NRC Studies on Protective Actions

Lori Dotson, Joe Jones

Sandia National Laboratories

National Radiological Emergency Preparedness Conference

Harrisburg, Pennsylvania

April 13, 2005

The Three Studies

- NUREG/CR-6864
- NUREG/CR-6863
- Review of NUREG-0654, Supplement 3

Sandia National Laboratories

NUREG/CR-6864: Status

- "Identification and Analysis of Factors Affecting Emergency Evacuations"
  - Volume I: Main Report
  - Volume II: Appendices
- Released January 25, 2005

Sandia National Laboratories

Major Findings of "Evacuation Study"

- Evacuations successfully protect public health & safety over a broad range of initiating circumstances & challenges
  - Public evacuations occur frequently (~once every 3 weeks)
  - Shadow Evacuations do not generally affect the implementation of protective actions
  - Emergency Workers report to duty when asked
  - Public Education is an important contributor to efficient & effective evacuations
  - Route Alerting is effective and is a significant contributor to efficient & effective evacuations

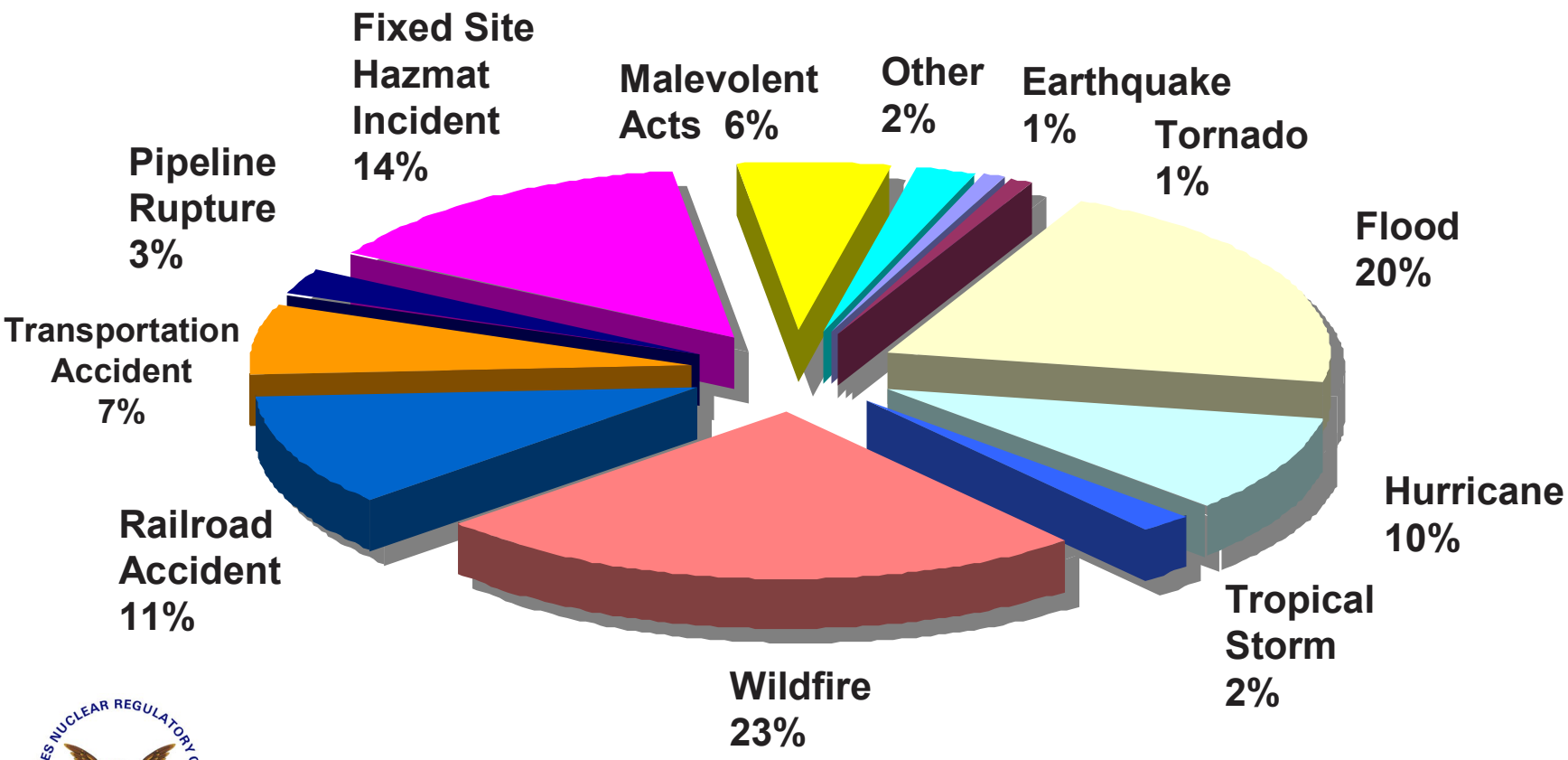
Sandia National Laboratories

Overview of Project

- Examined efficiency & effectiveness of public evacuations of 1,000 or more people, in response to natural disasters, technological hazards & malevolent acts, on the U.S. mainland between 1/1/90 & 6/30/03
- 230 evacuation incidents identified; subset of 50 selected for case study analysis
- Case study selection based on profiling & ranking scheme designed to identify incidents of sufficient complexity to challenge local & regional emergency response capabilities

Sandia National Laboratories

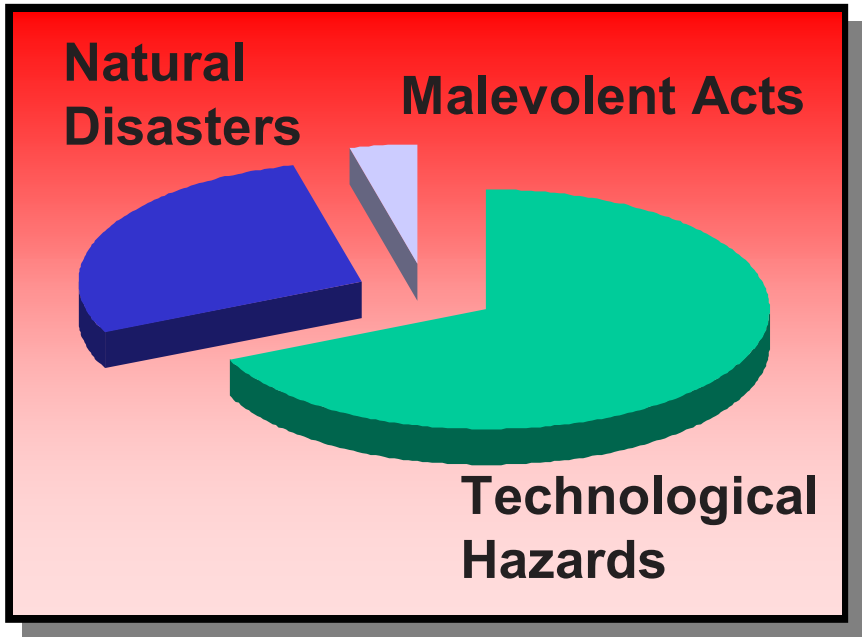
Principal Causes of Large-Scale Evacuations



Sandia National Laboratories

Case Study Cross-Section

- 50 case studies
- 33 (66%) due to **technological** hazards
- 14 (28%) due to **natural** disasters
- 3 (6%) due to **malevolent** acts



Case Study Examples

- All 50 evacuation cases studied safely evacuated people from the area, saved lives & reduced the potential number of injuries from the hazard

Eunice, LA Train Derailment & Chemical Spill (2000)

Hurricane Floyd (1999)

Centennial Olympic Park Bombing, Atlanta (1996)

Sandia National Laboratories

Case Study Questionnaire

- Evacuation decision-making
- Notification of response personnel/officials
- Citizen notification & warning
- Citizen action
- Emergency communications
- Traffic movement & control
- Congregate care centers
- Law enforcement Issues
- Re-entry Issues
- Shadow evacuations
- Special facilities evacuations
- Training & drills
- Type of emergency plan
- Community preparedness & history of emergencies
- Number of deaths/injuries
- Unusual, or special, circumstances

Sandia National Laboratories

Case Study Analysis

- Case study analysis included completion of a detailed question survey for each incident
- Advanced statistical methods (regression analyses & correlation analyses) used to identify factors contributing to evacuation efficiency
- Regression analyses identified that the following were statistically significant for a more efficient evacuation:
  - Community familiarity with alerting methods
  - Door-to-door notification

Sandia National Laboratories

Case Study Analysis (Continued)

- The following factors were statistically significant for a less efficient evacuation:
  - Traffic accidents
  - Number of deaths from the hazard
  - Number of injuries caused by the hazard/evacuation
  - People spontaneously evacuating
  - People refusing to evacuate & looting or vandalism

Sandia National Laboratories

Other Results

- Interviewees stated that the following contributed to the efficiency & effectiveness of their evacuation:
  - High level of cooperation among agencies
  - Use of multiple forms of emergency communications
  - Community familiarity with alerting methods
  - Community cooperation
  - Well-trained emergency responders

Sandia National Laboratories

NUREG/CR-6863 Status

- "Development of Evacuation Time Estimate Studies for Nuclear Power Plants"
- Released January 25, 2005

Sandia National Laboratories

Evacuation Time Estimate (ETE) Project

- Update to NUREG/CR-4831, *State of the Art in Evacuation Time Estimate Studies for Nuclear Power Plants* (1992)
- Technologies substantially changed since NUREG/CR-4831 issuance & additional potential considerations have emerged

Sandia National Laboratories

ETE = Estimated Time to Evacuate All Individuals From EPZ

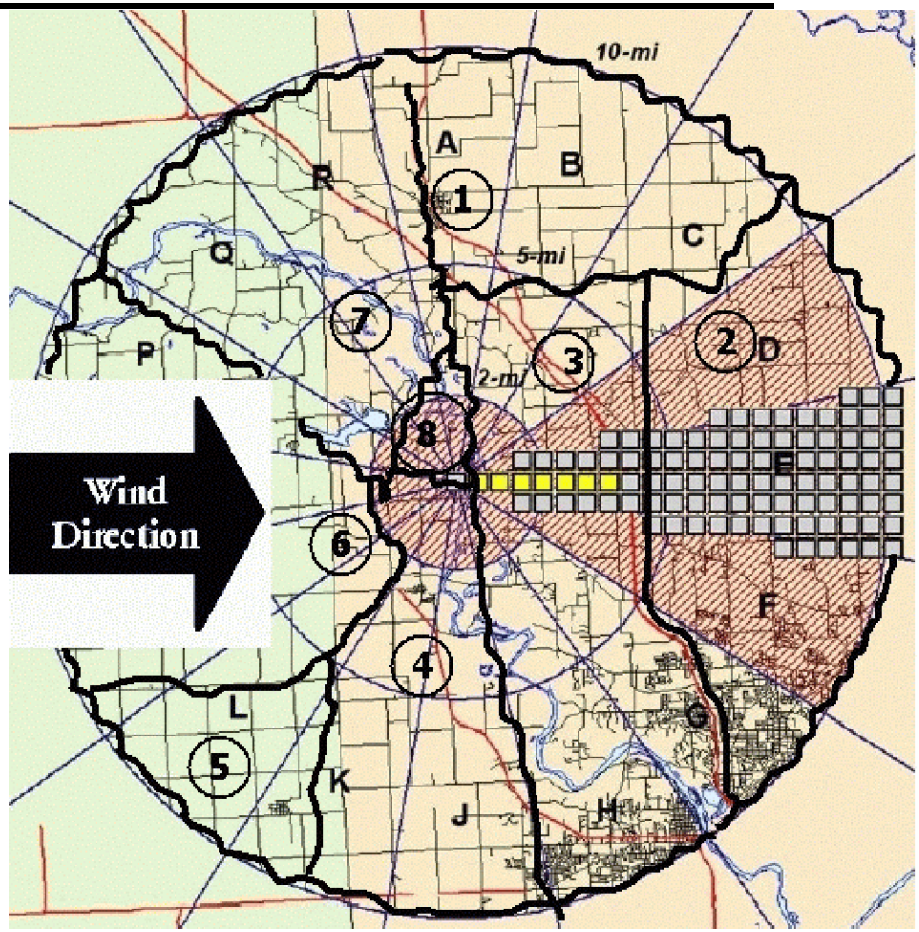
Some elements considered in the update include:

- Computer modeling
- Improved traffic management systems
  - Intelligent Transportation Systems
- Demand estimation
- Shadow evacuations
- Trip generation times
- Changes/additions to support Early Site Permitting (ESP) process
- Results of NUREG/CR-6864, the Evacuation Study

Sandia National Laboratories

Community Preparedness Essential to Support Defensible Assumptions

- Emergency Response Planning Areas (ERPAs) typically define local response boundaries
- Evacuation scenarios follow a ‘key hole’ approach
- Scenarios evaluated by rotating around the sectors & identifying a suite of ETEs



Sandia National Laboratories

Development of ETE

- Graded Approach
  - Not all EPZs are the same & not all ETEs require the same detail (e.g., Grand Gulf, Indian Point)
  - Methodology should be structured & defensible
- Modeling does not replace need for an analyst
  - Analyst must completely understand the model
  - Can be used to identify recommendations that would improve the ETE

Defensible & Transparent Documentation Is Important

Sandia National Laboratories

Modeling Can Support More Realistic ETEs

- Modeling Available for:
  - ETE calculations
  - Transportation modeling
  - Geographical information systems (GIS) platforms
- Model inputs & results require understanding of model & transportation activities
- Some parameters are highly sensitive

Sandia National Laboratories

Modeling Can Support More Realistic ETEs (Continued)

- Traffic Control automated with dynamic flow models that assign flow at intersections
  - Controlled intersections should be clearly identified
- Uncertainty in data should be identified & defended through sensitivity analyses
- Shadow Evacuations
  - Can be modeled to determine potential impact

Sandia National Laboratories

Transportation Analysis: Significant Component of ETE

- Trip generation times are developed to identify distribution of traffic loading:
  - Not everyone leaves at the same time
  - The sensitivity of trip generation times should be considered
  - Assumptions must be defensible
- Proactive traffic management can help maintain traffic flow & mitigate delays

Sandia National Laboratories

Summary

- Large-scale evacuations occur frequently in the U.S.
- Evacuations are effective, preplanned or ad hoc
- Public awareness is important contributor to efficient & effective evacuations
- NUREG/CR-6863 *Development of Evacuation Time Estimate Studies for Nuclear Power Plants* provides detailed guidance to be considered in developing or updating ETEs
- Methodology has not changed
- Calculations & assumptions must be documented & defensible

Sandia National Laboratories

Review of NUREG-0654, Supplement 3, Criteria for Protective Action Recommendations (PARs) for Severe Accidents

Sandia National Laboratories

Background

- 10 CFR 50.47(b)(10) requires licensees develop a range of PARs
- Identified areas for improvement & areas warranting further review & investigation
  - Concept is to investigate if reduction in dose may be accomplished through use of alternative protective actions

Sandia National Laboratories

NUREG-0654, Supp 3

- Guidance for determining protective actions for severe reactor accidents supported by conclusions from severe accident studies on effectiveness of protective actions
  - To be most effective, protective actions (evacuation or shelter-in-place) must be taken before or shortly after the start of a major radioactive release to the atmosphere
  - If a severe core damage accident occurs, people should immediately evacuate areas near the plant & shelter-in-place elsewhere for immediate future
  - Following a major radioactive release, dose from ground contamination may become significant in a few hours requiring prompt radiological monitoring to locate high levels of contamination

Sandia National Laboratories

PAR Activities

- Evaluation of PAR guidance will consider:
  - Technological advances
  - Spectrum of nuclear plant accidents or frequencies
  - Improvements in accident progression understanding
  - “Post-9/11 threat environment”

Sandia National Laboratories

PAR Activities (continued)

- Improvements in ETE technologies
- Additional sheltering strategies
- Additional evacuation strategies
- “Fast breaking” accident scenarios
- Improvements in dose projection techniques

Sandia National Laboratories

Research

- National & international literature review from the perspective of NUREG-0654, Supp 3, licensee & Offsite Response Organization (ORO) plans and procedures
  - Outline PAR practices, advances & trends
  - Meet with Stakeholders to discuss experience with implementation

Sandia National Laboratories

Accident Frequencies

- Catalog spectrum of accidents at ‘fleet level’
  - Develop a suite of reactor accidents - General Emergencies using NEI 99-01
  - Examine relative frequency of accidents considered ‘fast breaking’ or ‘severe’ vs. ‘not severe’ or with time to consider & prepare for PAR implementation
  - Determine sequences for which rapid ‘simplistic PARs’ may be necessary to reduce public dose
- Activity initially used accident progression analyses in NUREG-1150

Sandia National Laboratories

Technological Advances

- Examine advances that may affect understanding of PAR development & implementation
  - Accident progression
    - Integrate improvements since NUREG-1150
  - Dose progression techniques

Sandia National Laboratories

Technological Advances (Continued)

- Public notification methods
- Evacuation dynamics understanding
  - Incorporate results of Evacuation Study
  - Assess further details of evacuating an EPZ
- ETE technologies
  - Incorporate data from the recent evacuation work & ETE updates

Sandia National Laboratories

Modeling

- Perform analysis with MELCOR Accident Consequence Code System (MACCS2)
  - Determine relative advantages of alternative protective actions
  - MACCS2 = Gaussian plume model used for emergency planning
  - Multiple scenarios for assessment including:
    - Source terms
    - Weather conditions
    - Evacuation Time
    - Protective Action strategies

Sandia National Laboratories

Modeling (Continued)

- Examine efficacy of alternative sheltering & evacuation strategies in reducing dose to the public
  - Perform analysis to determine relative advantages of sheltering & evacuation
  - Timing of offsite release compared to the ETE
  - Dose savings for sheltering or evacuation vs. plume type
  - Timing of release vs. public notification time
  - Time for evacuation
  - Duration of sheltering

Sandia National Laboratories

Modeling (Continued)

- Alternative sheltering & evacuation strategies (continued)
  - Efficacy of sheltering as initial action followed by staged evacuation
  - Examine impact of sheltering one ERPA & evacuating others
  - Catalog implementation requirements for strategies that appear to reduce dose to assess feasibility of implementation

Sandia National Laboratories

Practical Considerations

- Assess implementation, realism & cost issues of alternative evacuation strategies
  - Cross-wind evacuation
  - Staged evacuation
  - Improvements in traffic control techniques
  - Efficacy of sheltering special needs groups
  - Other techniques for improving implementation

Sandia National Laboratories

Other Practical Considerations

- Determine likely public acceptance of alternate sheltering strategies
- Determine methods to communicate advanced PAR strategies
- Determine if other sociological factors should be considered in development of PAR strategies

Sandia National Laboratories

Summary

- Study evaluates potential PAR strategies
  - Dose savings to the public
  - Improve public confidence
  - Facilitate implementation of protective actions
- Must be a balance between PAR complexity & benefit
- Continued interaction with stakeholders

Sandia National Laboratories