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Re-evaluating Flood Hazards at Critical Infrastructure along the Mississippi River

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Illinois Association of Floodplain and Stormwater Managers
Springfield, IL

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GZA GeoEnvironmental, Inc.

BACKGROUND


1 Exploded Saturday, still poses meltdown risk
2 Exploded last night
3 Exploded yesterday and is still overheating
4 Currently on fire
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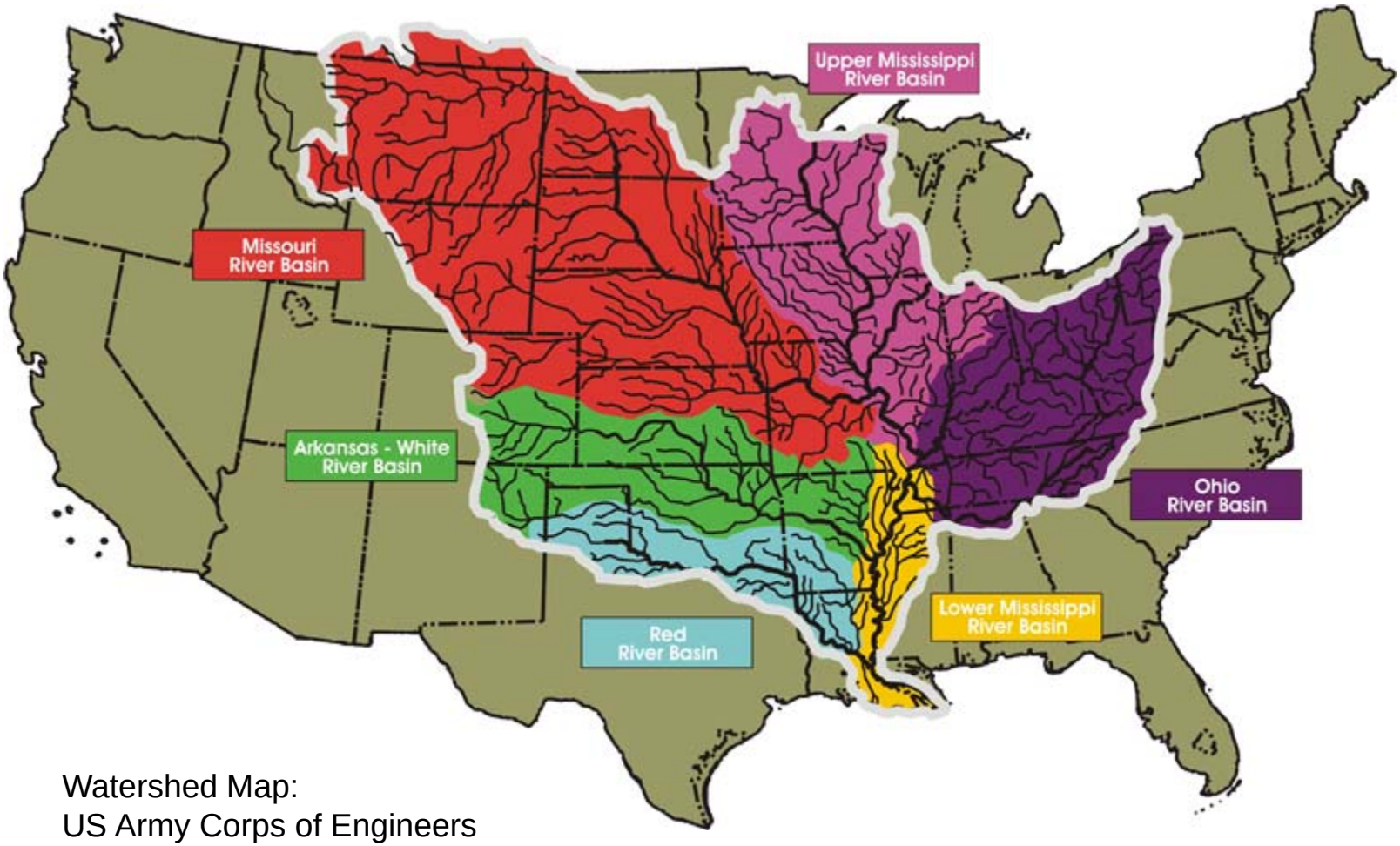
4
3
2
1

Post-Fukushima Actions

BACKGROUND

Hydrologic Setting



Watershed Map:
US Army Corps of Engineers

BACKGROUND

Flooding may result in

loss of property and lives

Flood of March 1993
Quad Cities Times

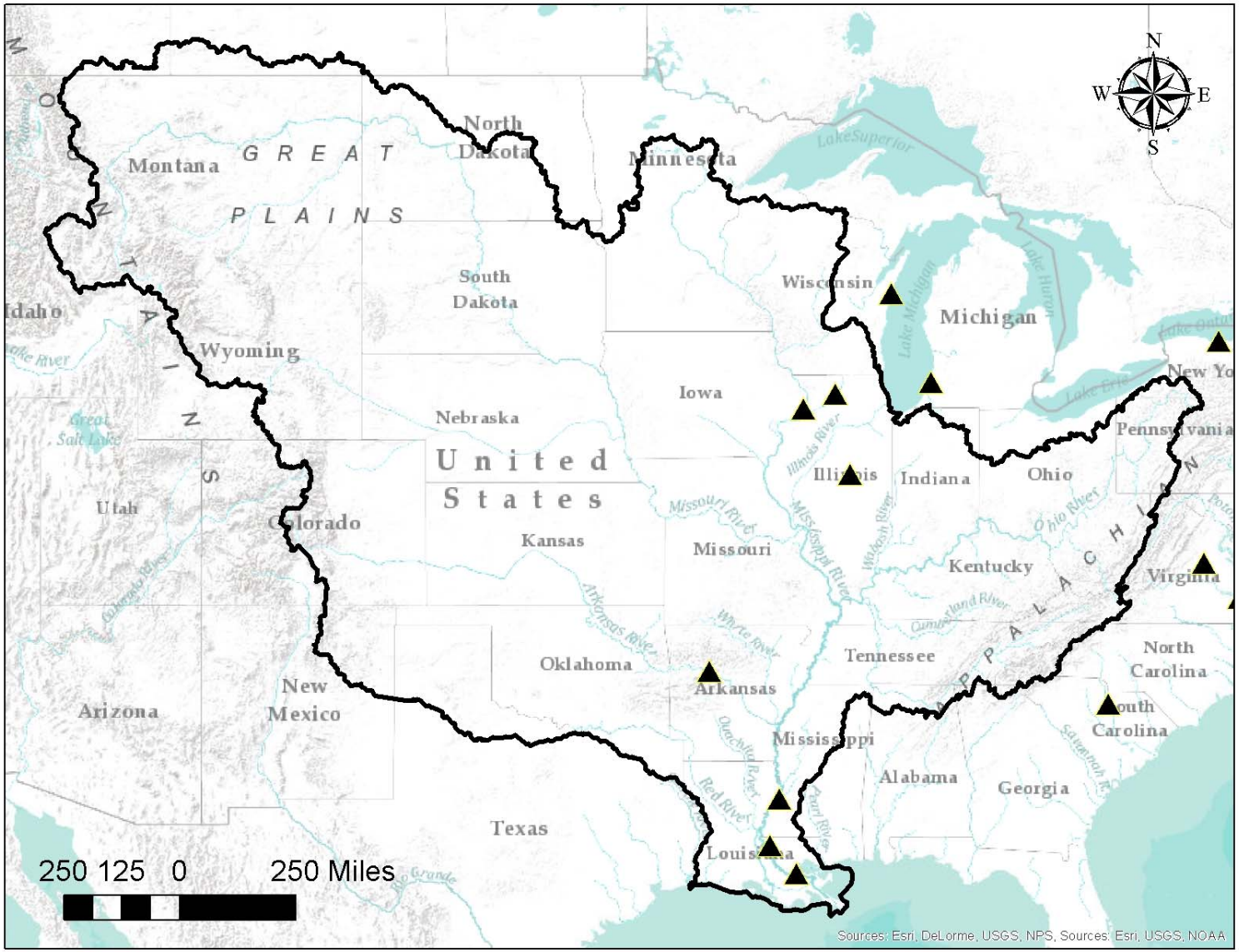
How much risk can you tolerate?

Critical Infrastructure outages have widespread impacts:

- Power
- Water
- Wastewater
- Transportation

Elevate/Mitigate

Select Flood Hazard Re-evaluation Sites



Post-Fukushima Actions

Flood Walk Down:
Identify existing physical vulnerabilities against existing licensing basis flood (1970s)

Flood Re-Evaluation:
Develop up-to-date estimates of flood elevations using current state-of-practice techniques

Integrated Assessment:
Develop flood protection / mitigation actions to address re-evaluated flood hazard

CONCEPTS

Probable Maximum Flood (PMF):
…resulting from the most severe combination of hydrologic and meteorological conditions that are considered reasonably possible.

Hydrologic: High antecedent flow

Meterologic: Historic high rain

Definitions provided in “Hydrologic Engineering Methods For Water Resources Development”, Volume 5, USACE, March, 1975. and the “Mississippi River & Tributaries Project” report

CONCEPTS

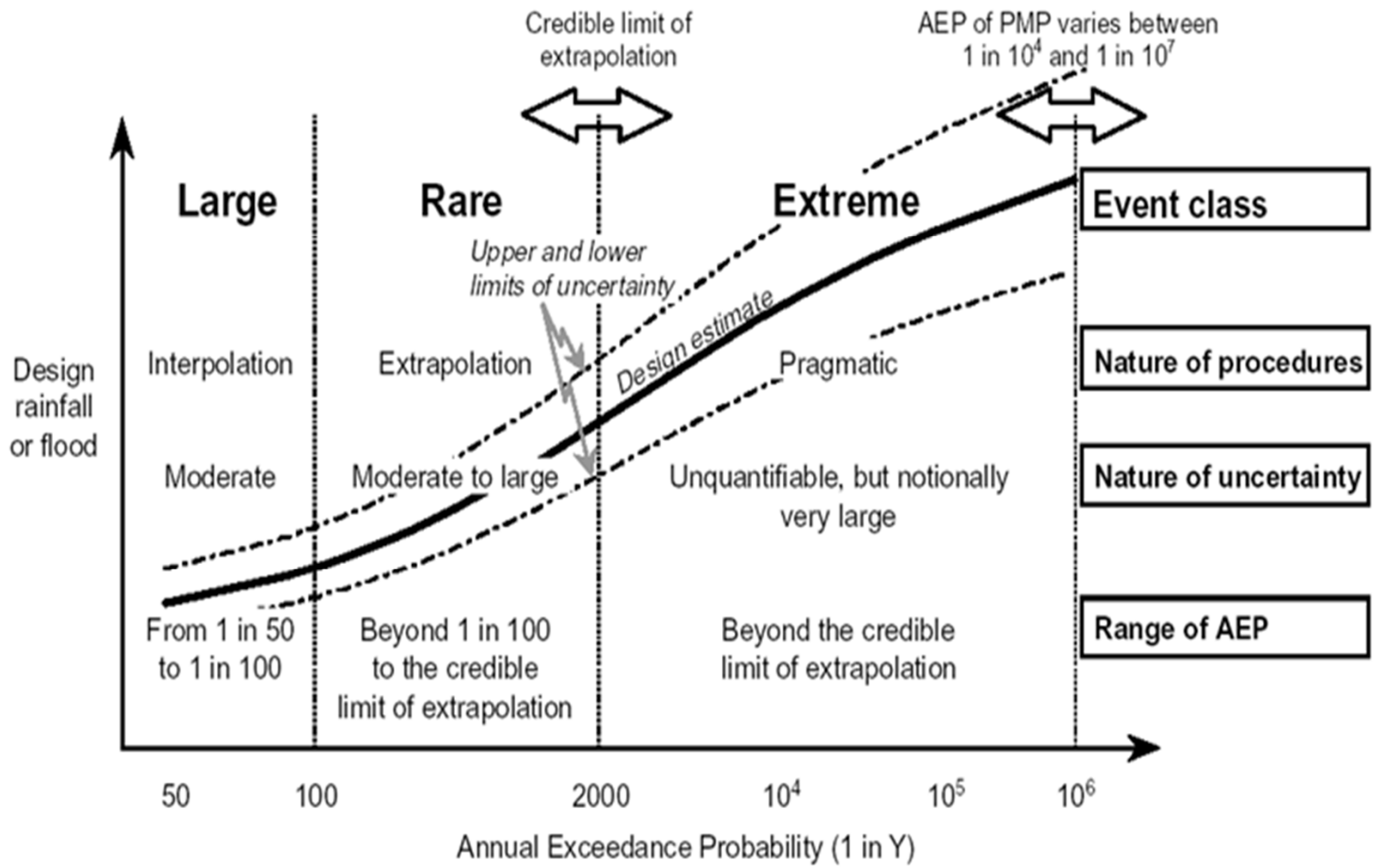


Figure provided in "Estimation of Large to Extreme Floods, Volume VI", *Australian Rainfall and Runoff*, Nathan R.J. and Weinmann, E.M, 2001

Methods for estimating the flood

Deterministic

"Probable Maximum…" Not associated with a recurrence interval

Create a model of the watershed

-Time consuming

-Many data inputs (precipitation, soil data, stream routing, etc.)

- Impractical if watershed is very large

Probabilistic

Probability of Occurrence (Recurrence Interval) (Annual Exceedence)

Use historic flood data, paleohydrology, statistics, Monte Carlo-type/stochastic approaches

- A developing approach to extreme flood estimation, gaining acceptance
- Used for smaller floods, such as 100-year and 500-year return periods
- Requires long term stream gage and other reliable data

Probable Maximum Flood - Steps

Probable Maximum Precipitation (PMP)

PMP Time Series

Probable Maximum Flood Flows (PMF)

PMF Flood Elevations

Site Specific

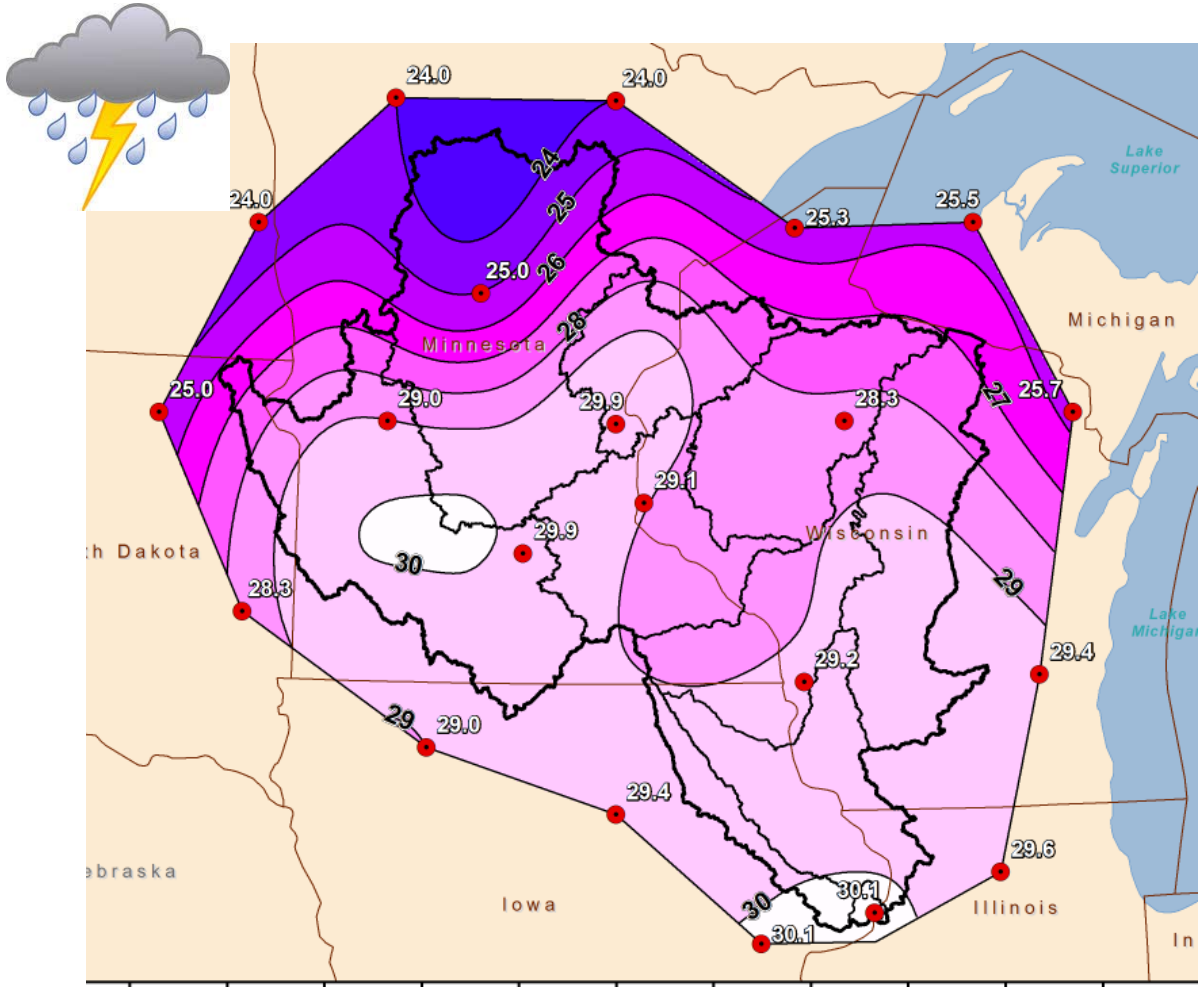
Probable Maximum Precipitation (PMP)

Why:

- Large watersheds
- Orographic effects
- Cool season PMP

How:

- Storm-Based
- Maximization
- Transposition



Antecedent Flow– before the PMP

- The ground is already wet– not much infiltration loss

Highest monthly average flow → **40% PMP over 3 days** → **3 dry days** → **PMP over 3 days**

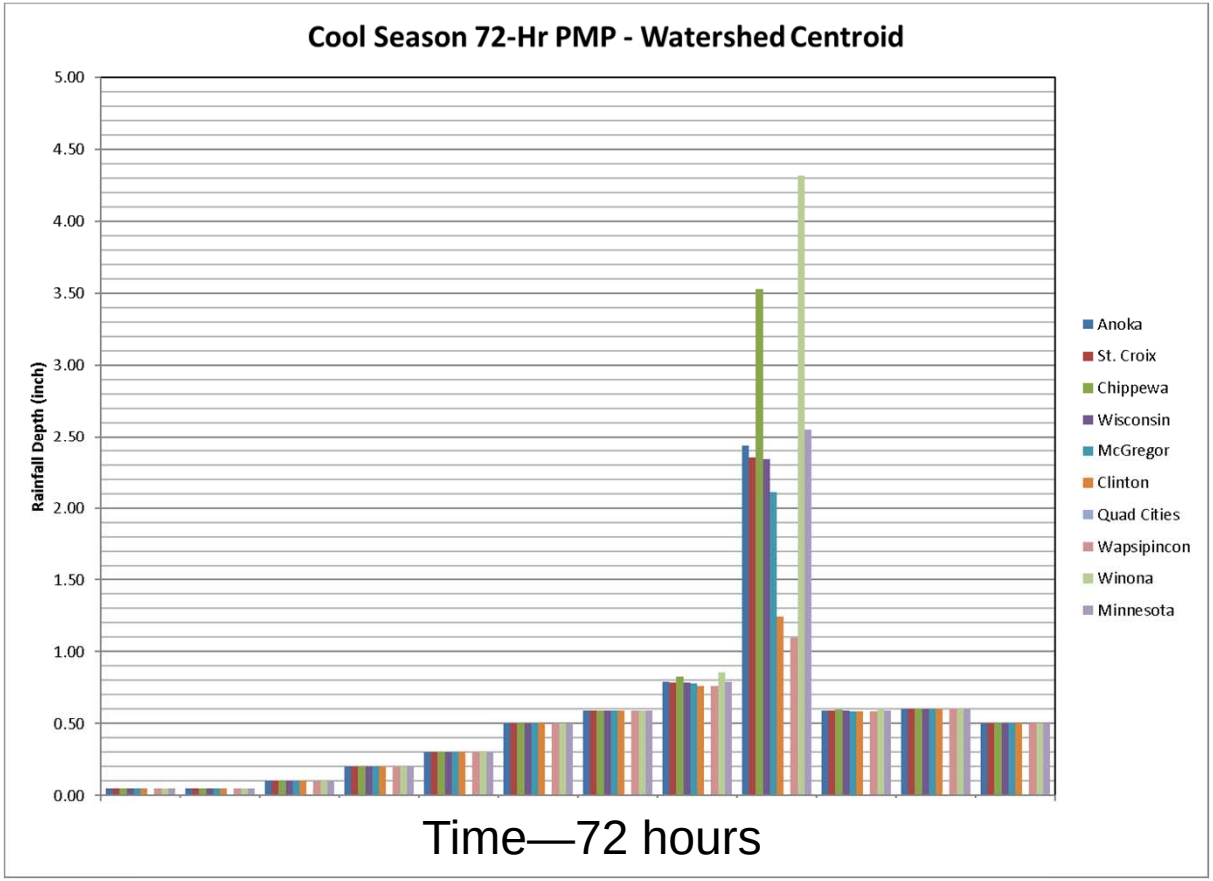
PMP Time Series

Depth-Area Duration Curves

Rainfall inches

5

0



Flood Flows (PMF)

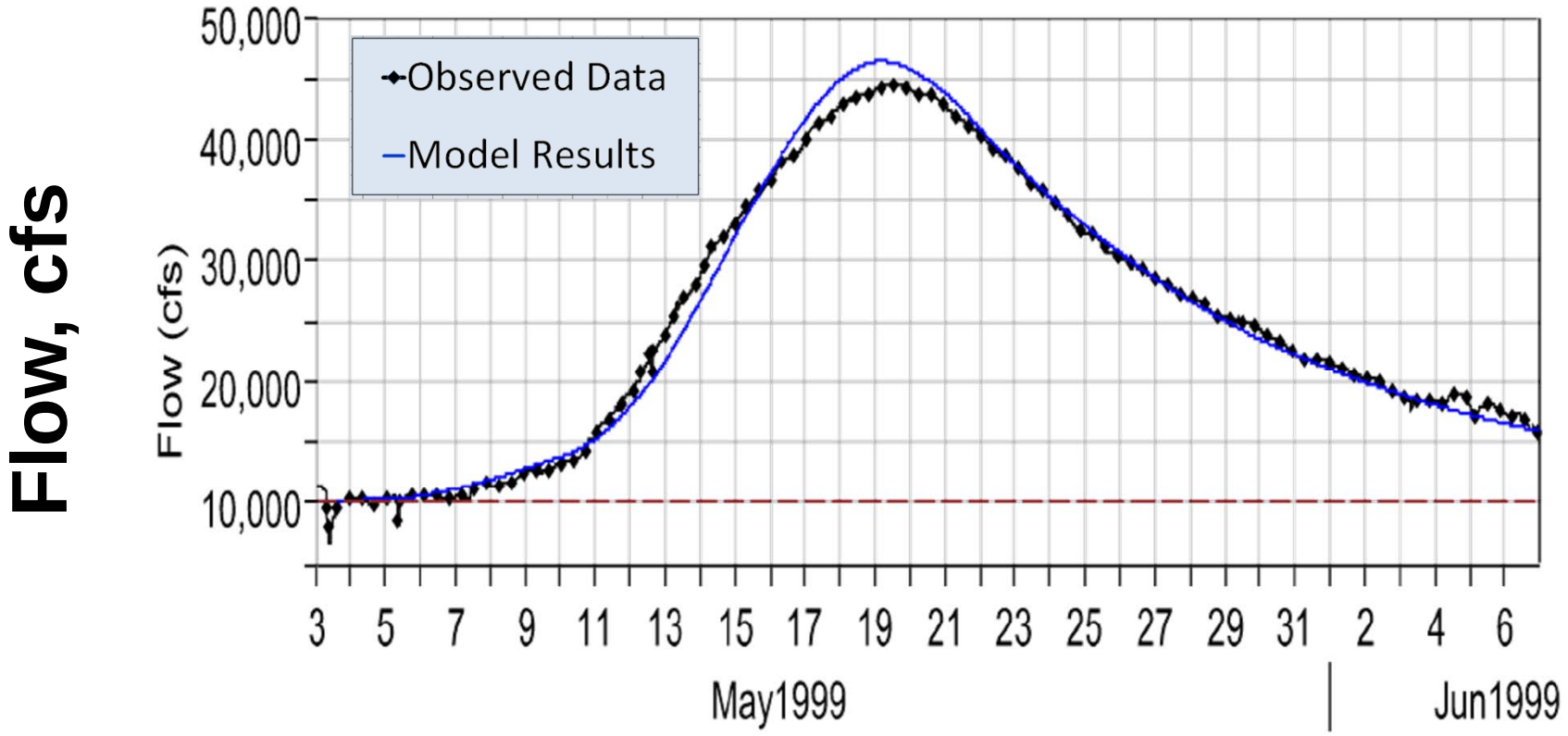
Army Corps of Engineers HEC-HMS Model

Watershed segmented into sub-basins

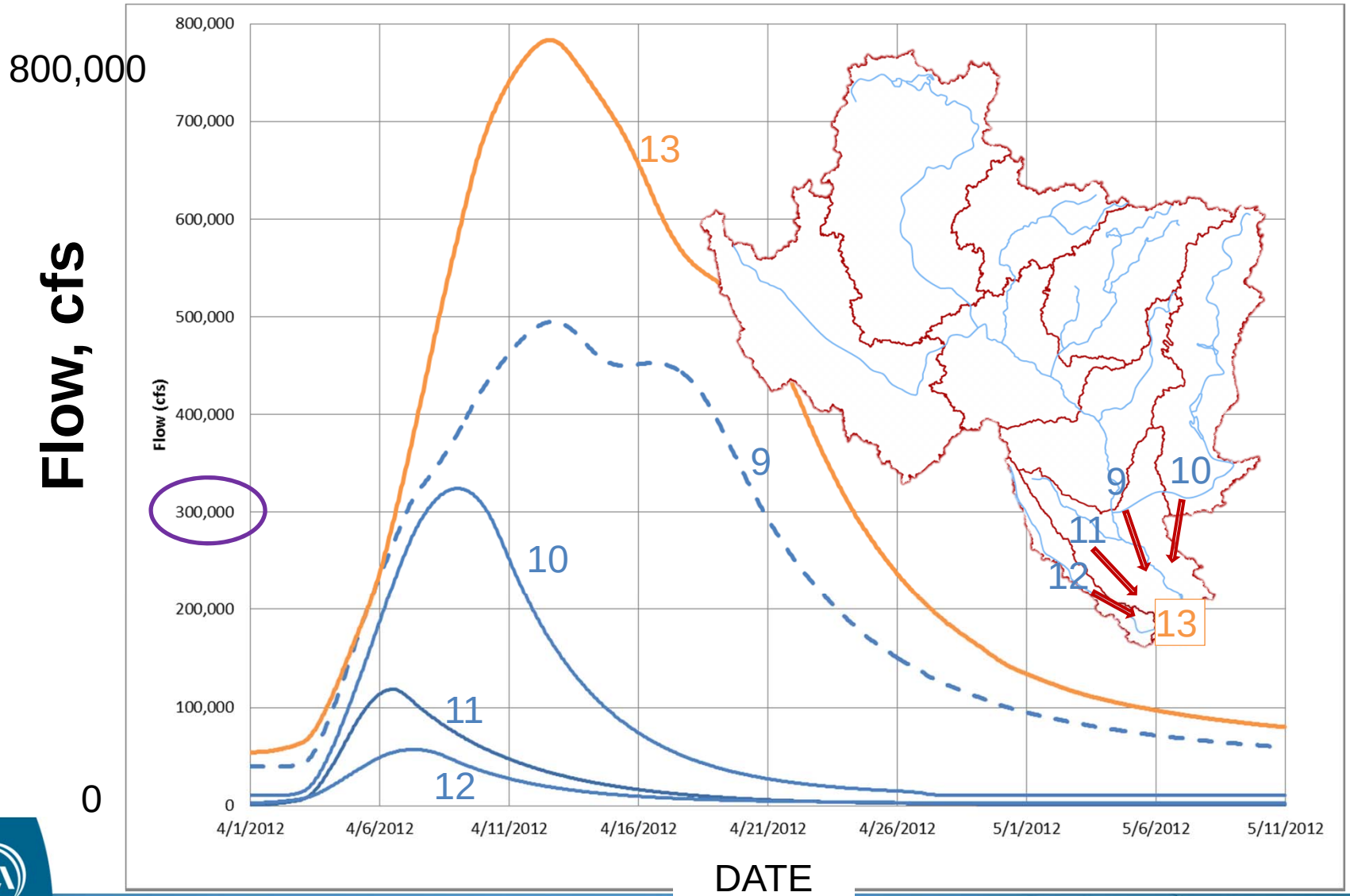
Rainfall simulated over watershed

Streamflow is simulated at outflow point of each sub-basin

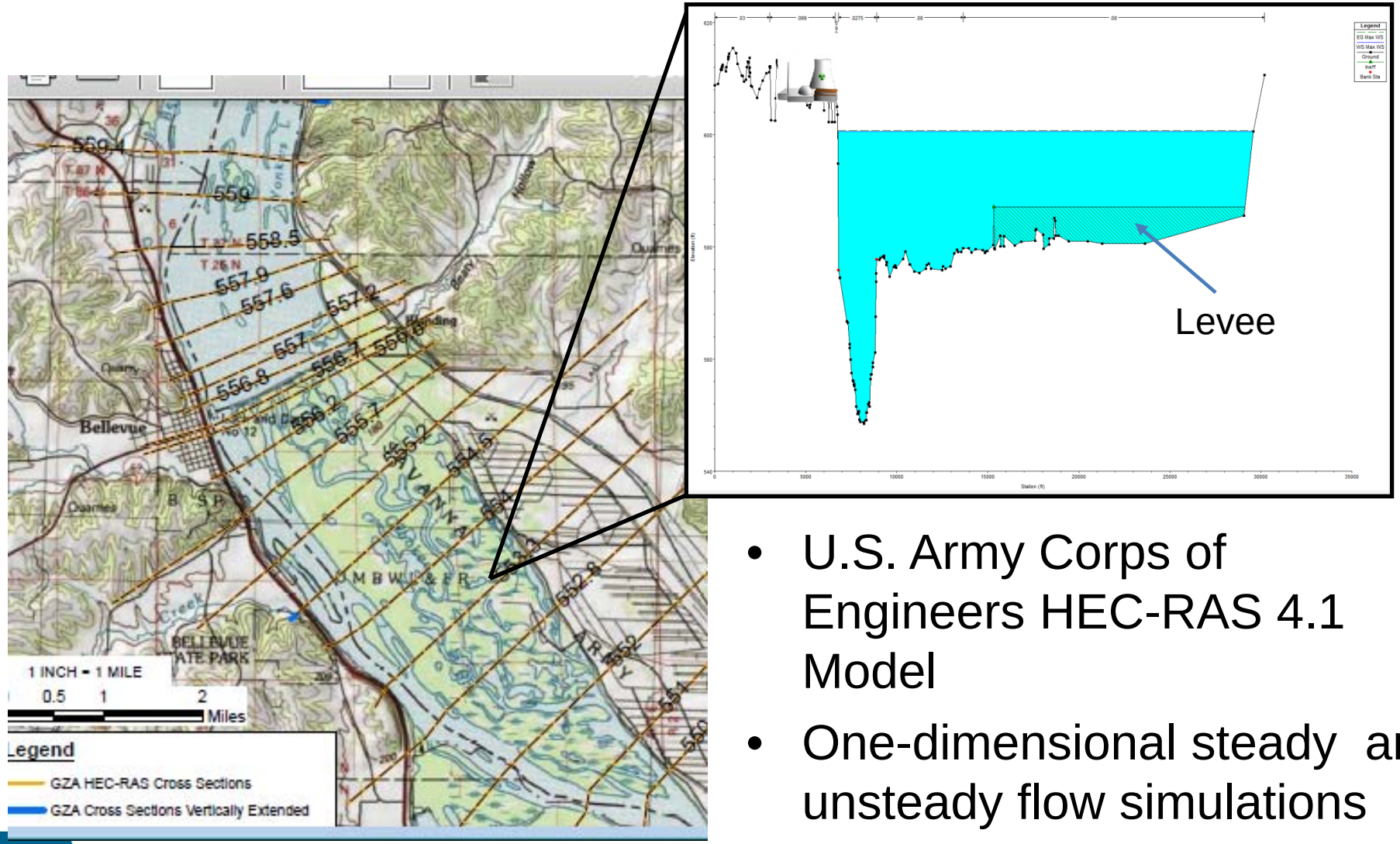
Model Calibration– 7 to 8 historic storms



PMF Hydrograph



PMF Elevation Model Development



- U.S. Army Corps of Engineers HEC-RAS 4.1 Model
- One-dimensional steady and unsteady flow simulations
- Calculates flood elevation

PMF Elevation Development

Includes locks, dams, levees (speed bumps)

Hierarchical Hazard Assessment

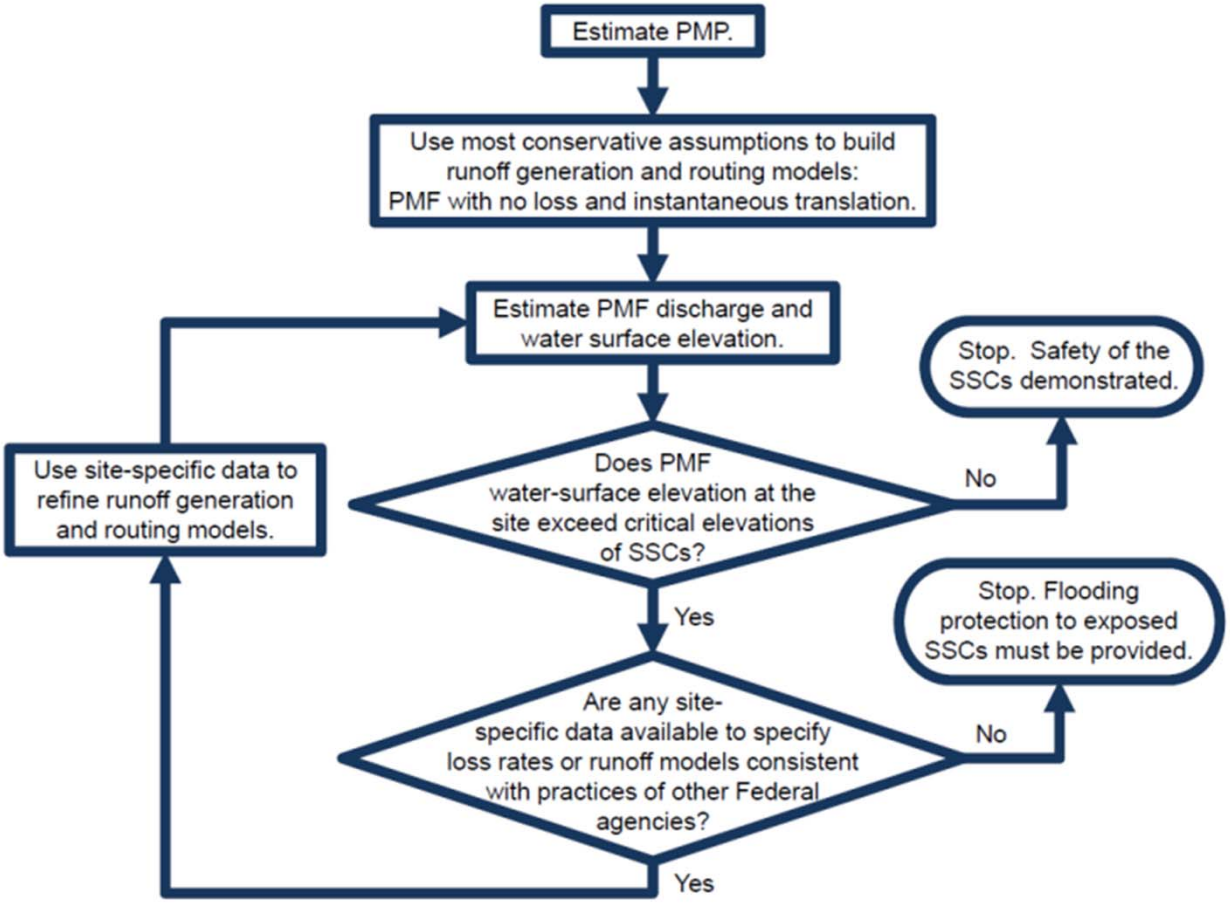
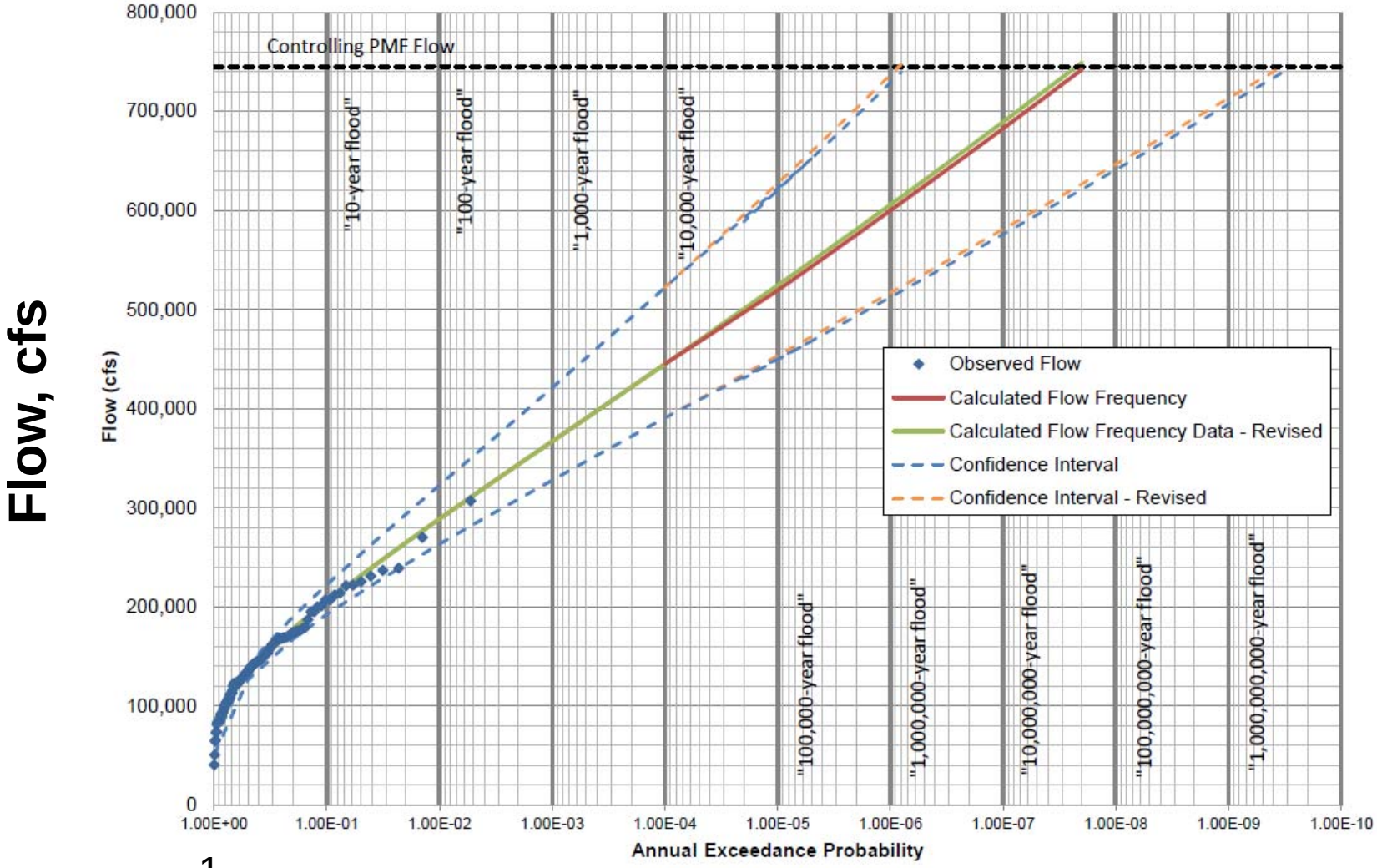


Figure 2-1. Flowchart Demonstrating the HHA Applied to Flood Hazards from a PMF Event

Deterministic vs. Probabilistic: Flow



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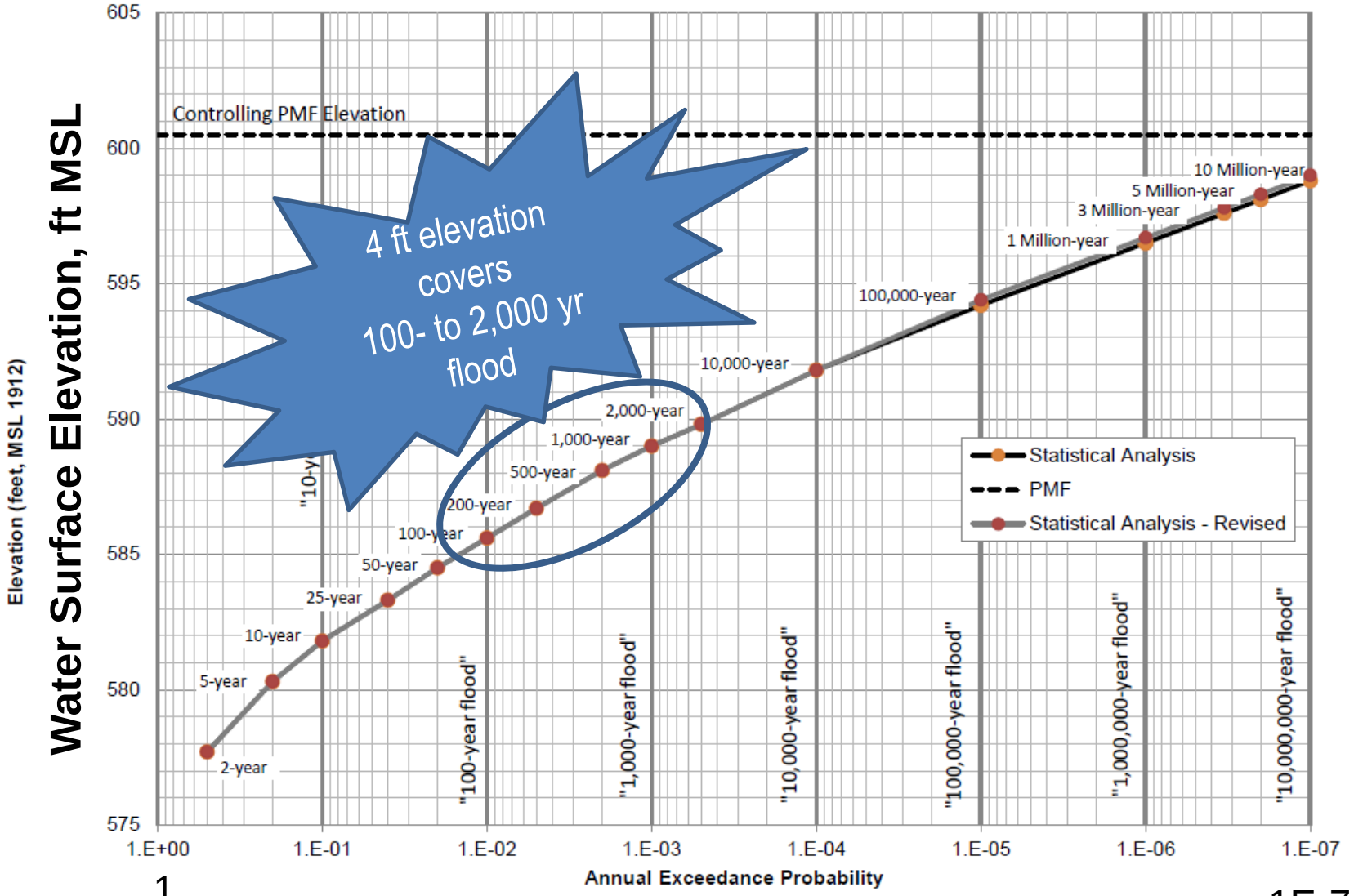
1E -10

Annual Exceedance Probability

Deterministic vs. Probabilistic: WSE



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Annual Exceedance Probability

1E-7

CONCLUSIONS

- Big challenge calculating a PMF elevation in this region due to:
  - Large watershed size
  - Controlled riverine system
- Strategies
  - Find alternative methods
  - Use conservative simplifying assumptions

Future Trends

- Probabilistic Analysis
- Risk Informed Decision Making
- Two or Three Dimensional Hydrodynamics

Thank You !

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