



# Extreme Hydrology & Climate Change

# Presentation Overview

- Overviews
  - Dam Safety Program
  - Mokelumne Watershed
- Hydrologic Extremes
  - PMP – PMF
  - Other Extreme Events
- Climate Change
- Projects – Programs



*Camanche Spillway, February 1986  
Peak Spill 1,630 cfs*

# Dam Safety Program Overview

- State & federal requirements
- Proactive management of dams
  - Rigorous monitoring
  - Emergency preparedness
  - Physical & Cyber security
- Periodic evaluations for extreme loading conditions
  - Seismic
  - Hydrologic extremes



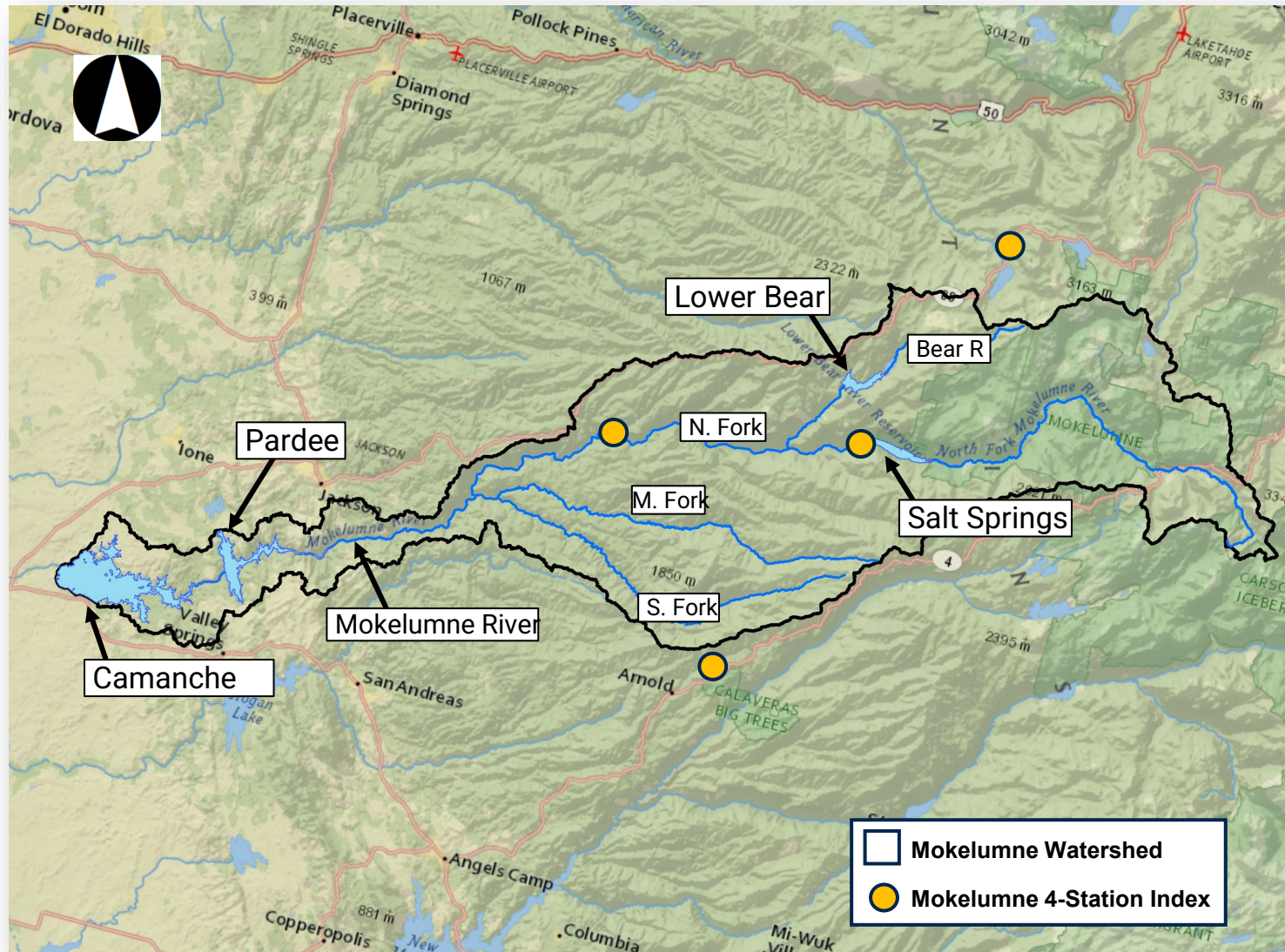
*Annual FERC Inspection at Camanche Dam in 2023*



*Seminar/Tabletop/Functional Exercise of Emergency Action Plan in 2023 at Pardee Center*



# Mokelumne River Watershed Overview



## Basin Area

- 621 sq mi

## Elevation

- 260' – 10,370'
- Snow > 5,000'

## Average Precipitation

- 48" (MOK 4-Sta)

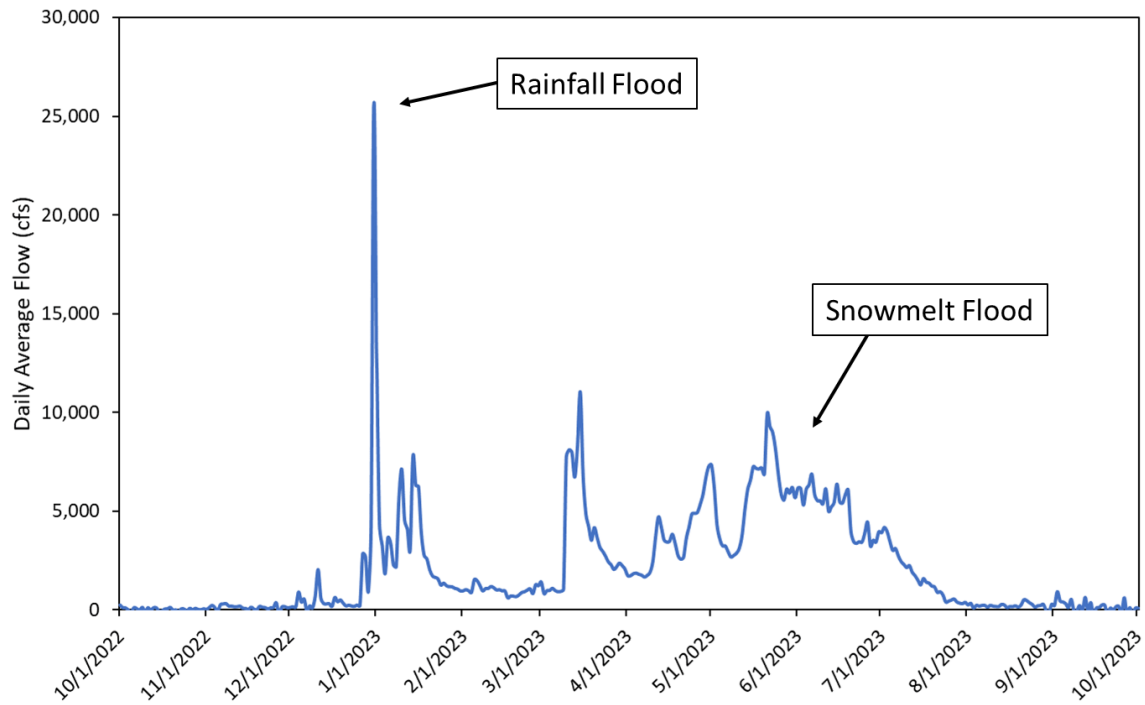
## Flood Types

- Rainfall (Oct-Mar)
- Snowmelt (Apr-Jul)

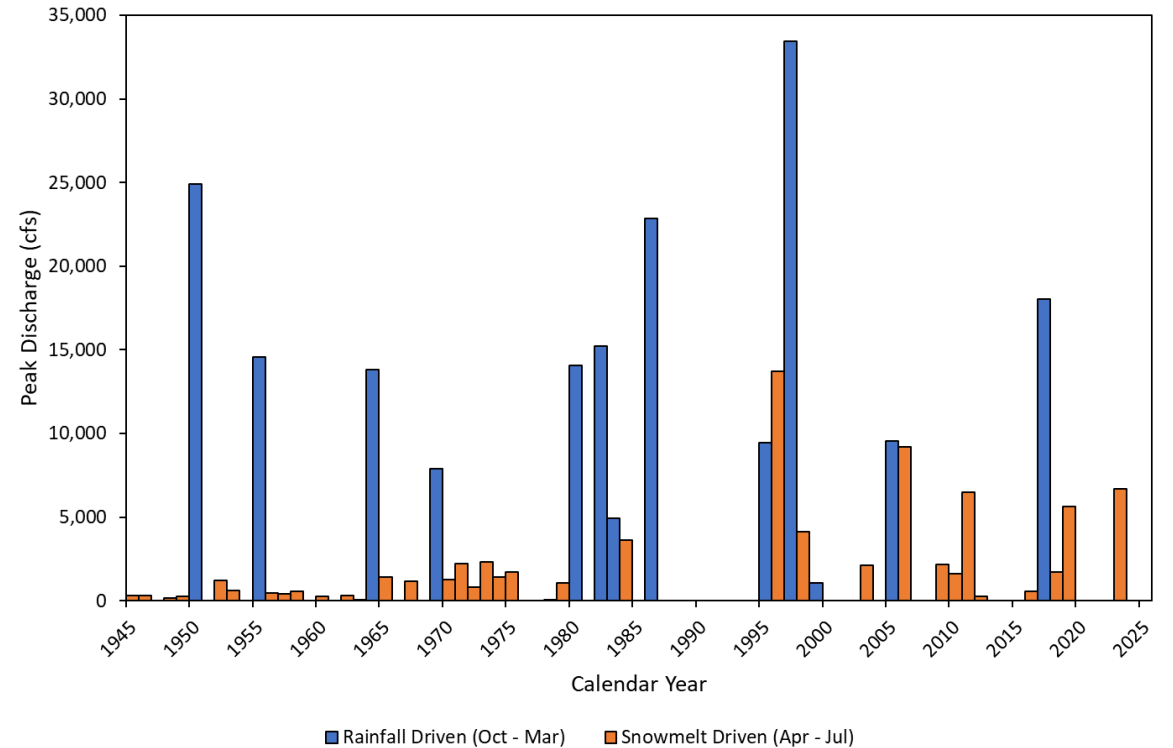


# Rainfall vs. Snowmelt Driven Floods

Computed Daily Average Unimpaired Flow  
Mokelumne River at Highway 49  
Water Year 2023



Annual Maximum Peak Spill  
Pardee South Spillway 1945 to 2023



# Extreme Hydrology – PMP / PMF

***Probable Maximum Flood (PMF) is the flood resulting from the most unlikely, but possible precipitation, termed Probable Maximum Precipitation (PMP)***

- High hazard dams
- Required by FERC & DSOD
- Prescribed by NOAA's HMR-59
- Provides 72-hour winter storm and resulting runoff



*Pardee Spillway, Jan 2017;  
Peak spill ~18,000 cfs*

*FERC: Federal Energy Regulatory Commission*

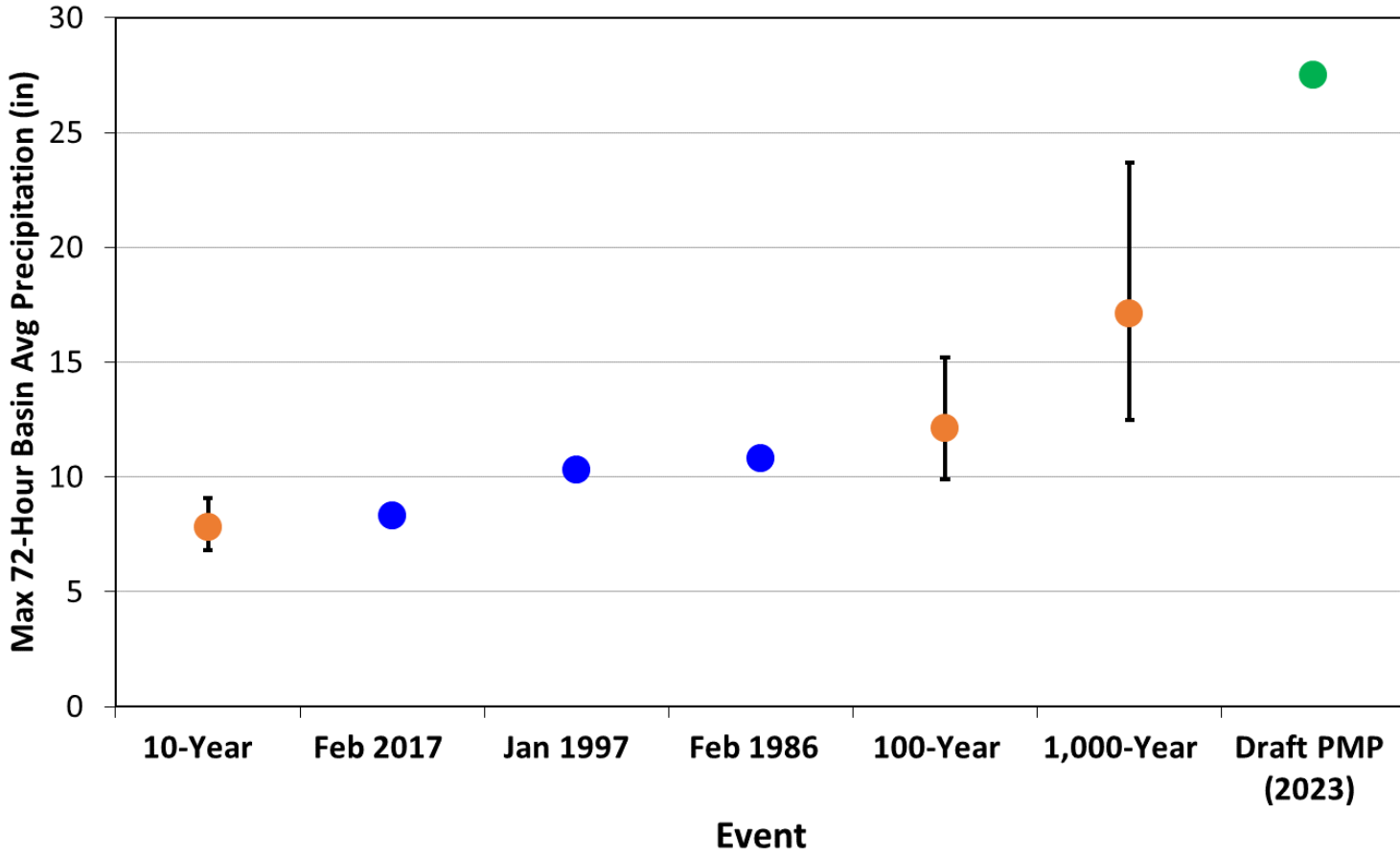
*DSOD: Division of Safety of Dams*

*NOAA: National Oceanic and Atmospheric Administration*

*HMR: Hydrometeorological Report*

# Extreme Hydrology – PMP

## Maximum 72-Hour Basin Average Precipitation in the Mokelumne River Watershed



*The PMP is a very extreme event intended to be larger than anything the basin will likely experience in the future.*

● Historical Storm ● PMP ● Avg Precip for given Return Period (NOAA Atlas 14) | 90% Confidence Interval

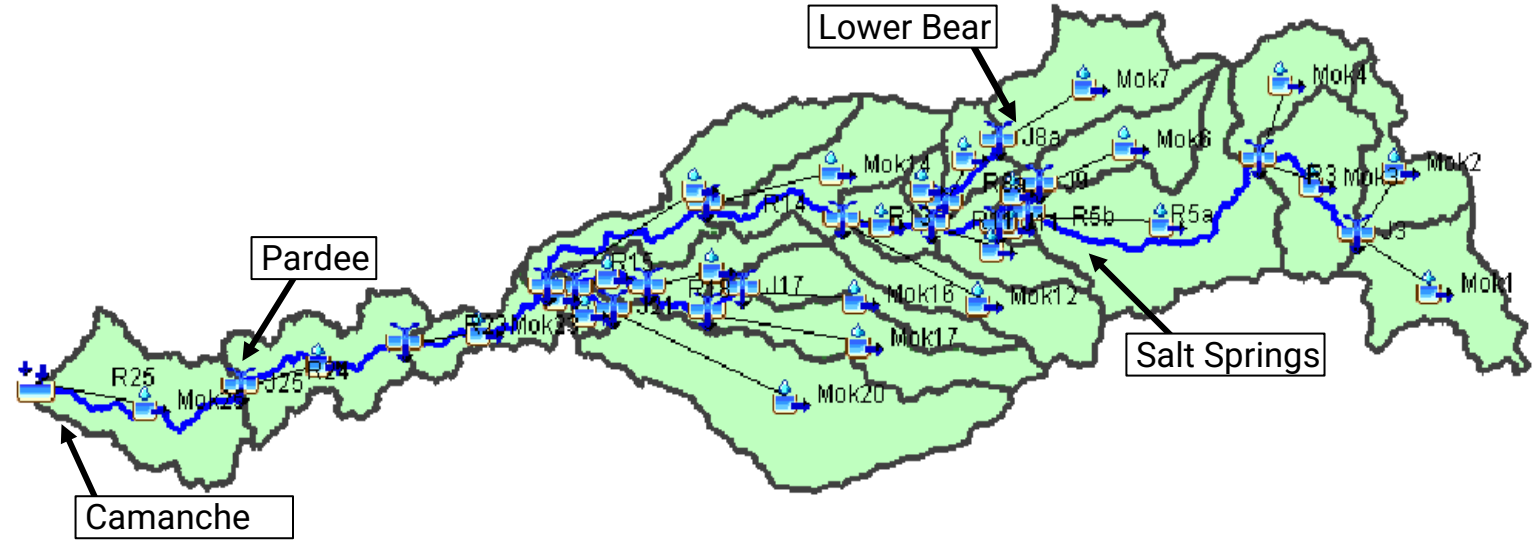


# Extreme Hydrology – PMF

Calibrated watershed model  
used to compute the PMF  
from the PMP

## Modeling assumptions

- 100-year snowpack
- Saturated conditions
- Warm temperatures
- Full reservoirs



Mokelumne Watershed Model

*Resulting extreme flood from PMP  
intended to be larger than any flood  
experienced in the watershed.*

# Other Hydrologic Events

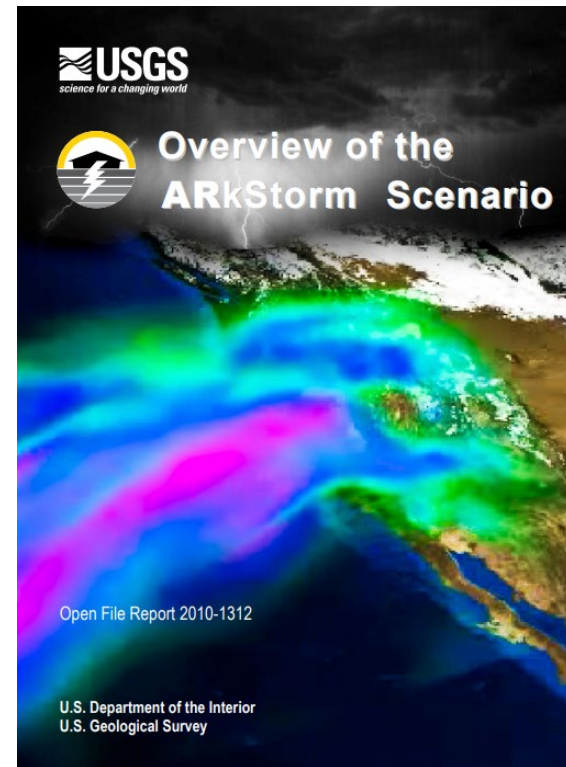
**The Great Flood of 1862:** The biggest flood in modern history that began with upwards of 15 feet of snow falling in the Sierras followed by a series of atmospheric rivers that brought warm rain and high winds.



**K Street, Sacramento, looking east  
1861-1862**

*Source of Pictures: USGS Open File Report 2010-1312*

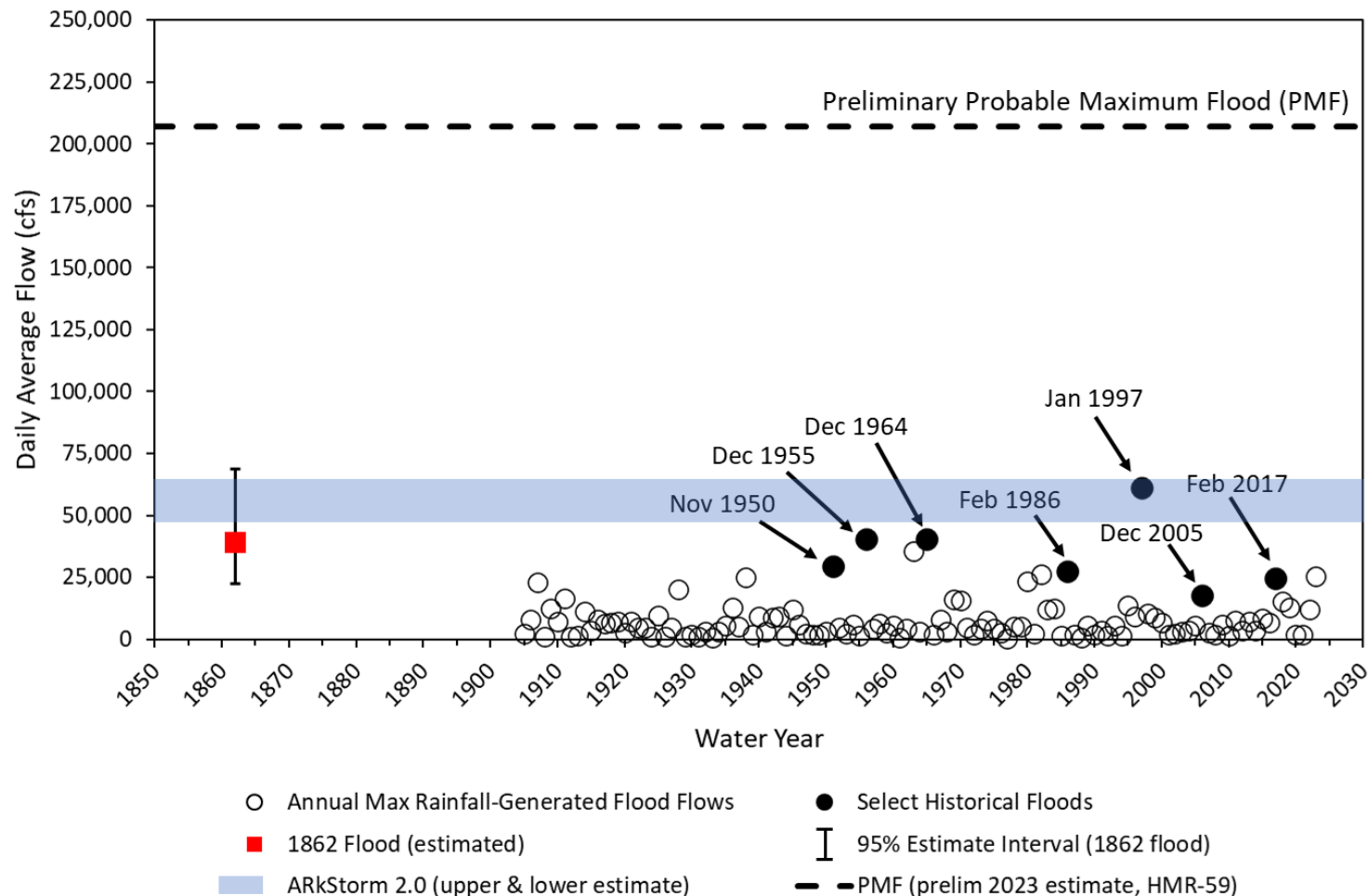
**ARkStorm 2.0:** A hypothetical storm based on the Great Flood of 1862 initially developed by the United States Geologic Survey for emergency planning purposes, and subsequently modified by academic institutions to include climate change.



- Based on 1861-1862 storm pattern
- Incorporates a warmer future climate
- Developed to aid in emergency planning
- Not a regulatory requirement

# PMF & Other Hydrologic Events

Comparison of PMF and Other Events to the Unregulated Annual Maximum Daily Flows on the Mokelumne River at Highway 49



*Similar to PMP, the PMF is intended to be larger than any flood the basin has experienced or will likely experience because of the high hazard classification of the dams.*

*This theoretical flood event would overwhelm our required flood reservation in a single day and would far exceed the maximum allowable release and downstream channel capacity.*



# Climate Change

- No State or Federal regulatory requirements currently in place
  - National Academies of Sciences, Engineering, and Medicine to make recommendations for the development of an updated approach that can serve as a national standard for estimating probable maximum precipitation in a changing climate.
- EBMUD proactively considering and incorporating into upcoming PMP/PMF analyses
- Need to develop long term adaptive management strategies to offset range of future conditions
- Need to expand data and tools to improve weather forecasting on the Mokelumne watershed

# Upcoming and Continuing Studies and Programs

## Site Specific PMP/PMF Studies

- Partnering with PG&E on Mokelumne River
- To incorporate climate change

## Probabilistic Flood Hazard Analysis

## Forecast Informed Reservoir Operations (FIRO)

- Evaluating feasibility of adaptively managed reservoir operations

## Data Collection & Monitoring

- Pursuing opportunities to install and maintain instruments to fill in data gaps

## Emergency Preparedness Program

- Continuing to engage with emergency management agencies and educate the public
- Reviewing, updating, exercising annually

