

# **Delta Risk Management Strategy Seismic Fragility Analysis**

## *Lessons & Questions*

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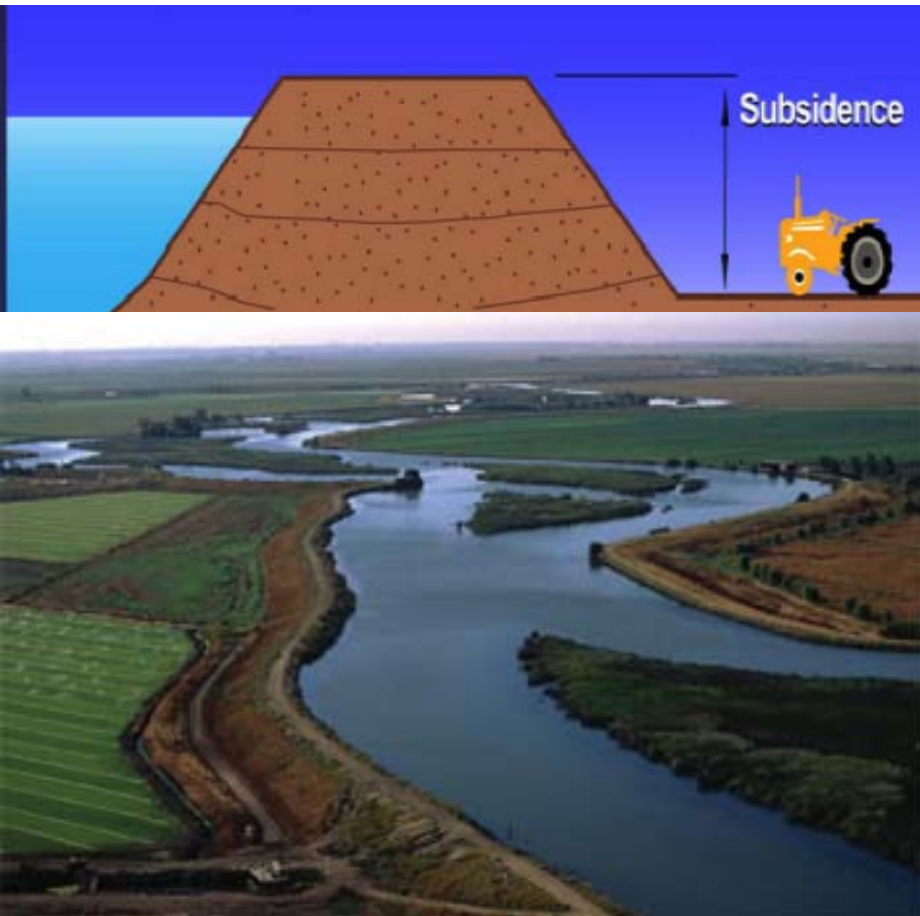
**October 1, 2011**

# Sacramento-San Joaquin Delta



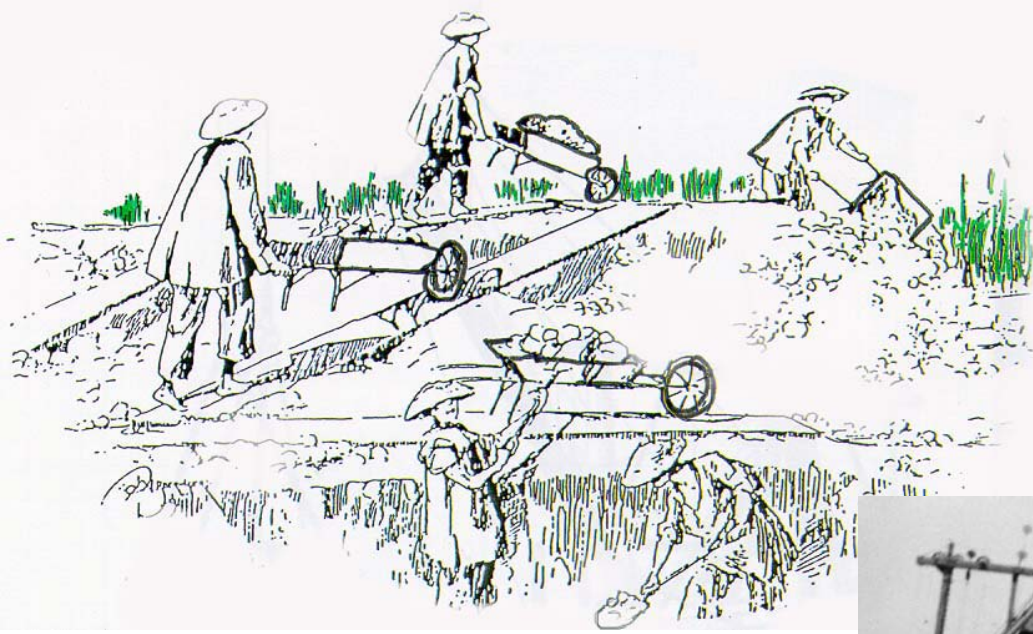
# Delta Levees

## Delta ~~Levees~~ Dams

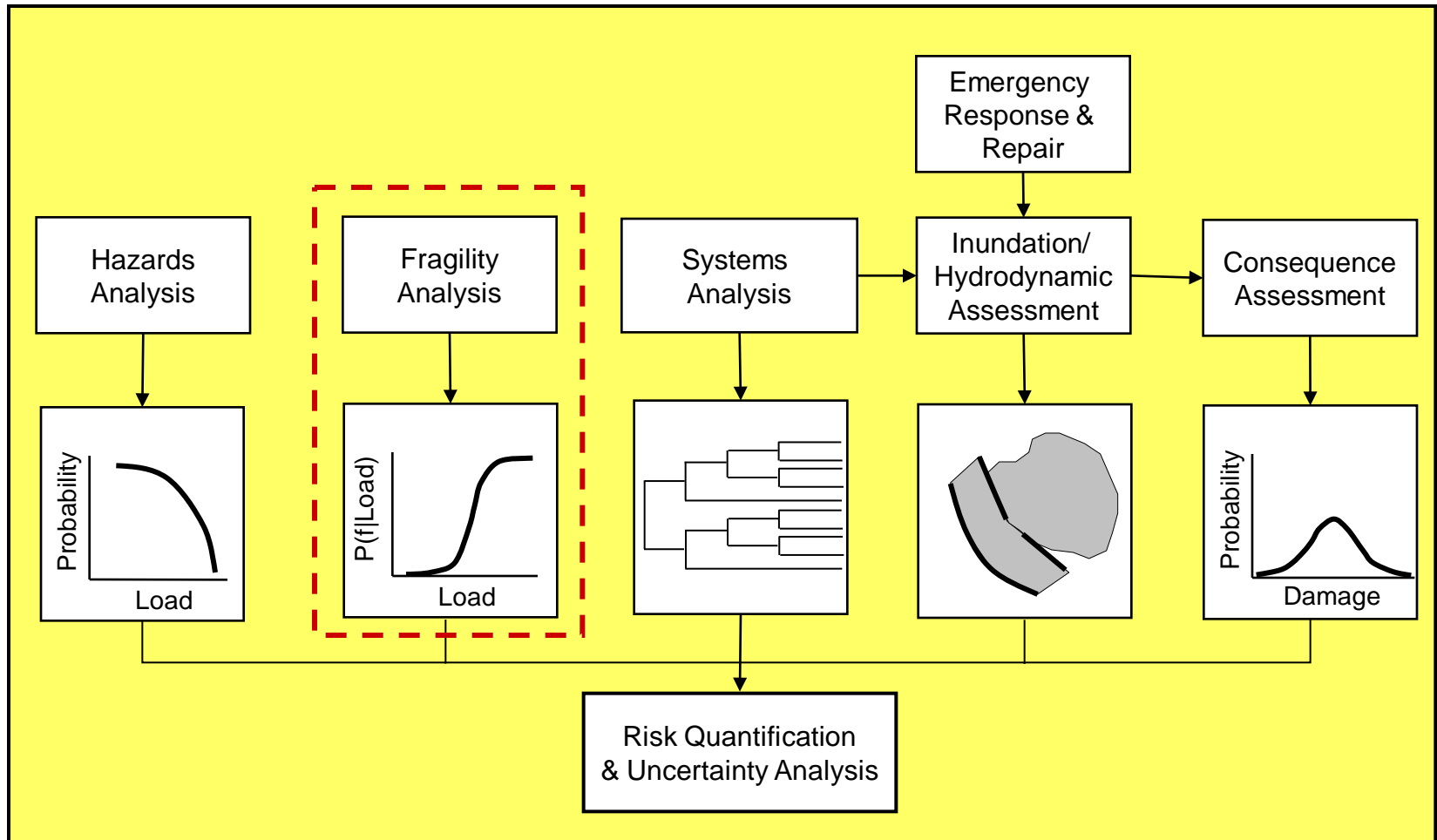


- Imagine a 'dam' 1,110 miles long
- Large fraction of the total length has blow counts of 20 or less; 80+ % liquefiable material
- What is the seismic fragility/ reliability of the 'system'?
- How many 'breaches'?
  - Number, or
  - Per mile
- How confident are we in the results?

# Levee 'Design' & Construction



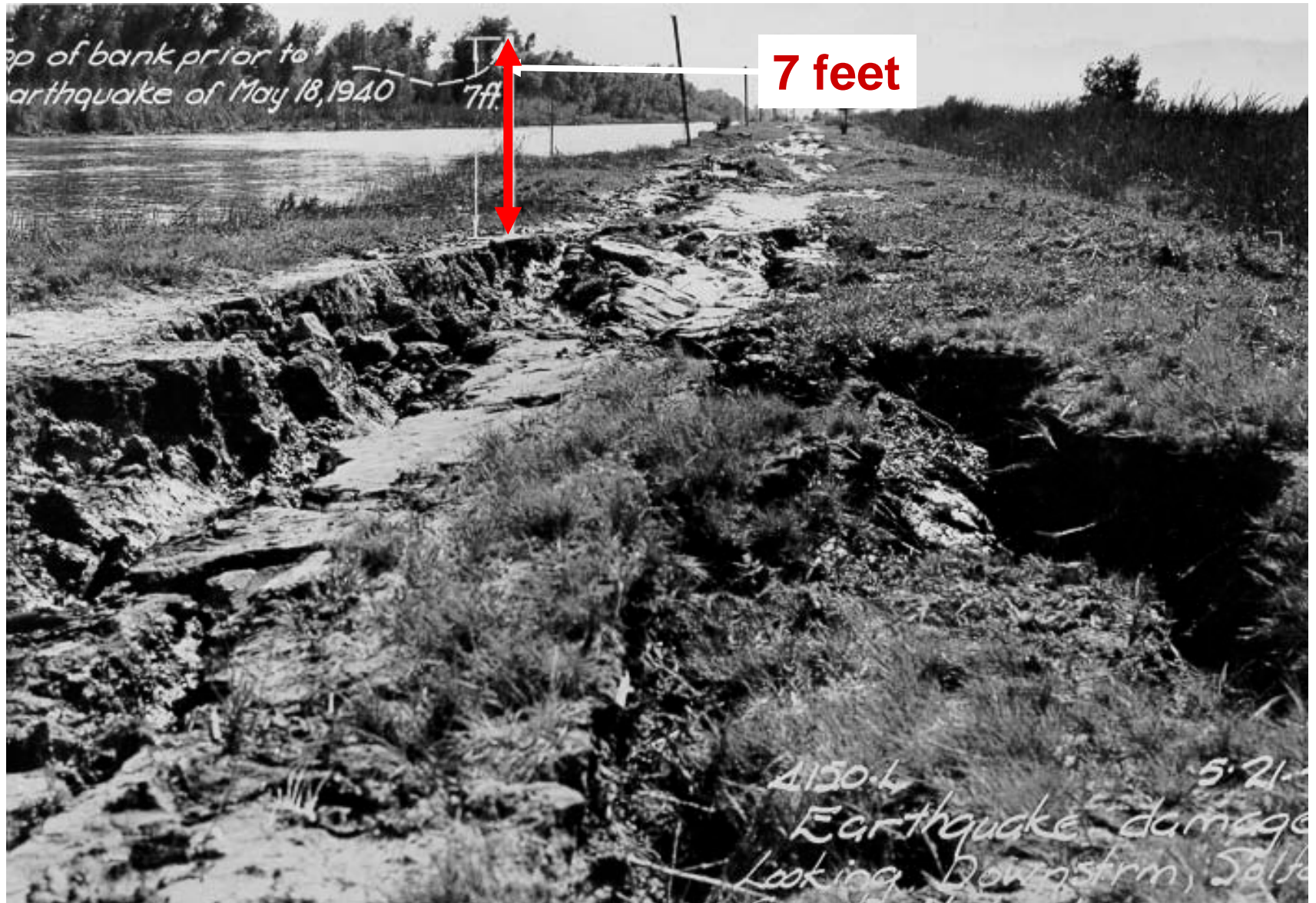
# Elements of a Seismic Risk Analysis



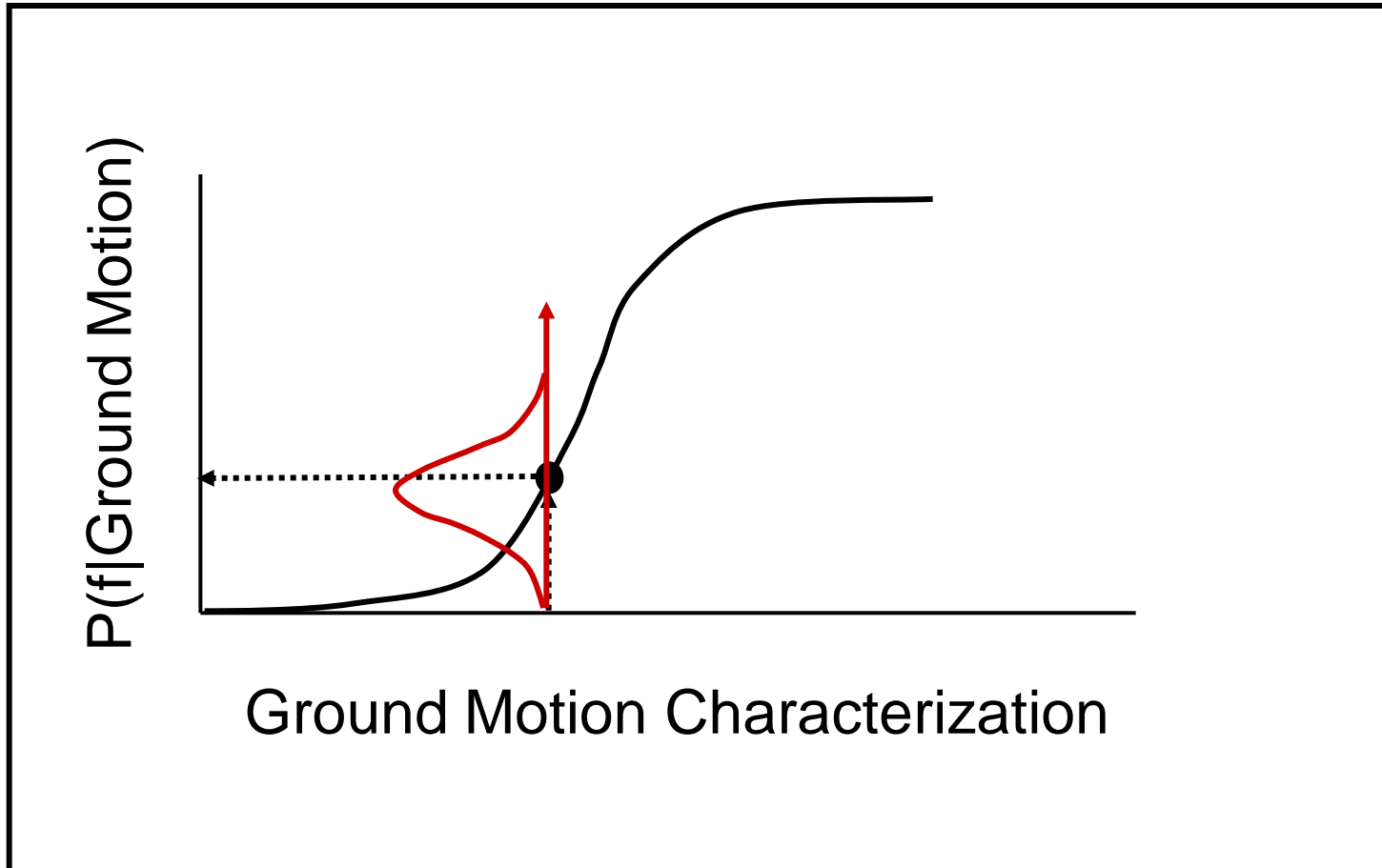
# What We Want to Predict: Breaching



# We Also Want to Predict: Non-Breach Damaged



# Fragility Representation

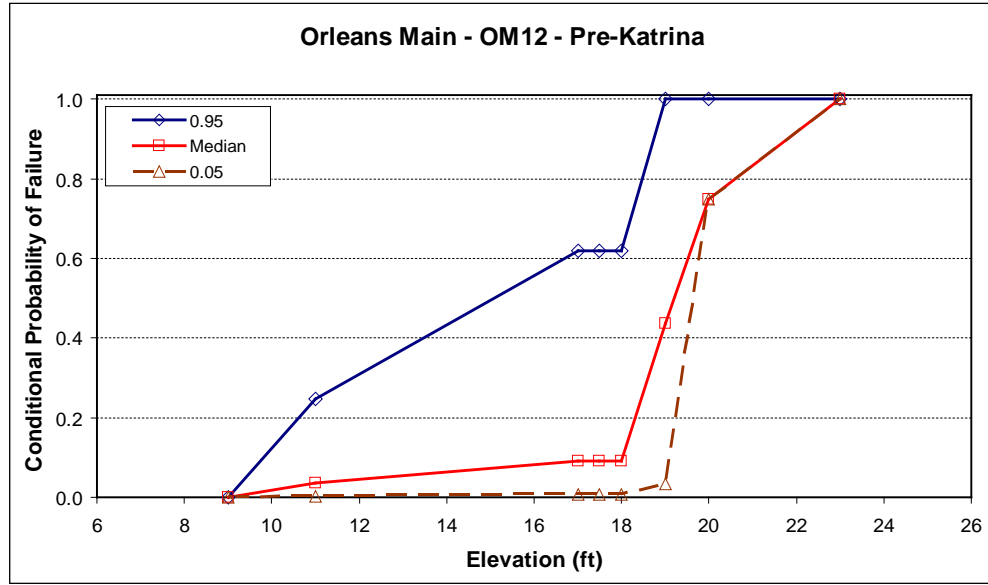
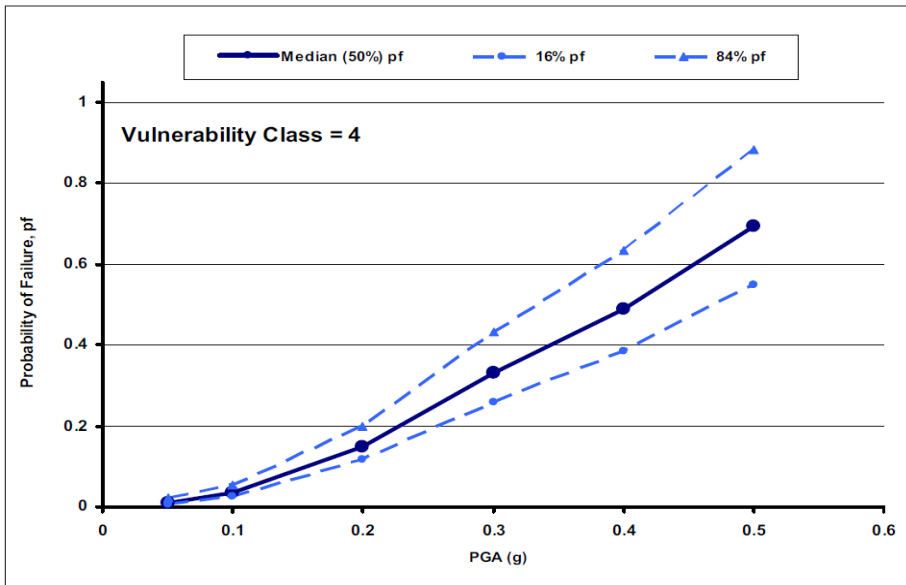
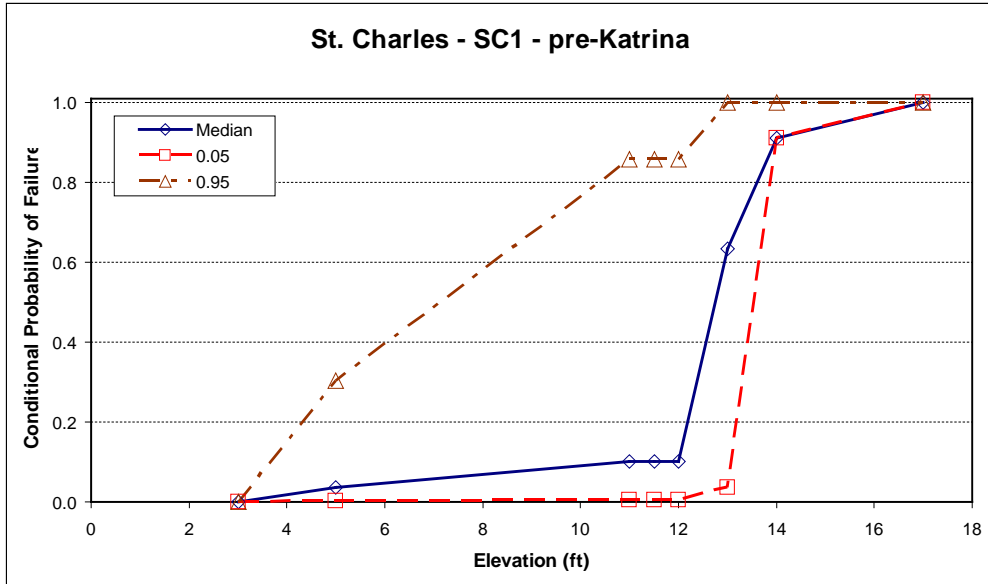
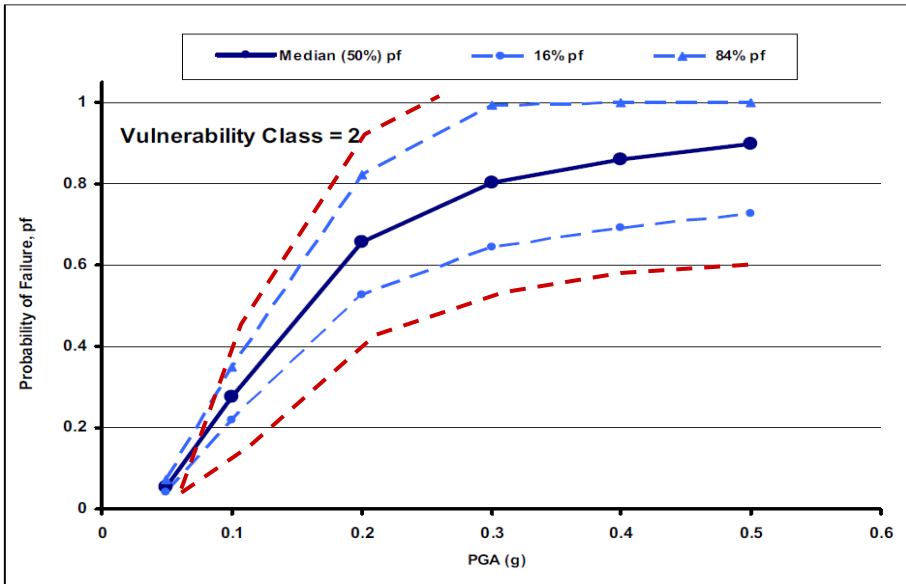


# Levee Fragility Analysis

- Fragility analysis estimates the conditional probability of failure as a function of a loading parameter (ground motion; elevation)
- For earthquake and flood (geotechnical) failures there is considerable uncertainty in estimating when failure occurs and how likely it is to occur
- Sources of uncertainty:
  - Defining the failure/performance state
  - Model uncertainties (modeling the 'real' world)
  - Estimating model parameters (prior to and at failure)

# Fragility Results

## Delta New Orleans

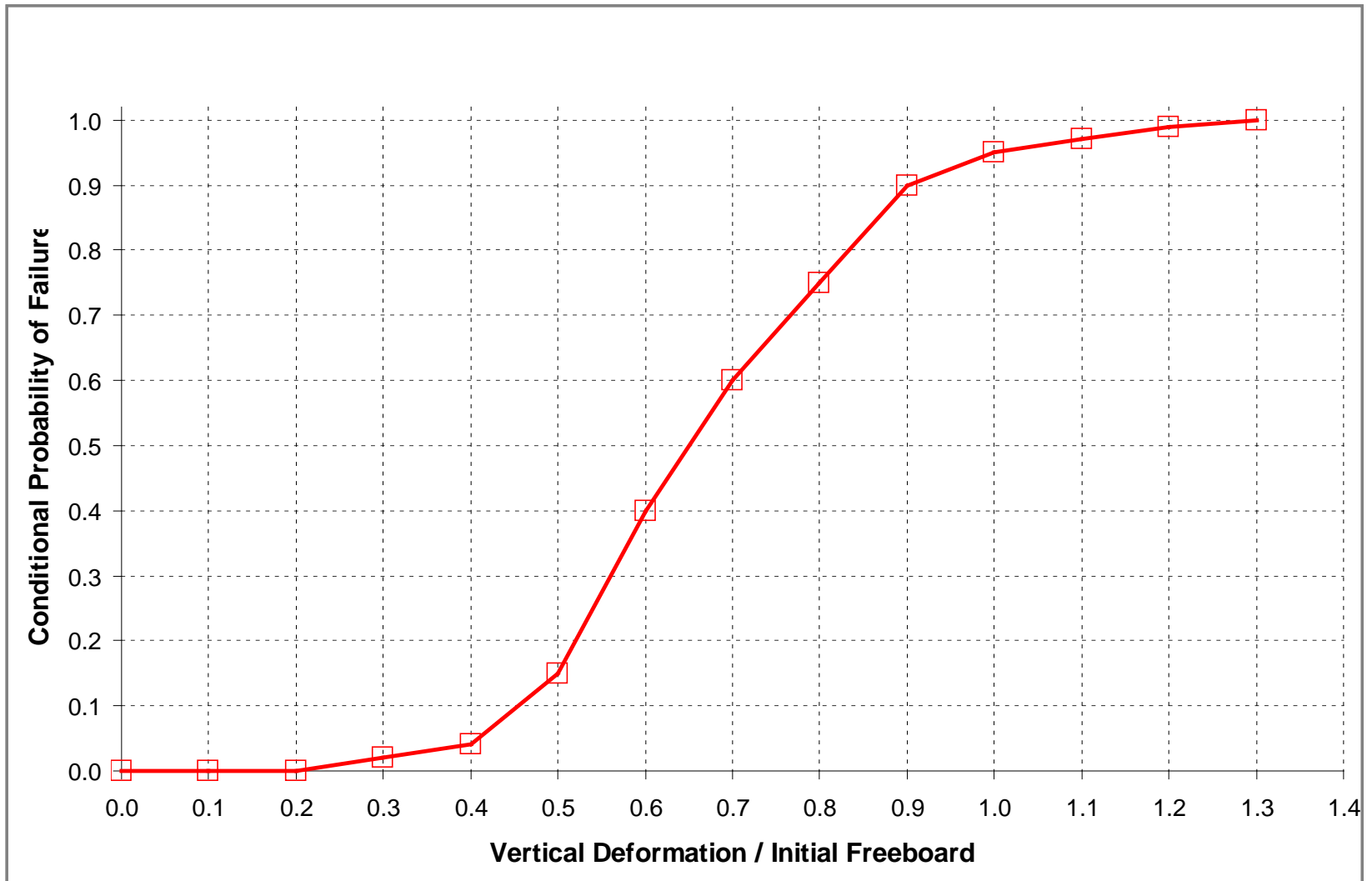


# Defining Failure / Estimating the Fraction of Times It Occurs

## (Aleatory Uncertainty)

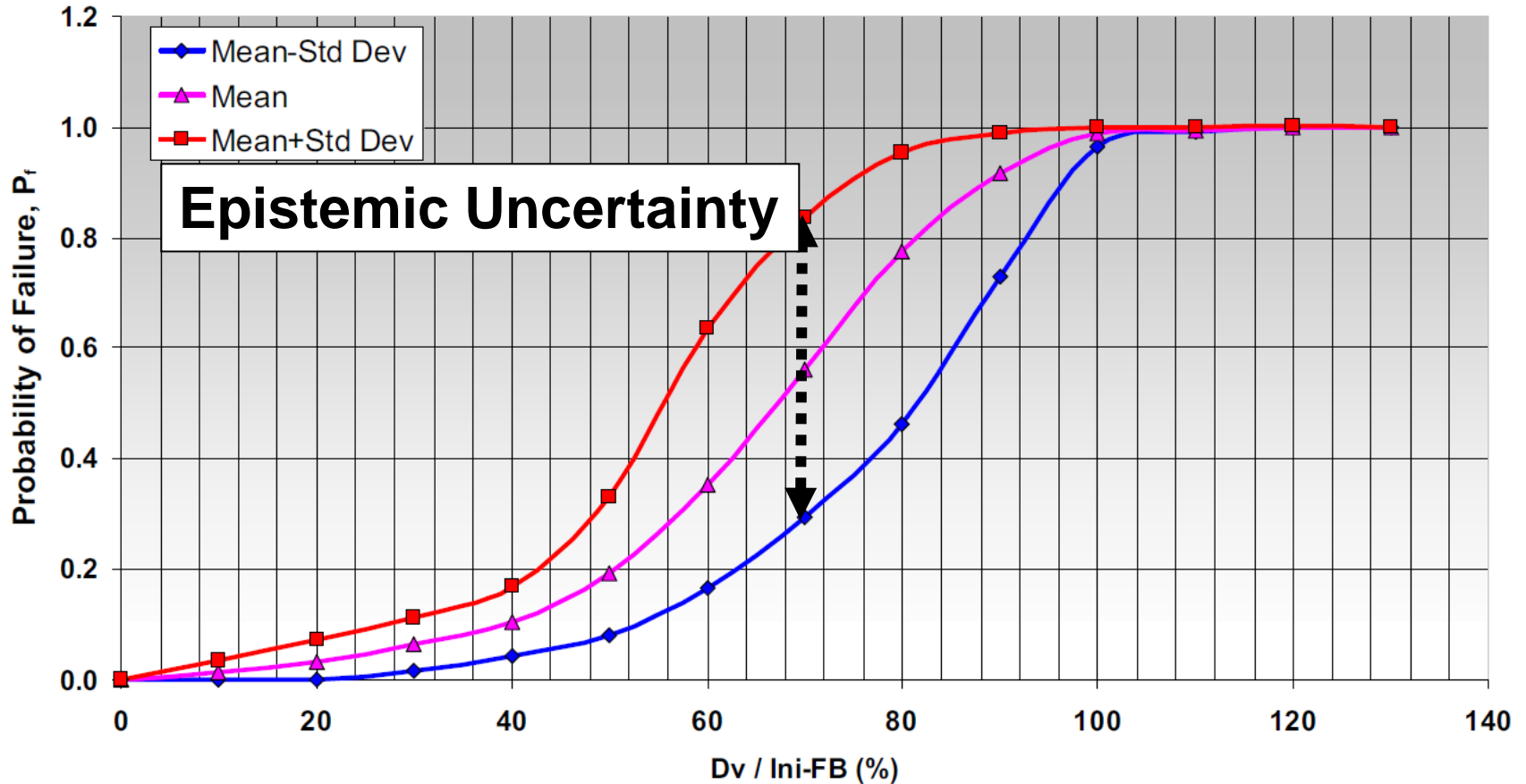
- Given calculated vertical deformations, when does failure occur?
- What fraction of the time will it occur?
- How certain are we?

# One Experts Results





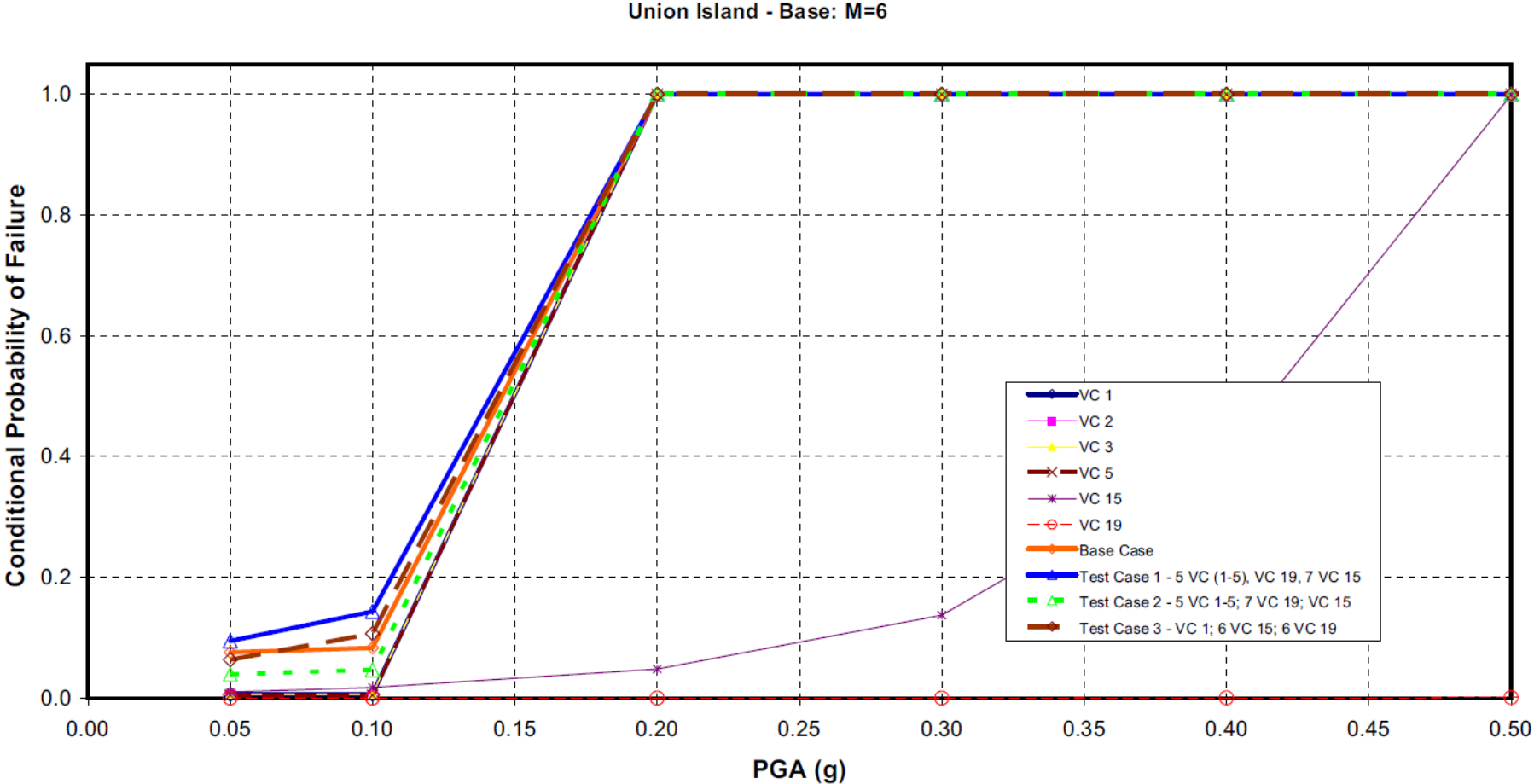
# Probability Distribution in the Displacement Fragility of Levees (Epistemic Uncertainty)



# Sensitivity Evaluation

- Union Island – located in the south Delta
- Modeled as a series of 13 ‘independent’ levee reaches defined by their physical characteristics (vulnerability classes)
- Issue – Looking at the ‘raw’ data, there seems to be different interpretations for the characterization of the levee reaches into different vulnerability classes

# Sensitivity Evaluation Results



# Lessons & Questions

(from DRMS and Other Experience)

# Lessons

- Evaluation of uncertainties; both aleatory and epistemic
  - Require a clear taxonomy of the types of uncertainty and their meaning
  - Experts need to be educated; Ask and you shall get an answer is not an expert elicitation process
  - Typically underestimated (cognitive short-coming; over-confidence)
  - Process should be formal;
    - What is being elicited
    - Expert interaction
    - Expert 'defense' of their interpretations
  - Interpretations/evaluations documented

# Lessons & Insights (cont.)

- It's a 'system' (ASCE, 2009)
- Fragility analysis provides unique insight to 'system' performance
- Risk Analyst Role
  - Modeler, Quantifier (run the numbers)
  - Trainer, Psychologist

# Questions

- Probabilistic analysis:
  - Better indexing system (Don't believe the numbers); a relative measure only, or
  - A more absolute measure of events of interest (chance of breaching), or
  - A framework (rules) for identify and evaluating uncertainties (aleatory & epistemic).
- Believe the numbers?

# Questions (cont.)

- 'Length Effect' Problem
  - The 'length' effect; spatial correlation of properties & performance
- System modeling
  - How does the system really perform
  - As a simple series system

Element	Epistemic	Aleatory
Modeling	<p>Uncertainty about a model and the degree to which it can predict events. Model, epistemic uncertainty addresses the possibility that a model may systematically (but not necessarily predictably), over- or under-predict events/results of interest (i.e., deformations).</p>	<p>Aleatory modeling variability is the variation not explained by a model. For instance, it is variability that is attributed to elements of the physical process that are not modeled and, therefore, represents variability (random differences) between model predictions and observations.</p>
Parametric	<p>Parametric epistemic uncertainty is associated with the estimate of model parameters given available data, indirect measurements, etc.</p>	<p>This uncertainty is similar to aleatory modeling uncertainty. However, this is variability that may be due to factors that are random, but have a systematic effect on model results.</p>