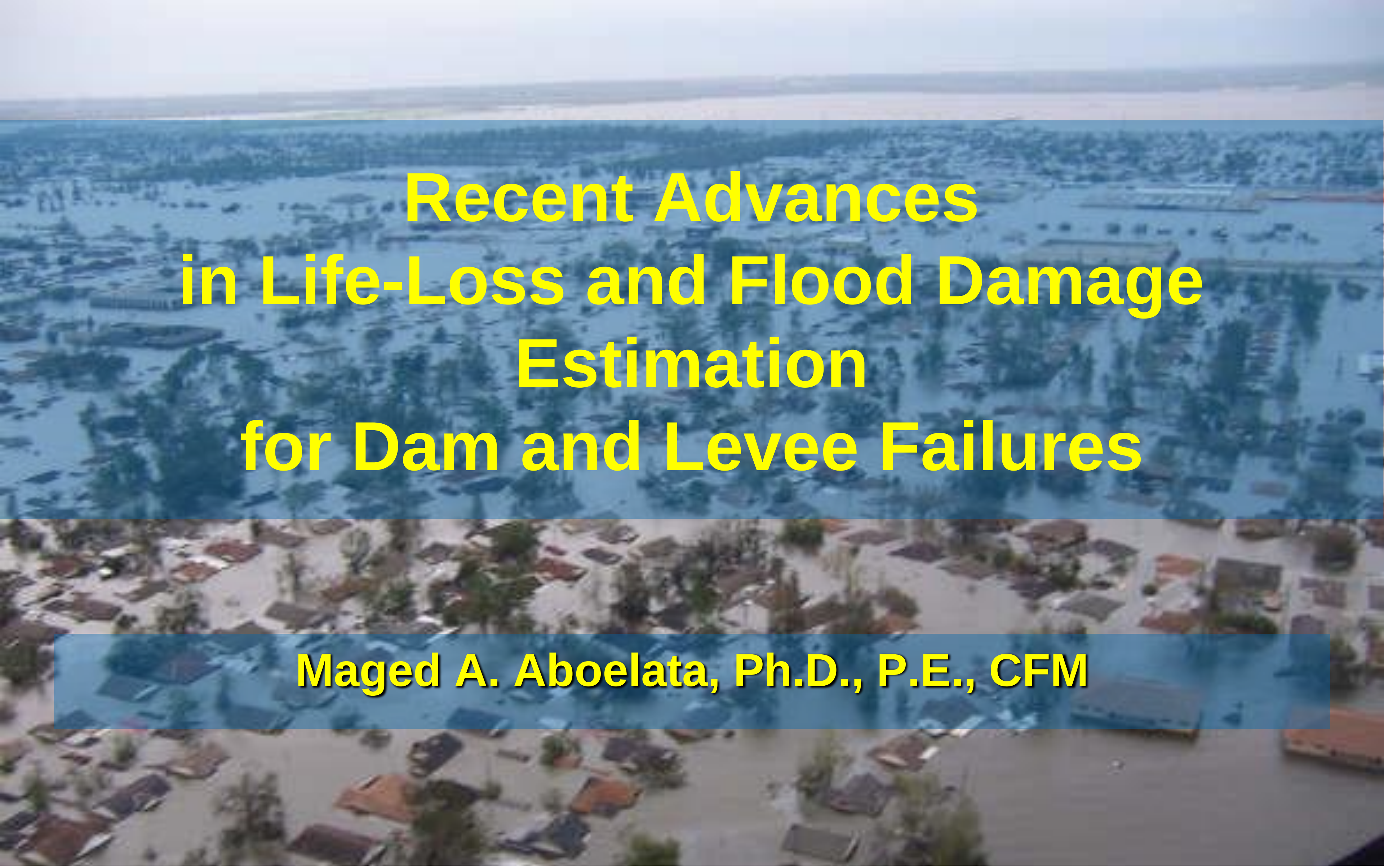


Recent Advances in Life-Loss and Flood Damage Estimation for Dam and Levee Failures

Maged A. Aboelata, Ph.D., P.E., CFM

Presentation Outline

- Why estimate life loss?
- LIFESim and HEC-FIA Methodologies
- Similarities and differences
- Future Development

Why Estimate Life Loss?

- Dam Failure Consequence Analysis
- Risk reduction measures
- Cost effectiveness/justification

Background

- Friedman (1975)
  - Function of the number of damaged dwellings and flood type (normal or flash)
- Petak and Atkinson (1982)
  - Loss of life is only due to structure damage.
- Paté-Cornell and Tagaras (1986)
  - 90% in the path of the flood wave and 10-15% in the rest of inundation area.
  - Factors are subjectively adjustable.
- USBR model (Brown and Graham, 1988)
  - Insufficient warning (function of Par.)
  - Sufficient warning.
  - Second version added warning time.
- Stanford/FEMA Model
  - Different functions for residential and commercial districts.
  - Function of Par, flood depth, and river mile.
  - Modified by IWR(1986) to include warning time instead of river mile.
- DeKay and McClelland Model (1991, 1993)
  - Function of population, warning time, and flood severity

Limitations of Statistical Methods

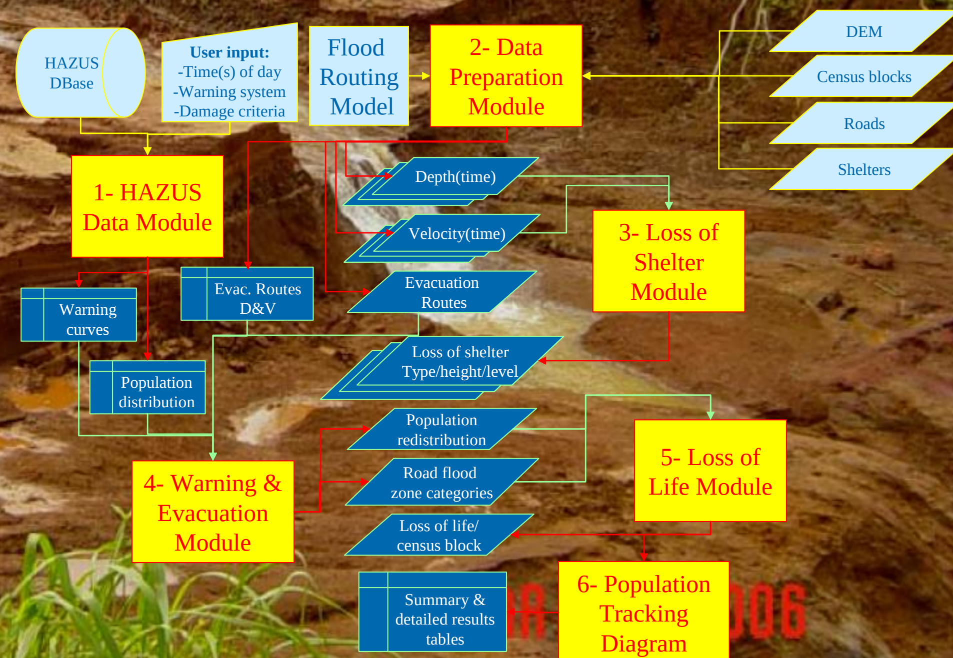
- Depending on limited number of factors.
- Large-scale averaging for flooding characteristics.
- Lumping of population at risk.
- Ignoring dynamics of warning and evacuation.
- Depending on regression for various events.

Factors Affecting Life-Loss

- PAR Location
  - Downstream distance
  - Elevation
- Warning System
  - Coverage
  - Effectiveness throughout the day
- Mobilization
  - Believability
  - Knowledge
- Roads
  - Capacity
  - Destinations

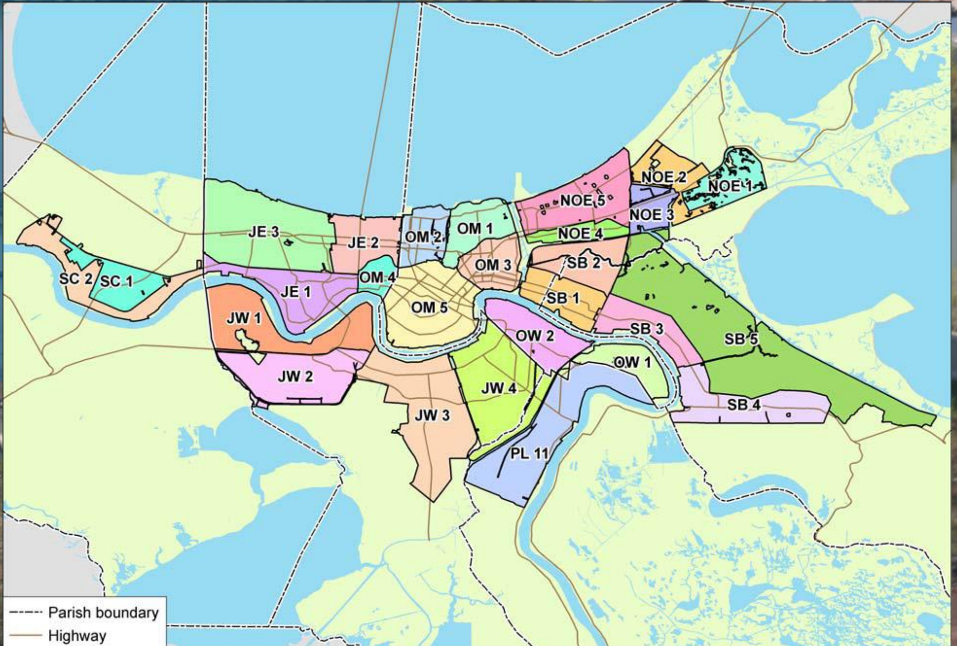
Modeling System Overview

- Initial Development at USU funded by US Army Corps of Engineers, ANCOLD & USBR
- Modular, Spatially-distributed, Dynamic Simulation System



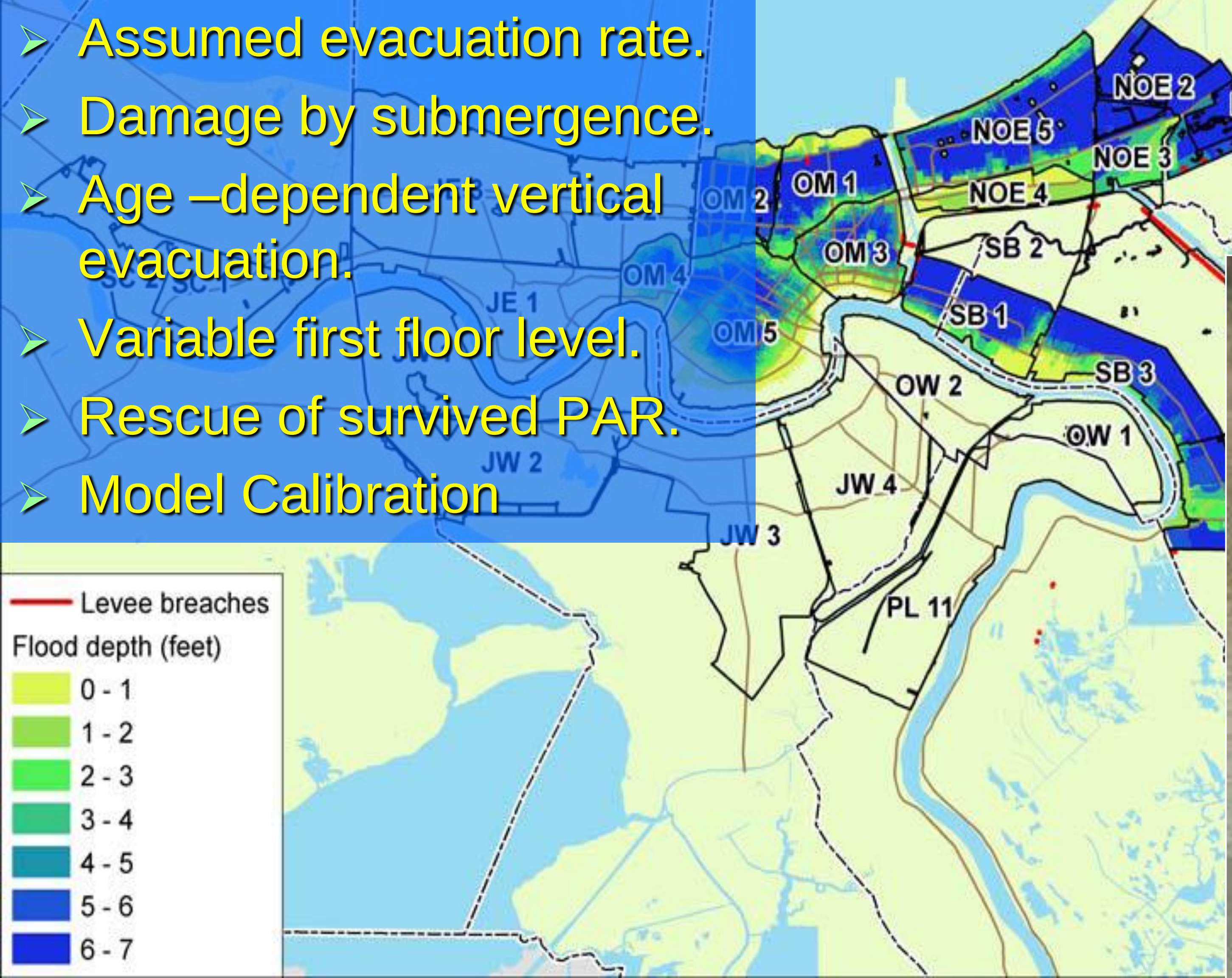
Hurricane Katrina Life-Loss Modeling

- USACE Interagency Performance Evaluation Task (IPET) Force.
- Estimate loss of life associated with hurricane-related future flood events.
- Pre- and post-event analysis:
  - 27 drainage basins.
  - Incremental life-loss.
  - Uncertainty analysis.



LIFESim Modifications

- Assumed evacuation rate.
- Damage by submergence.
- Age –dependent vertical evacuation.
- Variable first floor level.
- Rescue of survived PAR.
- Model Calibration



Wolf Creek Dam

- Owned and operated by the USACE
- Operation restrictions during repair
- Impact assessment for over 60 miles downstream of the dam

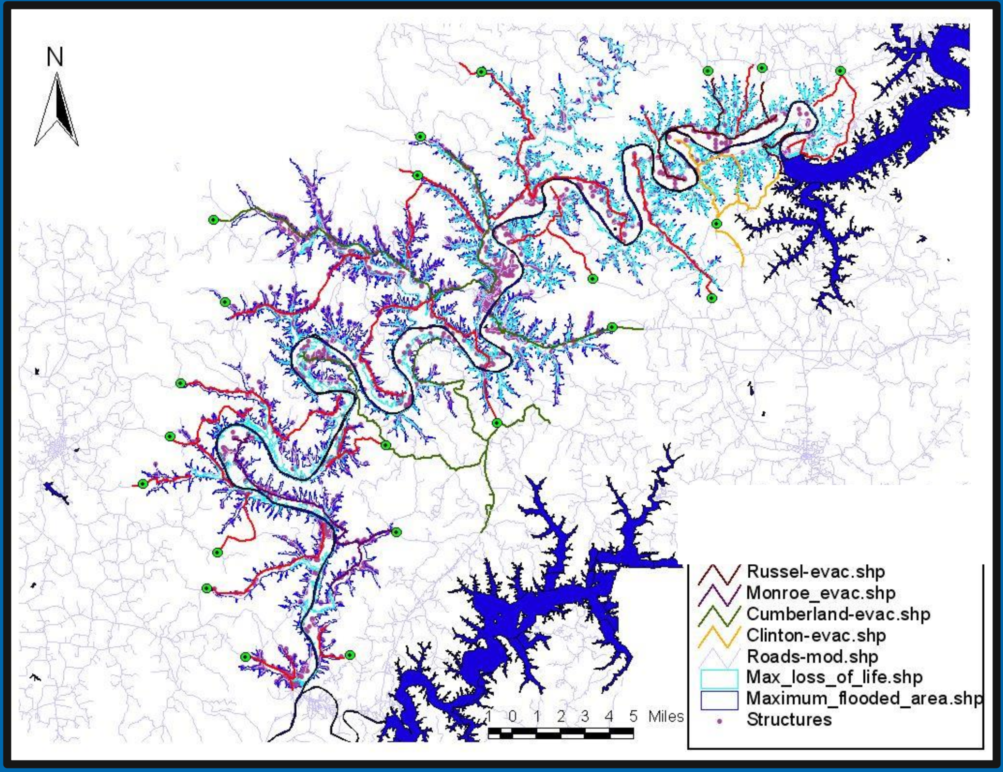
- Events
  - Eight dam breach cases

- Exposure
  - At two-hour intervals

Wolf Creek Dam, KY

Wolf Creek Dam

- Lessons learned:
  - Time of day population and activities variation
  - Extra-long warning time
  - Multiple Emergency Planning Zones
  - Structure Survey Data



Method Overview

- Two Versions:

  1) LIFESim
     - Deterministic Mode
     - Uncertainty Mode

  2) HEC-FIA
     - Simplified processes
     - Less data requirement

- Development Philosophy

  - Include important processes
  - Readily available data
  - Empirically-based fatality rates
  - Reasonable implementation effort

Life Loss Cases for RA
Event-Exposure Scenarios

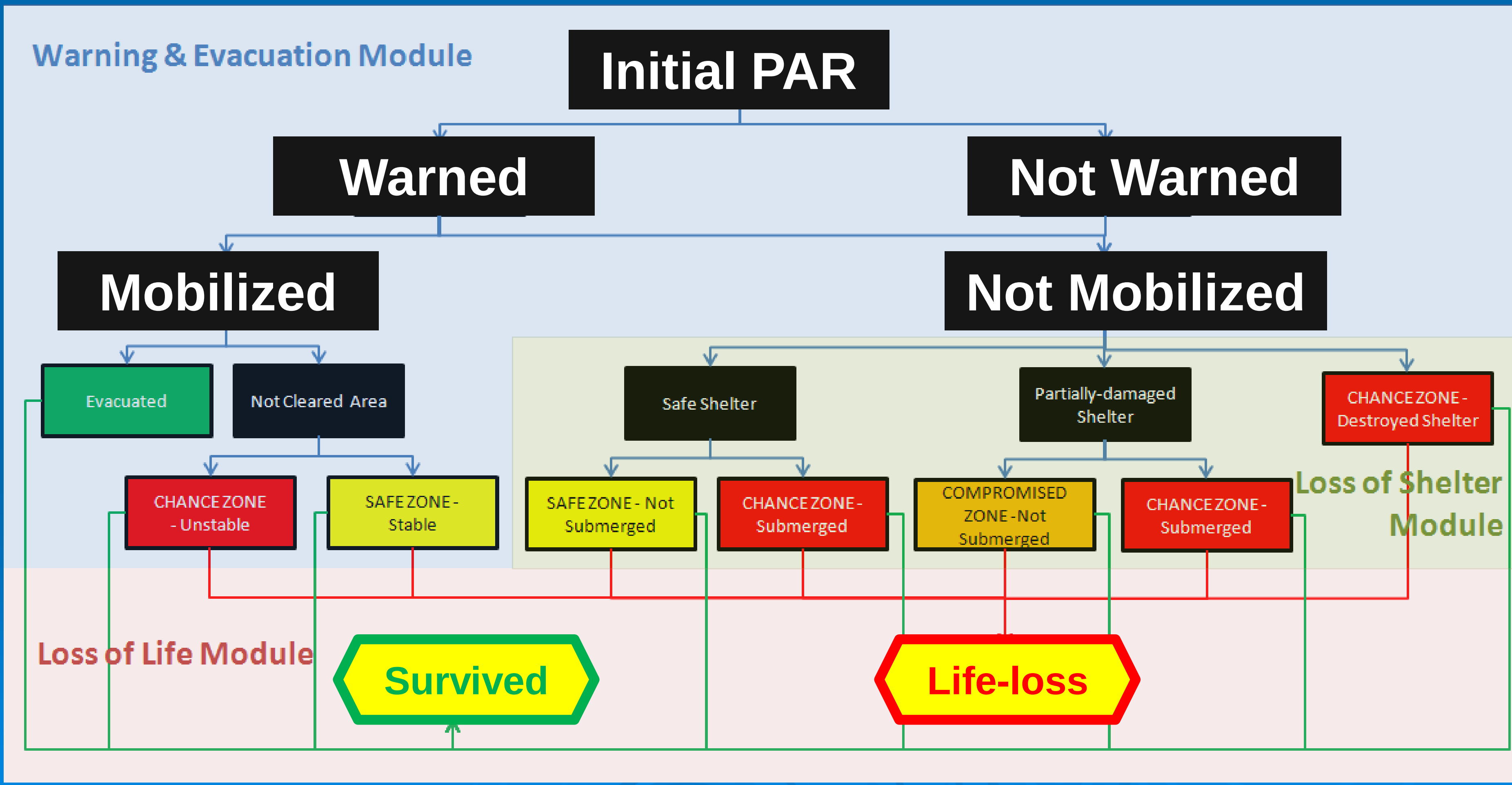
- Events:
  - Failure modes and locations
  - Reservoir levels and inflow floods
  - No-failure floods

- Exposure Cases:
  - Season
  - Time of day
  - Weekend/weekday

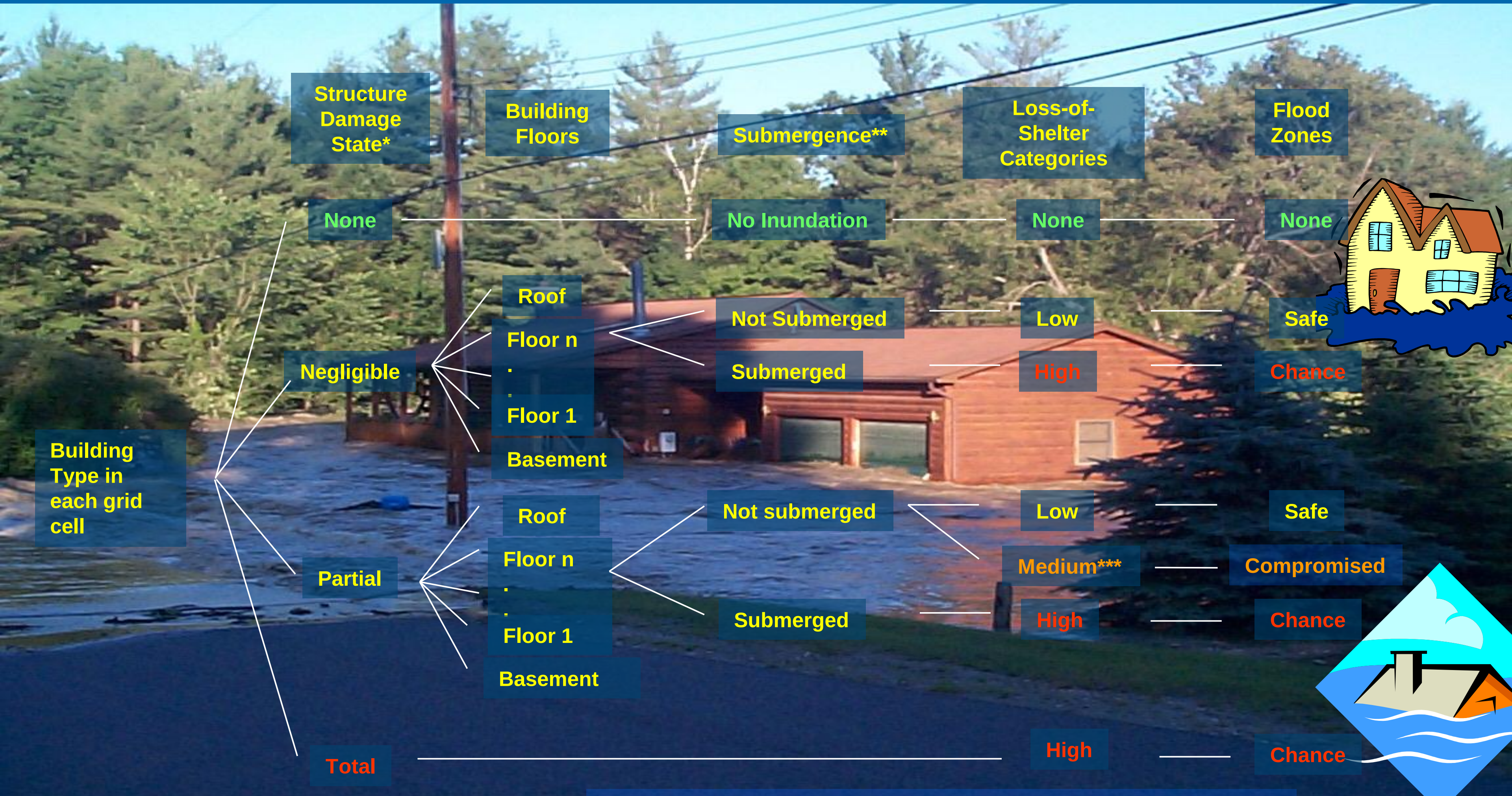
Data Sources

- Census Data
  - Census blocks
  - Roads
  - Hydrology
- USGS
  - DEM
- HAZUS-MH
  - Population activity distributions for 3 time-of-day scenarios
    - Night
    - Day
    - Commuting
  - Building information

Modeling Approach

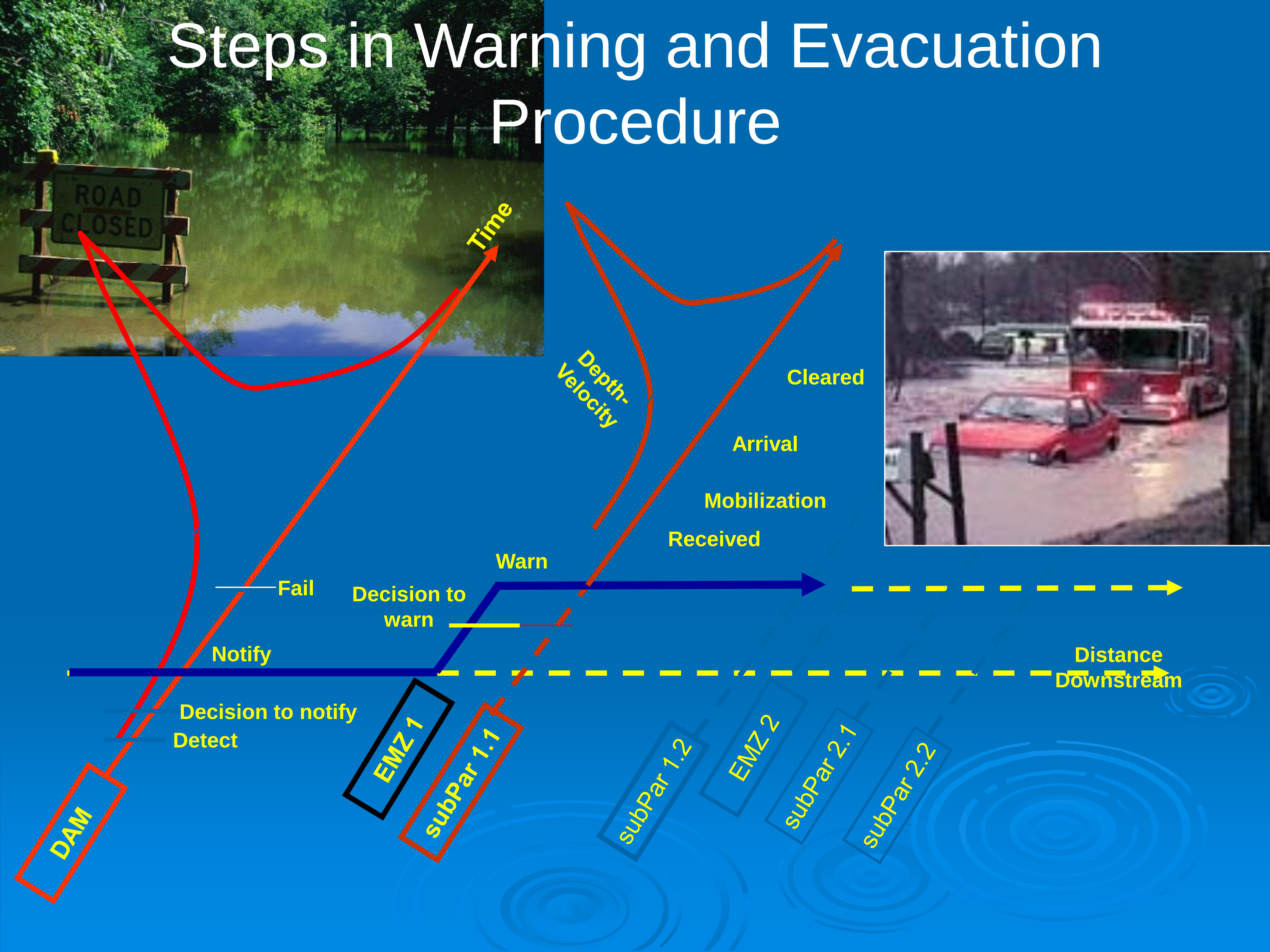


Loss-of-Shelter Categories/Flood Zones for Buildings

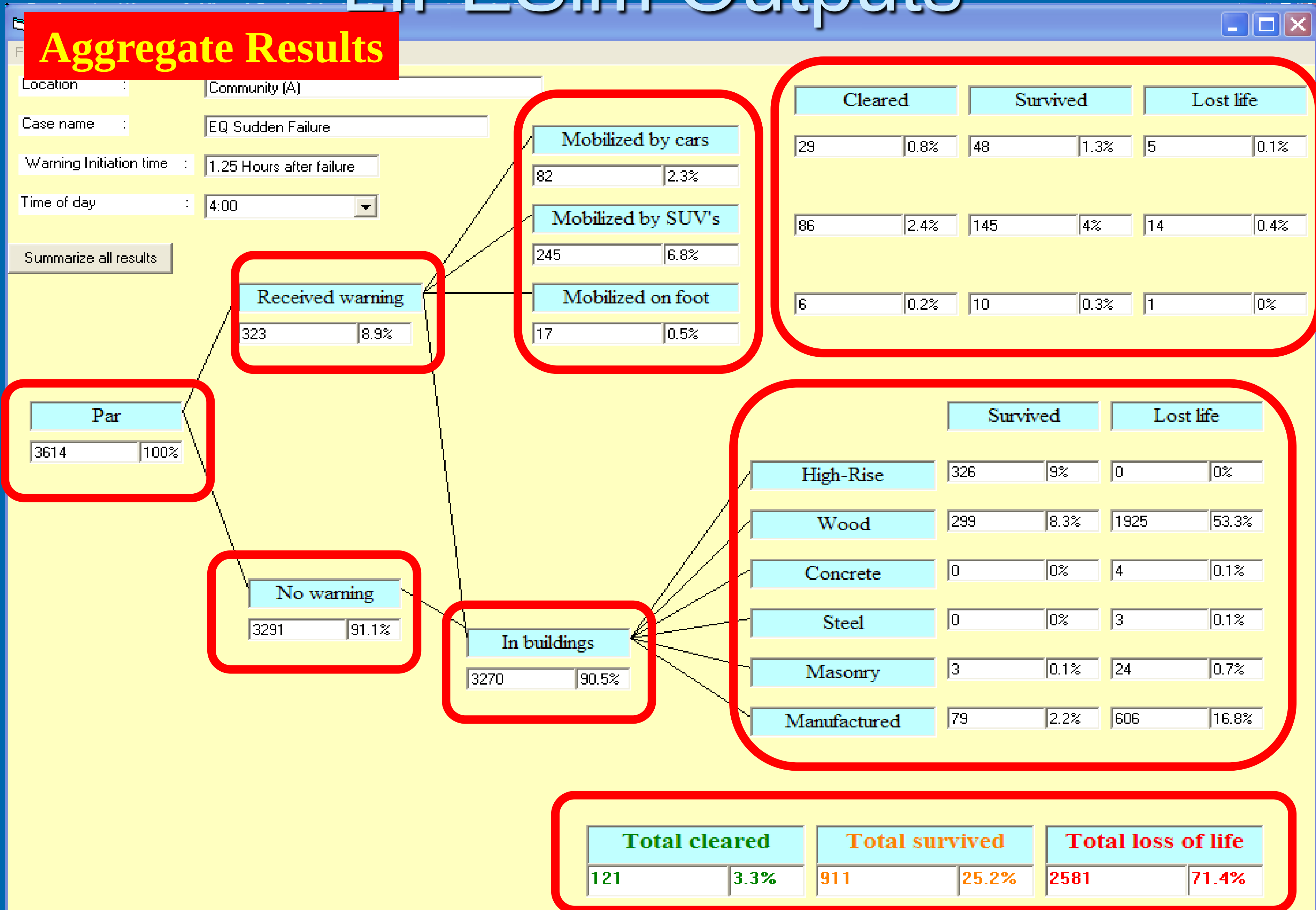


*	Use building performance criteria
**	Use loss of shelter by submergence criteria
***	Use human stability criteria

Steps in Warning and Evacuation Procedure

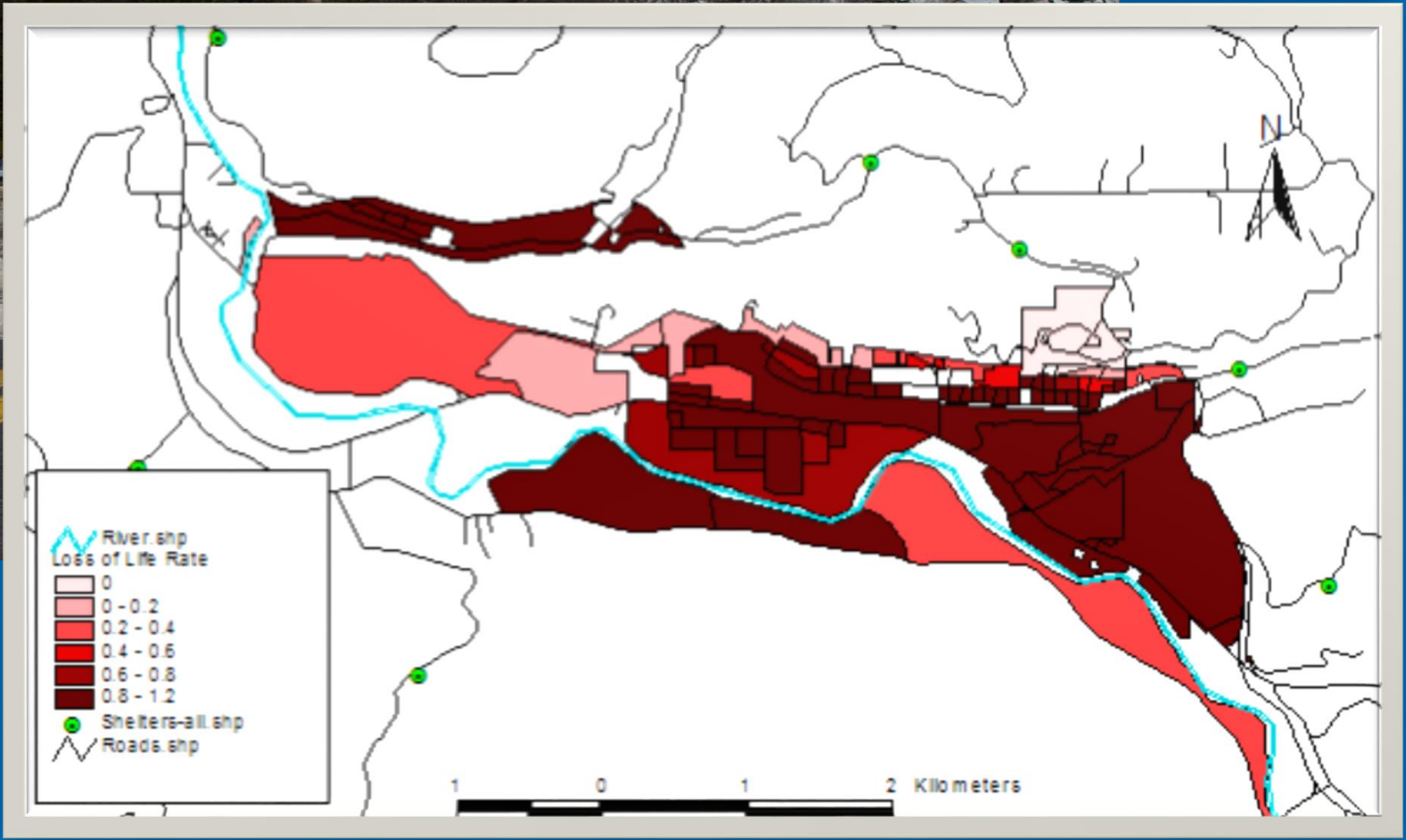


LIFESim Outputs



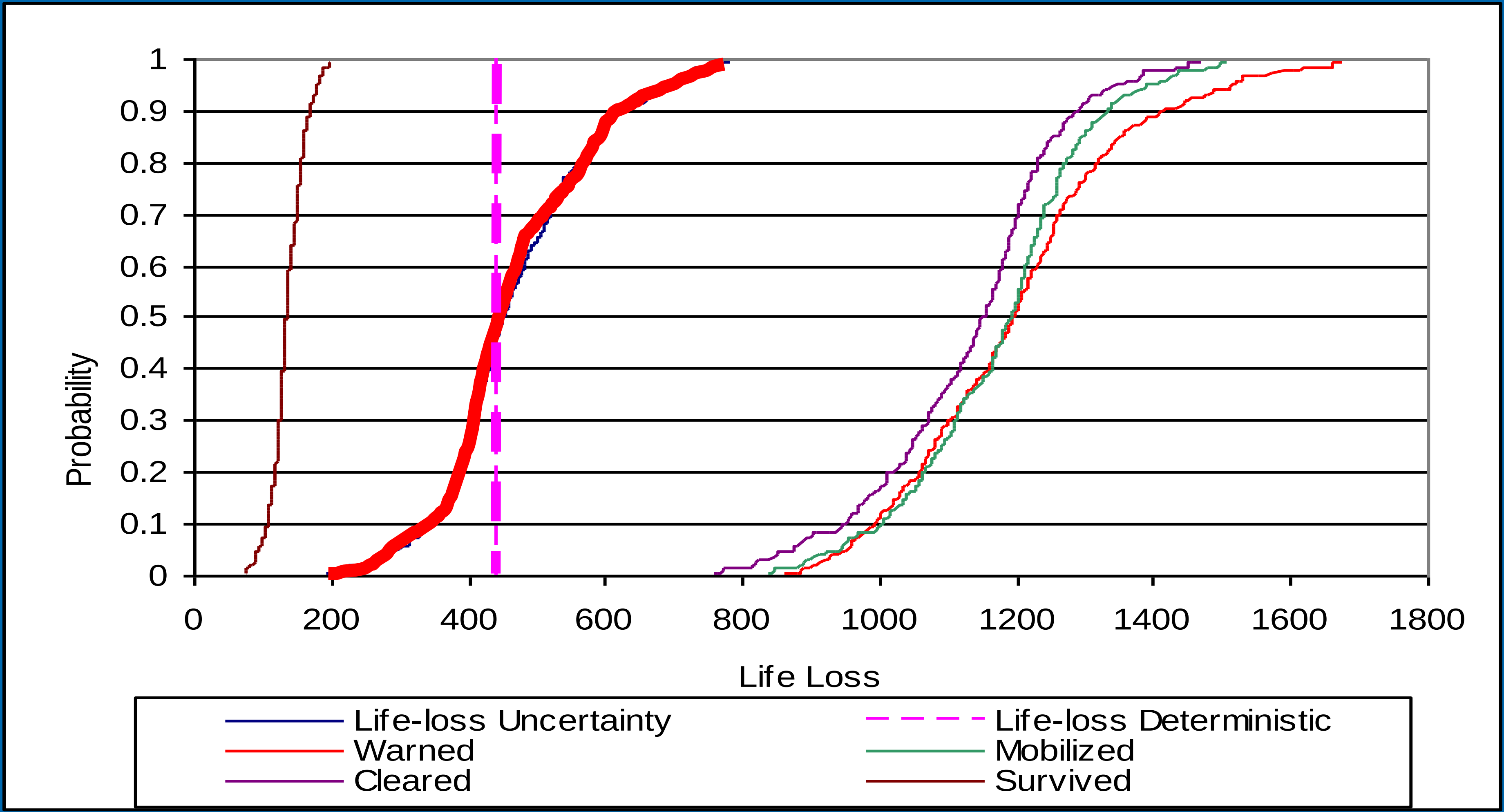
LIFESim Outputs

Spatially Distributed Results



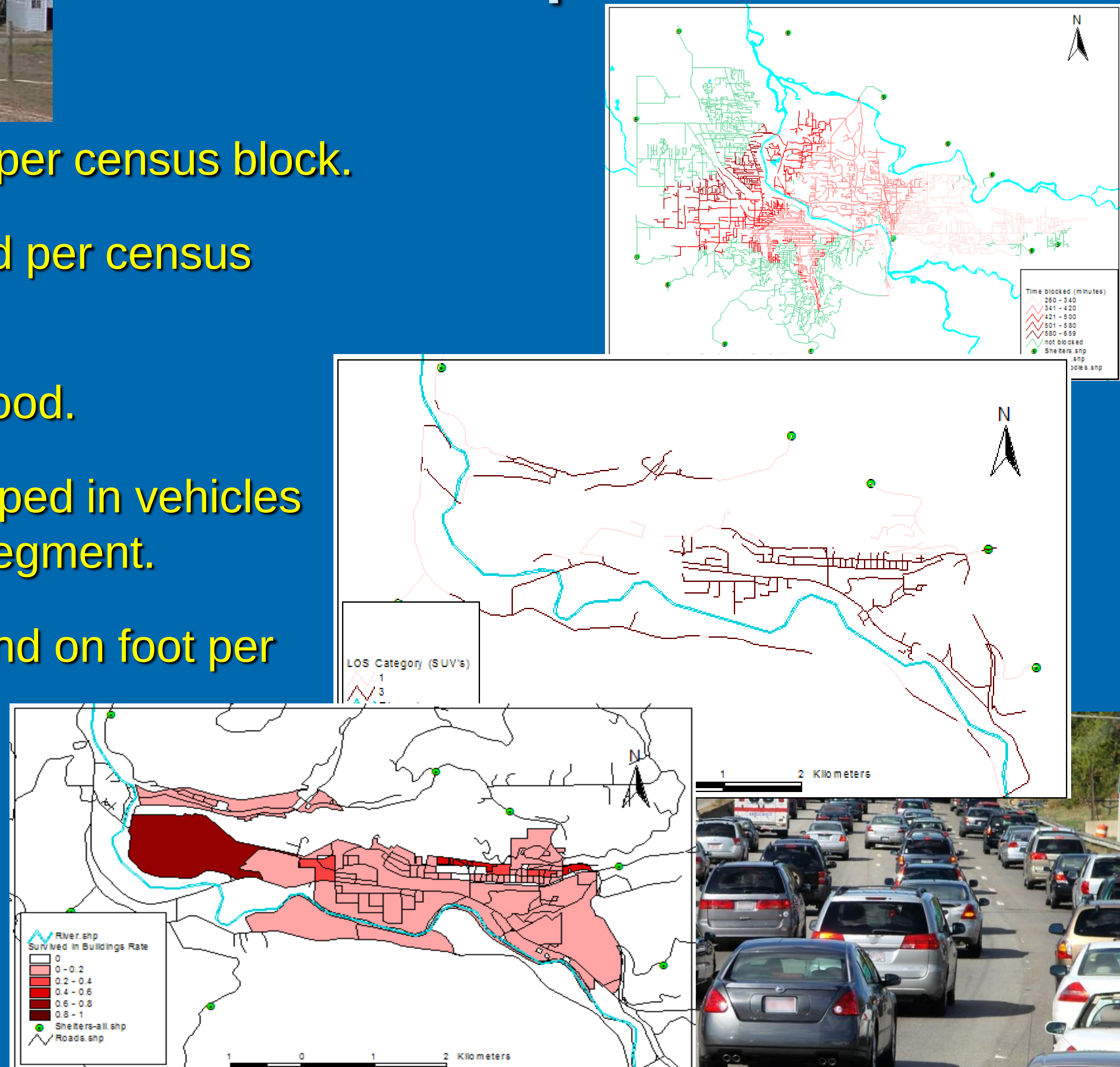
LIFESim Outputs

Probability Distributions



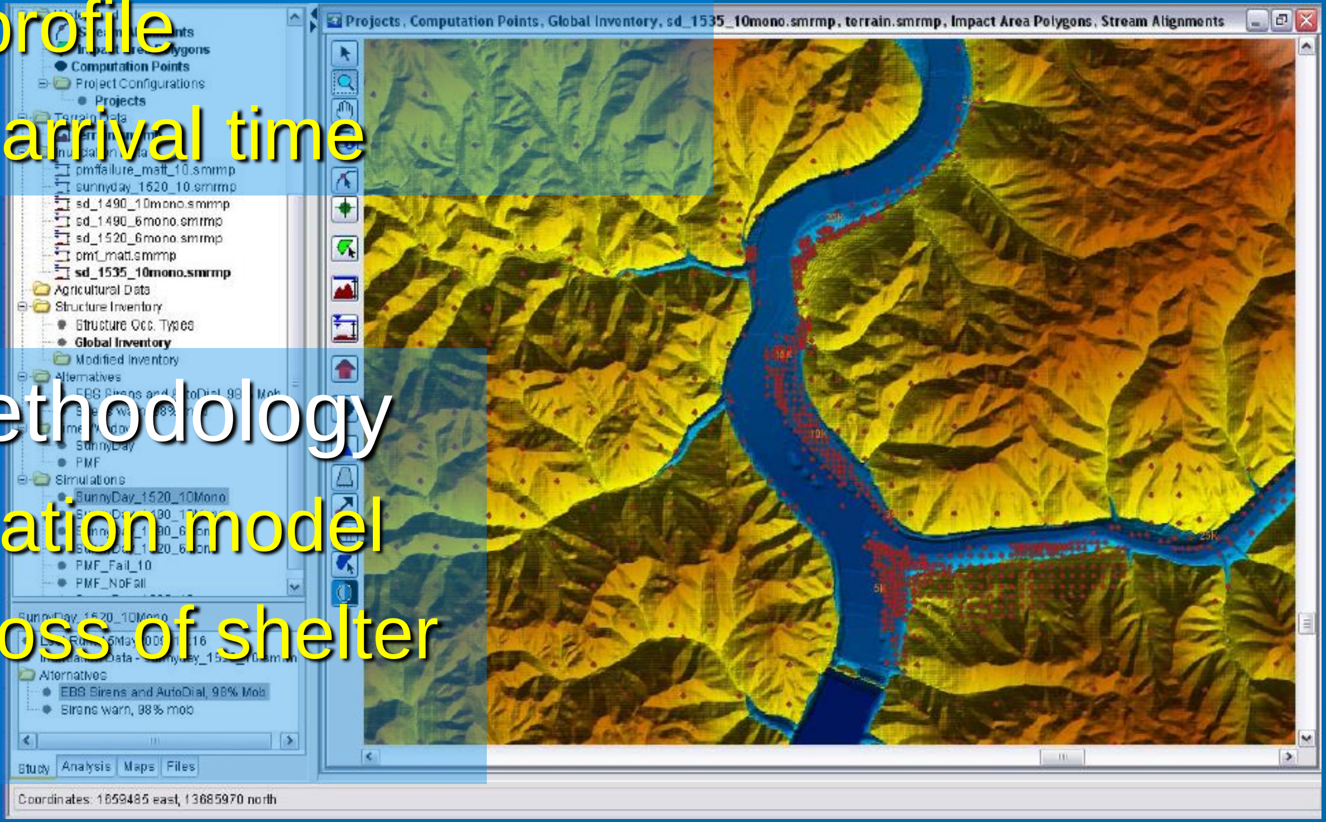
Other LIFESim Outputs

- Percent PAR warned per census block.
- Percent PAR mobilized per census block.
- Time to blockage by flood.
- Number of people trapped in vehicles and on foot per road segment.
- Fatalities in vehicles and on foot per road segment.



HEC-FIA

- Simplified Data Requirements
  - Peak flood profile
  - Flood wave arrival time
- Simplified Methodology
  - Basic evacuation model
  - Depth-only loss of shelter



What's Different?

Module	LIFESim	HEC-FIA
Hydraulics	uses spatially distributed time series of depth and velocity	uses spatially distributed peak water surface elevation and arrival time
Loss of shelter	depth and velocity time series	peak depth
	individual structures or census block data	individual structures
	progressive damage assessment throughout the flood event	damage at peak depth
	depth and velocity dependent	depth dependent
Evacuation	time series of depth at structures and along roads	flood wave arrival time
	dependent on road conditions	fixed for each structure
	uses road network to shelter	straight distance to shelter
	traffic dynamic simulation	fixed evacuation time per structure
Life-loss	per structure and road segment	per structure
uncertainty	Monte-Carlo simulation	sensitivity analysis

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LIFESim or HEC-FIA?

- Study area characteristics
- Goals of assessment
- Time limitations

Current Status

- Collaboration with USACE-HEC:
  - Reprogramming to improve user friendliness
  - Rigorous model verification
  - Socio-economic analysis for mobilization

- HEC-FIA:
  - Requires less data
  - Produces faster estimate

- Additional improvements
  - Rescue simulation
  - Improve evacuation simulation

Conclusions

- Reasonable life-loss estimates are an essential input to Dam Safety Risk Assessment
- Life loss is intrinsically uncertain
  - Incorporate uncertainty in
    - life-loss estimates and
    - Risk Assessment results for decision makers
- LIFESim & HEC-FIA
  - Under continuing development
  - Requires reasonable effort
  - Multiple levels of details
  - Demonstrated and applied to several dams and levees
  - A tool for evacuation planning tool for emergency managers

Questions??

E-mail:

maged.aboelata@urs.com