



## NRC PFHA Conference



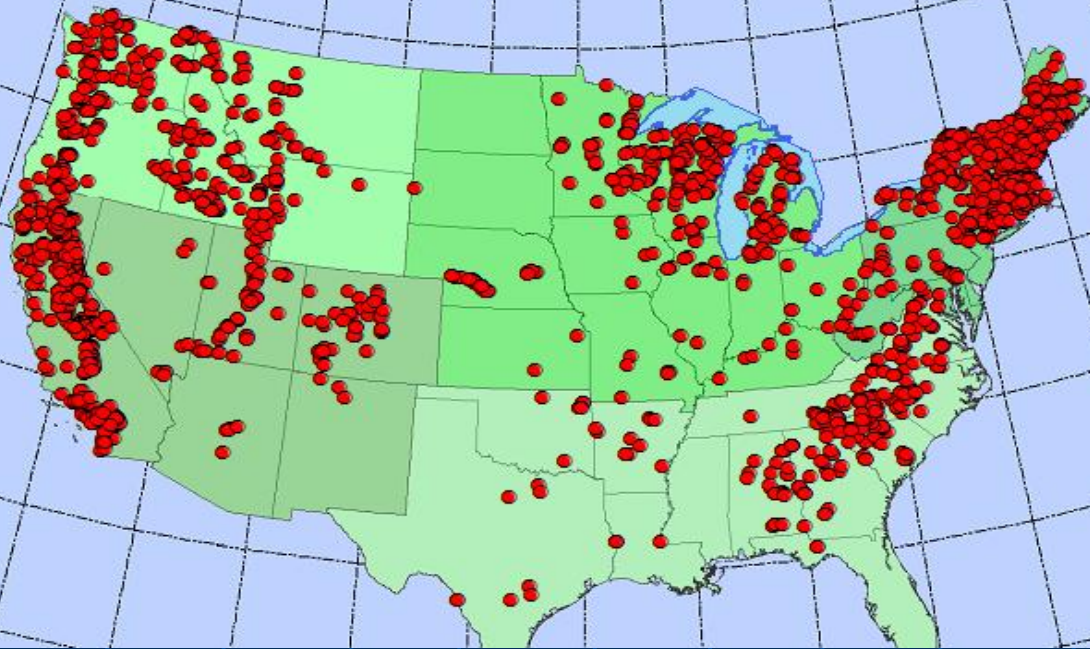
# FERC'S Need for PFHA

**From Deterministic  
to Probabilistic**

**David Lord, P.E., Dam Safety  
Risk team – Portland, Or**

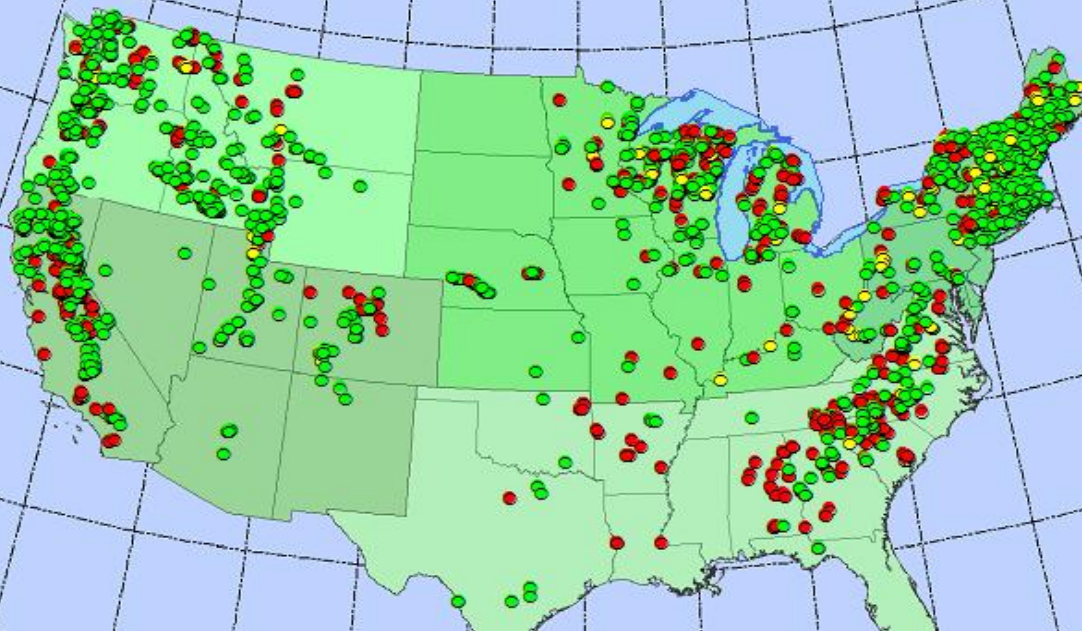


## FERC Regulates 2948 Dams and Project Structures





834 High Hazard Potential  
234 Significant Hazard Potential





# In the Beginning... for FERC

- The FERC's modern dam safety program - implementing regulations in 1981.
- The Division of Dam Safety and Inspections (D2SI) - regulatory responsibility for FERC-licensed hydroelectric dams.
- Dams are classified into low, significant, and high hazard potential.



# In the Beginning... for FERC

- The high hazard classification - worst case dam failures might cause loss of life.
- Significant hazard dams - economic or sensitive environmental issues.
- Standards-based program - relied on conservative deterministic analyses.
- Probable Maximum Flood and Maximum Credible Earthquake



# PFMA

- In 2000 - D2SI established a Potential Failure Modes Analysis (PFMA) program for all high and significant hazard (HSH) dams.
- In 2009 - Commission's strategic plan - develop a probabilistically oriented program, titled Risk-Informed Decision Making (RIDM).
- In 2012-13, RIDM Engineering Guidelines - include Hydrologic Hazard Analysis (HHA) chapter.
- Drafts of these guidelines are to be completed by September 2013.



# FERC's RIDM Program

- You will hear more extensive discussions of flood risks to and from dams later in this workshop.
- Reclamation's program for estimating flood frequencies and reservoir level exceedance curves is well respected
- Our new HHA chapter will rely heavily on the current Best Practices used by Reclamation.



# FERC's RIDM Program

- However, we are a regulator and not a dam owner like Reclamation.
- FERC has hundreds of dam owners and dozens of consultants many with a limited understanding of probabilistic hydrologic hazard analyses.



# Probable Maximum Flood Calculations

- FERC owner's and consultants are good at Probable PMP and PMF calculations.
- Many newer studies are based on site-specific or state wide PMP analyses.
- These newer studies generally use HMR concepts.
- Meteorological science has progressed since the HMRS were developed and some HMR procedures are questionable



# Probable Maximum Flood Issues

- The conservatism inherent in the HMR estimates of PMP have often been removed - up to 56 percent reductions in PMP.
- These reductions raises concern on the reasonableness of these new estimates.



# Probable Maximum Flood Issues

- PMP value using the HMRs is an estimate – not necessarily the true upper limit
- PMF numbers are treated as having zero probabilities, i.e., as upper bounds that can't be exceeded, rather than having a relatively low probability.
- Some interior parts of the country, farther from a warm ocean moisture source, PMP and PMF estimates likely have equivalent AEPs of about  $1 \times 10^{-7}$  or lower.



# Probable Maximum Flood Issues

- In coastal regions closer to warm moisture sources, PMP and PMF estimates may have equivalent AEPs as high as between  $1 \times 10^{-3}$  and  $1 \times 10^{-5}$ .
- Result is uneven treatment between dams
- Also these possibly relatively frequent AEPs means some dams might not have been analyzed for a flood that is sufficiently unlikely.



# Probable Maximum Flood Issues

- Dam overtopping PFMs are often from a combination of circumstances, i.e.,
  - Trash build-up on spillway gates
  - Inability to open a spillway gate during a relatively frequent flood.
- AEPs between  $1 \times 10^{-2}$  and  $1 \times 10^{-4}$  may be of greater concern combined with these events than an extreme flood event.



# FERC Dam Safety Decision-Making

- All of our dams currently meet the standard of being able to pass the PMF, or are in process.
- Our owners have spent approximately \$130 million in the last 10 years for inadequate spillways.
- Under current guidance, the only alternative is to show there is no home at risk from a dam failure during an extreme flood.



# FERC Dam Safety Decision-Making

- Two projects at the FERC have been evaluated using PFHA concepts.
- Panel 3 has a presentation on one of them.
- The Baker River Project, has another.
- The following slides will briefly show this process.



# Upper Baker Dam





# West Pass Dike





# West Pass Dike





# Frequency of Maximum Reservoir Level

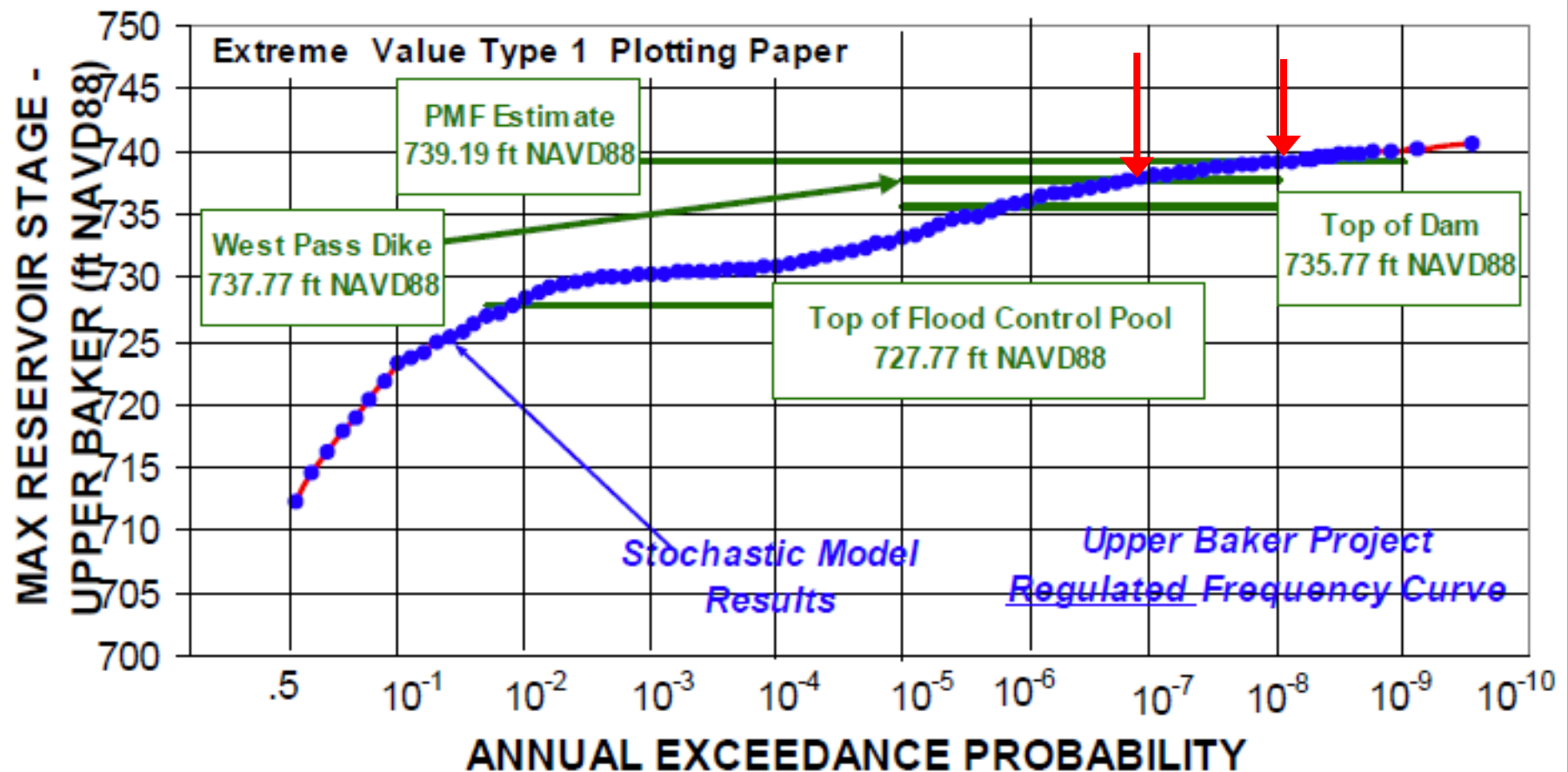


Figure 6-10. Flood-Frequency Curve for Upper Baker Dam – Maximum Reservoir Elevation



**Table 6-10. Estimates of Maximum Reservoir Elevations at Upper Baker Dam for Select Annual Exceedance Probabilities**

<b>AEP</b>	<b>Reservoir Elevation (ft NAVD 88)</b>	<b>Reservoir Zone/Project Feature</b>
$1.0 \times 10^{-8}$	739.19	Results of Routed PMF
$1 \times 10^{-7}$	738.12	
$1.5 \times 10^{-7}$	737.77	Crest of West Pass Dike
$1 \times 10^{-6}$	736.14	
$1.4 \times 10^{-6}$	735.77	Deck Elevation of Upper Baker Dam (at centerline)
$1 \times 10^{-5}$	733.13	
$1 \times 10^{-4}$	730.90	
$1.7 \times 10^{-4}$	730.77	Maximum Surcharge Pool Elevation
$1 \times 10^{-3}$	730.31	
$1 \times 10^{-2}$	728.49	
$1.3 \times 10^{-2}$	727.77	Maximum Flood Control Pool Elevation (normal full pool)



# Probable Life Loss (PLL)

PLL as follows

• Kulshan Campground	0
• Concrete	1
• Down through Hamilton Mile 12 to 29 –	0
• Down through Sedro Woolley Mile 29 to 42 -	0
• Down past Mt Vernon – Mile 42 to 64	*
• Total	1

\*Flow less than 1 ft/s about 1 ft high



# Risk Decisions – West Pass Dike

- Flood Frequency Analysis did not include other alternative methods or uncertainty.
- We concluded that any repair decision should be delayed until the FERC's RIDM program was more developed.
- Eventually a Risk Analysis will be performed to further evaluate this risk.



# FERC's Need for PFHA

- PFHA will be a critical part of our RIDM program to:
  - Evaluate extreme flood overtopping
  - Evaluate PFMs for lesser floods



# Questions about PFHA

- Should the PMP be the upper bound of any frequency estimates of extreme storms?
- Are there simple procedures for precipitation and flood frequency estimates to judge whether more robust estimates are needed at a dam?



# Questions about PFHA

- When should a probabilistic estimate augment or replace a deterministic estimate? Is it based on the risk?
- If current PMP and PMF estimates are inadequate at a dam, are new deterministic estimates needed, or should we rely only on new probabilistic calculations?



# Questions about PFHA

- How do we deal with uncertainty?
  - We can refine estimates of more frequent events using old historical (research of very large, non-gage recorded estimates) and paleoflood data
- How are the PFHA results going to be reviewed?
- A set of expert interaction procedures similar to SSHAC would be helpful. Can this be developed?