into an overall risk mitigation and management strategy?

2. Given that the contamination of soil, water and so forth makes originally identified shelters inhabitable, how and where will evacuees and victims be sheltered?

3. The involvement of toxic material could affect health conditions. Will there be long-term monitoring of health effects?

4. Realistic response and recovery planning requires an understanding of the capacities and resources available locally as well as regionally. What resources are in the area to respond to an earthquake, flood and contamination event?

5. The Nation has not yet experienced a combined technological and natural event of large magnitude. How will USACE coordinate its mission assignments with various Federal, state and local governments as well as the National Response Teams?

Section 5
Implications of Scenarios for the U.S. Army Corps of Engineers

5.1 Changes to Come

Any of the three scenarios in the preceding section are certainly possible as Hurricane Katrina, Three-Mile Island or the Indian Ocean Tsunami vividly demonstrate. These scenarios illustrate the non-linear character of catastrophic events—the unexpected failure of virtually infallible safety procedures and infrastructure and/or the occurrence of a most unlikely event.

While it is impossible to plan and prepare for every worst case disaster scenario, there is a common set of factors that drive catastrophic outcomes. By the year 2030, it is anticipated that the following factors will represent challenges to the EMS and if not adequately addressed will significantly add to increased losses:

1. More people will be exposed to hazards due to continued population growth.

2. More people will move into hazardous areas (e.g., California, Florida, Texas) attracted by economic opportunities and coastal life styles.

3. More people will be unfamiliar with the local hazardscape due to limited experience in their new environment.

4. An increasingly diverse population will require customized approaches of risk communication or else will be reluctant to take precautionary measures.

5. More people will require state and Federal assistance during and after an event given their inability to evacuate or protect themselves.

6. More insurance companies will abandon risky markets and insurance premiums will either increase or not be available at all, which reduces resiliency.

7. The natural system will provide less natural protection from disasters due to the destruction of wetlands, on-going land development, etc.

8. The pressure on natural resources will increase and their resilience will decrease due to heightened environmental pressures (e.g., climate variability, temperature extremes) and human-induced changes in environmental systems.

9. The occurrence of extreme events will increase due to a more variable climate.

10. The entire U.S. coastline will experience increased damages from erosion, storm surge, severe storms, hurricanes and flooding due to sea level rise.

11. The globalization of disasters will bring new and old hazards to the U.S. (e.g., malaria, avian influenza) that people, emergency professionals and procedures are unfamiliar with or unprepared for.

12. A deteriorating infrastructure system (e.g., levees, dams) will expose the Nation's populations to additional risks.

13. The lack of redundancies within the system of critical infrastructure enables cascading failures and catastrophic outcomes on a daily basis and not just in extreme conditions.

14. Aging infrastructure will be the weakest link in effective emergency response and will slow down response and recovery efforts.

Emergency management agencies need to incorporate these anticipated changes and plan ahead to avoid escalating losses. To prepare for these upcoming challenges adjustments regarding budget, staffing, training, equipment and procedures are required. What does this mean for the U.S. emergency management infrastructure and USACE in particular?

5.2 Planning

5.2.1 Mitigation

Given that hazardous events will become more frequent, the likelihood for complex hazard events increases as well. Complex hazard events (the occurrence of multiple hazards or cascading events) have the potential to go beyond the immediate zone of impact and are capable of affecting the entire Nation. Although each hazard is well-researched, little is known about interaction effects and potential societal consequences. One reason is that the linkages within and between hazards and the social, economic, technological and environmental systems are insufficiently studied and understood.

To account for the social, economic and technological vulnerabilities of localities, emergency response and mitigation plans need to go beyond simplistic hazard profiling. What is required are comprehensive assessments with a systems perspective. Losses can only be avoided when there is a clear understanding of what is at stake and how the inventory of hazards, hazardous facilities, critical infrastructure and assets can potentially interact.

Awareness and mitigation of interdependencies are required to prepare the Nation for worst-case and complex disasters (TISP 2006). The risk assessment methodology proposed in the NIPP is one step to create such an inventory. However, the NIPP lacks a robust risk management and communication components to engage society and to be able to establish mutually agreed upon security and safety goals. People care less about, for instance, dam failure due to a terrorist attack and more about general infrastructure safety and maintenance since this impacts them directly and on a daily basis through declines in property values and so forth.

Over the past decades, local, state and Federal governments ensured people's personal safety and protection (Sylves 2007). Much was invested into preparedness, rescue and response training and equipment and emergency procedures. Individuals, society, the economy and/or insurance companies absorbed losses without much problem. Mitigating losses is recognized as important goal and cost-saving tool (Multihazard Mitigation Council 2005) but not really successfully integrated into the emergency management cycle. With escalating risks at hand (e.g., climate change) and more people in harms way, governmental responsibilities will increase while the lack of comprehensive, long-term mitigation and adaptation strategies will become more apparent.

To use existing mitigation strategies to its fullest potential, it is imperative to draw on all programs of the national mitigation strategy administered by FEMA: the Hazard Mitigation Grant Program, the Flood Mitigation Assistance program and the Pre-Disaster Mitigation program. According to the Association of State Floodplain Managers (ASFPM) though, funding for the Pre-Disaster Mitigation Program is insufficient and inconsistent and the competitive nature of the application process seems to favor resourceful states (ASFPM 2006). It is vital though for FEMA and its partners to foster mitigation and to reduce the costs of future disasters given that proactive measures reduce on average $4 for every dollar spent according to the Multihazard Mitigation Council (2005).

Society, as well as emergency management agencies need to adapt to a changing environment and adopt flexible and sustainable strategies. If structural protection continues to be the main focus USACE will be trapped in a race with nature to keep up and/or improve already inadequate design levels of its flood protection infrastructure. Ultimately, USACE will have to shift from an organizational focus on water quality, supply reliability and cost effectiveness to social interaction strategies when it comes to managing risks (Rayner et al. 2005). Adaptive management and mitigation strategies that are driven by negotiations of self-identified local problems and context-specific solutions will create flexible responses for a challenging future. If USACE wants to avoid increased (negative) visibility spawned by infrastructure failures then the agency cannot solely focus on water resource management. Managing threats imposed on people that depend on such infrastructure has to become a priority. Reducing engineered threats without creating new ones are the hazard mitigation challenges faced by USACE.

5.2.2 Preparedness, Response and Recovery

Continuing the Nation's reactive approach to disasters rather than a pro-active one will contribute to escalating financial and human losses. The country's response and recovery ability is already at its limits as seen during and after Hurricane Katrina. Without drastic improvements in response and recovery capacities as well as efficiency, disaster victims neither can nor should rely on swift and orchestrated rescue in the future. In response to Hurricane Katrina, TISP among others has compiled an extensive list of needs and recommendations to improve future response, recovery and restoration efforts (HSAC 2006; TISP 2006). Table 7 lists some of these findings that pertain to USACE.

In addition to tasks identified by TISP and others, the authors also identify the need for coordinated local, state, regional and Federal contingency plans for natural, technological, chemical and biological hazards as well as multi-hazards and catastrophic events. Disaster contingency plans at each response level would define and outline available assets, resources, stakeholders and their responsibilities in case of an emergency. Pre-planned strategies for staging responses, setting up shelters, distributing goods and so forth could quickly be implemented—in a coordinated effort based on pre-existing agreements and acknowledgements of capabilities and capacities. In addition, it would be possible to develop plans that consider events ranging from 100-year flood events to worst-case scenarios—before a

TABLE 8
EXAMPLES OF ACTIONS TO IMPROVE PREPAREDNESS AND RESPONSE

Preparedness	▪ Raise awareness and improve understanding of infrastructure interdependencies. ▪ Develop models and simulation capacities to assist decision making and understanding of interdependencies. ▪ Use catastrophic disaster scenarios to examine evacuation and sheltering capacities. ▪ Expand monitoring and sensor system to improve threat detection. ▪ Establish public-private partnerships to share information, build trust and develop joined preparedness strategies.
Response	▪ Develop procedures for establishing virtual EOCs that consider assets and resources (e.g., existing command centers and EOCs) of local entities (local, state, Federal agencies), DOD, public and private organizations. ▪ Develop plans for removing and disposing huge amounts of debris and abandoned vehicles. ▪ Establish a certification process to ensure access for emergency personnel. ▪ Improve logistics to ensure provision of water and ice to shelter facilities and off-site victims. ▪ Identify staging areas and transportation routes and identify potential interdependencies-related vulnerabilities. ▪ Establish non-bureaucratic procedures to expedite response and recovery. ▪ Ensure adequate stockpiling of fuel, generators, medical supplies, etc.
Source: TISP (2006)	

disaster strikes. A National Disaster Contingency Plan would work in accordance with the NRP and be implemented using NIMS (Figure 17).

Currently, contingency planning is only implemented for emergencies involving hazardous substances, pollutants, oil and weapons of mass destruction. Given the emerging issue of critical infrastructure and interdependencies such as distinct separation between responses to natural hazards and technological hazards makes little sense especially in instances where hazards of both origins occur.

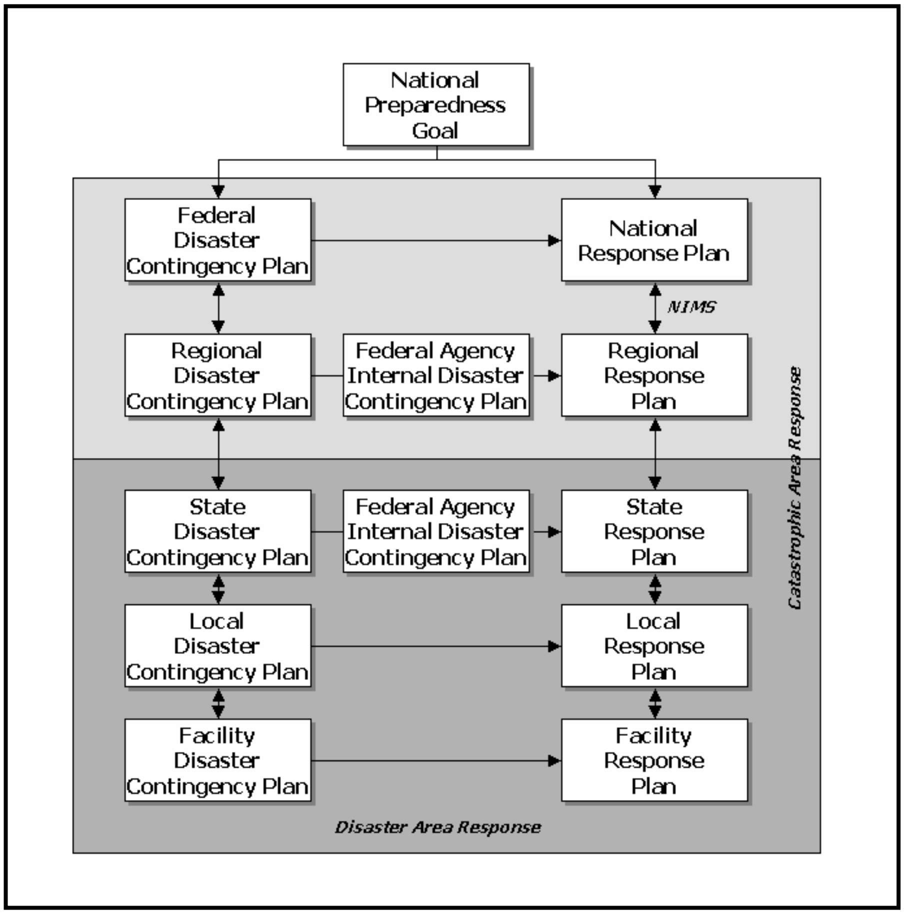

FIGURE 17
INTEGRATION OF EXISTING PLANS WITH CONTINGENCY PLANNING AT ALL LEVELS

5.3 Capacities

5.3.1 Infrastructure

In the near future, more people will depend on existing structural flood and storm surge protection due to the effects of population growth. Areas such as Sacramento, New Orleans or the Columbia River Basin that rely heavily on infrastructure for flood protection, water supply, transportation, habitat protection or recreational purpose have already entered a phase of uncertainty where neither infrastructure standards nor public safety can be ensured by government agencies.

The Nation is trailing in the infrastructure maintenance race. The backlog of aged and deteriorating flood infrastructure keeps growing while funding for maintenance and upgrades is shrinking. Given the deterioration of critical flood infrastructure, political commitment and tremendous expenditures will be necessary to (a) restore design levels, (b) elevate design levels and (c) incorporate redundancies to minimize interdependencies of critical infrastructure. Although a (financially) daunting task, it is a window of opportunity to prepare the Nation for what is to come. Sea level rise and a more variable climate will solidify the dependence on safe and reliable infrastructure (e.g., levees, warning systems). Hurricane Katrina was a wake-up call. The Nation realized that flood protection and emergency management infrastructure only provide safety to a certain degree, which might even be below expected standards and design levels.

Lessons learned from Hurricane Katrina suggest to not only evaluate structural systems but to rethink the entire design process. The IPET findings (2007) propose that USACE should incorporate adaptive management strategies in order to overcome problems posed by dynamic factors. From a systems perspective, this would imply uniform levels of protection throughout the entire system "to be conservative enough to accommodate unknowns" (IPET 2007: I-4). Mitigation planning would advance from a stove-piped, hazard-specific, local approach to a portfolio approach, which "seek(s) to minimize not risk associated within individual events but risk across the social unit as a whole" (Allenby and Fink 2005: 1034). The USACE in collaboration with FEMA, for example, could seek solutions to questions of social adaptation rather than asking for larger construction projects. Examples of questions that should be asked are: How will the coastal U.S. adapt to sea level rise? Will engineered solution promulgate unsustainable waterfront development? How to protect wetlands and people at the same time? Is a gradual retreat from the coast feasible?

The threat of sea level rise and increased hazardousness has many countries again locked in gigantic construction projects: Japan built a monumental underground reservoir and waterway system to prevent Tokyo from flooding during the rainy season and typhoons; Italy attempts to protect Venice from storm surge by mobile storm barriers; London has for years relied on the Thames flood barrier; and new levee systems for New Orleans exist already on the drawing board as well as sea gates for New York City. The case of Venice is particularly interesting since structural protection efforts once more trumped efforts to restore natural protection. All these measures of engineering ingenuity though have to anticipate and incorporate future environmental changes to maintain their protection levels should sea level rise and the possibility of accelerated sea level rise occurs. Hence with every structural project the question remains: How safe is safe enough—i.e., what level of protection is adequate?

5.3.2 Missions

The goal of minimizing risks by increasing design levels and adding redundancies potentially conflicts with other missions of USACE such as environmental stewardship or water management. The semiarid West, for instance, already experiences conflicts between the various USACE missions (Service 2007). Under the assumption of climate change (i.e., warmer temperatures, reduced snowfall and exacerbated flood risks) conflicts between sustaining fishing habitat, securing energy supply and agricultural production and flood protection are inevitable. A smaller snow pack equates to a reduction of the natural water reservoir. This ultimately will tax artificial reservoirs, which will be forced to maintain water supply throughout the entire year by storing more water. However, storing more water in dam reservoirs reduces their ability to buffer floods events, which for example along the Columbia River have been eliminated almost entirely. Thus, USACE will have to rethink not only emergency management but also water management in times of climate change.

In other instances, flood protection questions have the potential to turn into highly contested and controversial issues. With the decertification of levees across the Nation and forcing homeowner to purchase flood insurance, USACE has raised awareness concerning levee failures. It has also raised the visibility of risky planning, zoning and land use approaches by some communities (e.g., Sacramento). Furthermore, USACEs procedural change in levee certification could be an opportunity to directly influence homeowners' behavior and their locational decisions: living in the shadow of a non-certified levee appears less attractive—financially and in terms of risks. Additionally, increasing personal responsibility and obligating homeowners to acquire flood insurance could reduce Federal liabilities and alleviate USACE from possible lawsuits.

The NFIP eliminates the need for risk-averse decisions and instead transfers flood losses from homeowners to every taxpayer. In the face of climate change, it is most likely that the NFIP will continue to exceed its financial limits since it already had to increase its borrowing authority from $3.5 billion to $20.8 billion since 2004 (King 2006). Ultimately, private insurance companies as well as the NFIP will have to raise their premiums or pull out entirely of non-lucrative markets. As seen since 2004, insurance companies have cancelled hurricane policies in Florida and across the Gulf Coast leaving local residents with no other option as to recoup their own losses or move out of hazardous areas. Although, this is a non-desirable solution for local residents it is more sustainable than reimbursing homeowners that suffer repetitive losses.

5.3.3 Information and Communication

The recent publication "Successful Response Starts with a Map" by the National Research Council (2007) offers a comprehensive picture regarding geospatial data and tools and their role in disaster management. The report highlights the deficient recognition and incorporation of spatial data and technology into plans ranging from the NRP and NIMS to local efforts (e.g., land use planning, zoning) as well as data sharing and compatibility issues between agencies. The USACE as an agency that both uses and produces geospatial data throughout all phase of the emergency management cycle needs to join in with other governmental agencies to develop guidelines and policies concerning data acquisition, data sharing, data quality, timeliness, data archiving, real-time communication, reporting, information dissemination and interoperability requirements to expedite decision-making between and across agencies. By using geospatial technologies to their fullest potential it is possible to save lives, properties and ecosystems.

In past emergencies such as Hurricane Andrew, 9/11 and Hurricane Katrina, these long-standing issues have surfaced over and over again without having been resolved in post-disaster conditions (Walker 2006). In a post-9/11 environment with heightened security and restricted data accessibility, these problems seem to be more persistent than ever before.

Geospatial data and technologies are also crucial during the mitigation phase. Here, they inform long-term strategies and often times help to manage uncertainties through models, simulations and scenarios as in risk assessments. The process of collecting and producing data though is a never-ending cycle since continuous model refinements with better spatial and temporal resolution require constant efforts to keep databases, inventories and assessments up-to-date. Thus, funding for data collection and data processing should be a key priority in a data-heavy agency such as USACE.

To be prepared for the future means managing uncertainties and anticipating future risks. Risk assessments as well as engineered structures need to possess a "risk" buffer and incorporate future risks to maintain protection levels despite increased risk levels in the coming years—a lesson learned the hard way during Hurricane Katrina (IPET 2007). Quantifying future risks though is a difficult task since it is associated with many uncertainties and knowledge gaps. Particularly in the case of sea level rise, processes such as heat penetration, thermal expansion and the effects of melting ice sheets and glaciers are not fully understood (Jacob et al. 2007). More research needs to be invested in understanding basic physical processes. Other data types beneficial for advanced assessments are: detailed topographic data, flood insurance maps considering future risks, inventories of storm damage and infrastructure vulnerability, more detailed storm surge models, etc.

Much has been done in recent years to improve data collection (e.g., real-time stream gauge data, Light Detection and Ranging Sensor [LIDAR] data) and data processing (e.g., flood models, loss estimation models). However, the improvements have not necessarily trickled down to local and operational emergency management levels (Cutter 2003) or translated into policies—largely due to the fact that many scientists and agencies tend to avoid political involvement (Pielke and Sarewitz 2005; Sarewitz and Pielke 2001). Also, scientific facts are rarely drawn upon to evaluate policies. In the context of USACE, the agency has largely benefited from catastrophic flood events in the early to mid 1900s to expand its network of structural flood protection without fully evaluating ecological and social impacts. Over the past decades, USACE was forced by external pressure to consider issues of environmental stewardship, which often conflicted with water management missions. Today, we are at a similar cross-road: To build or not to build? With much of the infrastructure at the end of its lifetime, USACE needs to carefully reevaluate how much protection is really needed and at what levels.

5.3.4 Funding

These questions can hardly be answered using USACEs traditional approach of NED and its outdated framework for economic feasibility analyses. Traditional benchmarks to determine the feasibility of a proposed USACE project are the damage potential and reduction in damages to physical structures and buildings (NRC 2004). This approach though neglects the entire suite of socioeconomic consequences from a disaster and the costs of emergency response services. It severely underestimates the true costs and impacts of a structural measure. As a result, current NED procedures penalize projects that would avoid or reduce future losses based on higher design standards or added redundancies.

The ability to follow a more cautionary approach and acknowledge related non-structural, socioeconomic impacts of proposed projects would enable USACE to pursue comprehensive flood mitigation strategies. Projects would be judged based on the relationship of spent dollar to avoided dollar in regard to costs of emergency response services, the provisions of humanitarian services, debris removal, dewatering, etc. A USACE case study for the Folsom Joint Federal Project (USACE 2007c) though revealed that the incorporation of non-structural societal impacts is a challenging task. At the moment, there are no established theoretical frameworks or procedures in place on how to capture and quantify non-structural benefits. Much depends also on the quality and availability of information on the costs of disasters and emergency services. Thus, for a better understanding of the societal impacts of USACE projects, the agency needs to join forces with other institutions such as FEMA to improve baseline data on the costs of disasters.

5.3.5 Staffing

To translate scientific results, incorporate social information into engineering projects, moderate water resource conflicts, raise flood risk awareness, foster risk-averse land development strategies and to increase public participation, USACE requires either additional staff trained in these techniques or additional training for existing personnel. Also, existing emergency response personnel will probably be stretched thin with expanding response and recovery missions. Therefore it seems unavoidable that USACE will need to increase its pool of core staff. Without adequate surge capacity to respond to disasters, USACE will fail to fulfill its missions.

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Section 6
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IWR Future Directions

IWR's Future Directions program activities include the identification of emerging water challenges and opportunities and the tactical engagement of USACE senior leaders on these issues. Such critical thinking is seen as an essential prerequisite to strategy development and planning.

IWR employs a variety of approaches to encourage strategic thinking, including the development of Water Resources Outlook papers and the conduct of topic specific provocation sessions with senior leaders.

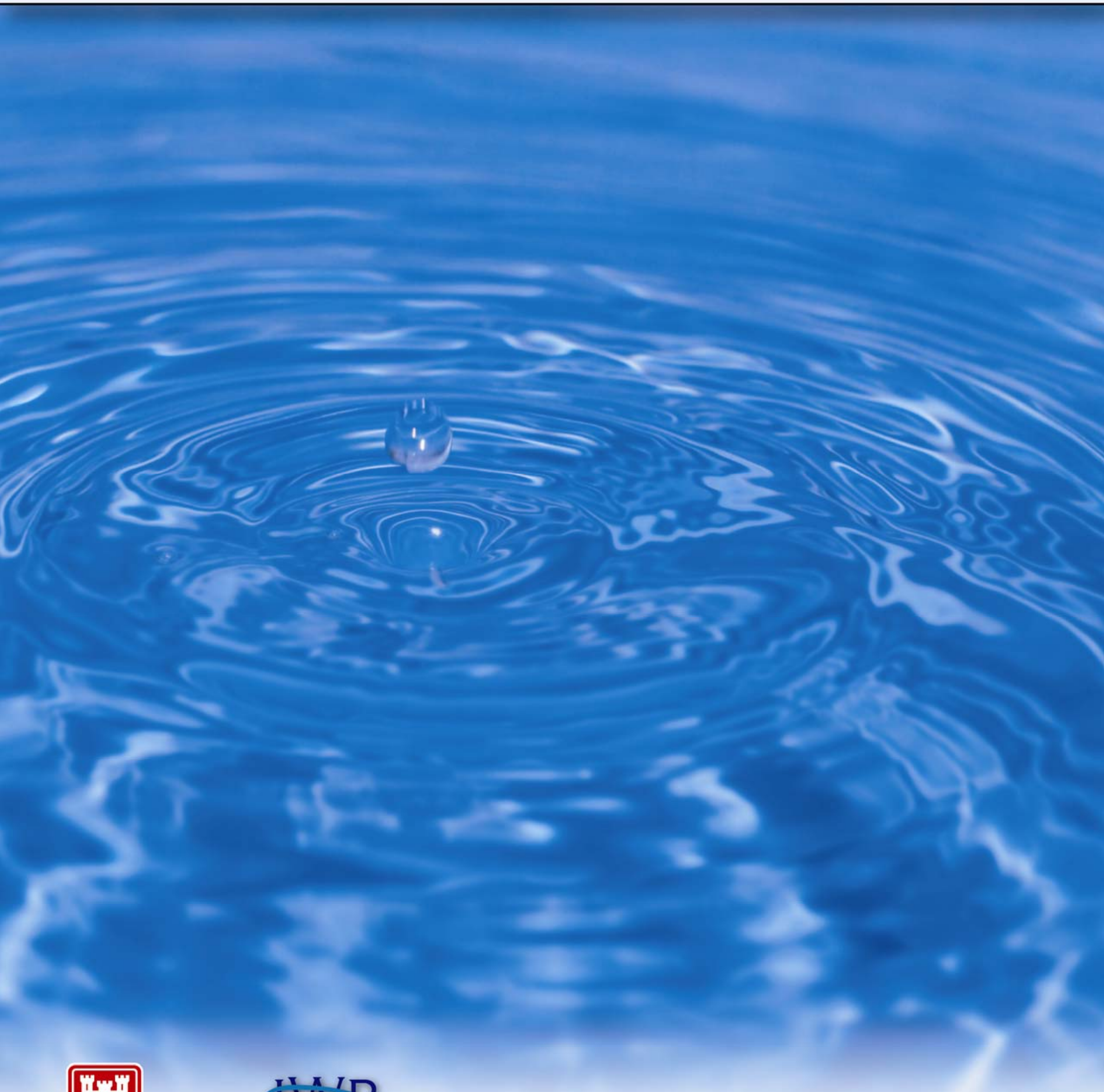
Other tools IWR has recently developed to engage senior leaders strategically are the Castle Forum and the Lunch Roundtable. The Castle Forum is an off-site event where senior leaders and external thought leaders can engage in out-of-the-box thinking regarding subjects not usually addressed by them. The Lunch Roundtable brings in water experts from outside the Corps to provide different perspectives on issues familiar to senior leaders.

Future Directions activities include:

- Water Resources Outlook papers
- Post-Katrina Studies
- Interagency Performance Evaluation Task Force (IPET)
- Planning Framework for Coastal Louisiana
- Hurricane Protection Decision Chronology
- Twelve Actions for Change
- Louisiana Coastal Protection and Restoration (LACPR)
- National Shoreline Management Study
- Strategic Planning
- Policy Development
- Other activities headed by the USACE Chief Economist

For more information about the Future Directions program, contact:

Norman Starler, IWR Future Directions
U.S. Army Corps of Engineers
Institute for Water Resources
Casey Building, 7701 Telegraph Road
Alexandria, VA 22315-3868
www.iwr.usace.army.mil



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