Folsom Dam
PMF Failure Analysis

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Overview

• Model Folsom Dam Flood Scenarios
  • During Probable Maximum Flood (PMF)
  • Varying Folsom Dam Outflows
  • Multiple Breach Locations and Methods

• Results
  • Floodplain Depths
  • Mortality
  • Property Damage

• Why?
  • Information not Available to public
  • To Obtain Masters Degree
Background

- Built in 1956
- Owned by USBR
- Storage
  - Approx. 1 Mil Ac-ft
- 12 structures
  - Concrete
    - Main dam
  - Earthen
    - 2 Wing Dams
    - 1 Auxiliary Dam
    - 8 Dikes

Reference: USBR “Folsom Dam Facility Map”
Location

Sacramento River

Folsom Reservoir

American River
Inflow

Probable Maximum Flood

- American River Basin
- PMF
  - Developed by USACE
  - Project Design Flood
  - Approx. 25,000 year event

Peak ≈ 900,000 cfs
Outflow

- Powerhouse
  - Flow = 6900 cfs
- 8 Tainter Gates
  - 5- Main
  - 3- Emergency
- Auxiliary Spillway
  - Designed to PMF event
Hydrology

Dam Outflow

Overtopping Elevation

PMF Event
Breach Information

- **Mechanisms**
  - Overtopping
  - Piping
  - Earthquake
  - Etc

- **Right Wing Dam**
  - Northern Breach

- **Mormon Auxiliary Dam**
  - Southern Breach

- **Tallest and longest earthen structures**
## Breach Information

<table>
<thead>
<tr>
<th></th>
<th>North Earthen structure</th>
<th>South Earthen structure</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>MacDonald et. al.</td>
<td>MacDonald et. al.</td>
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<tr>
<td></td>
<td>Von Thun &amp; Gillette</td>
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<tr>
<td>Width- ft</td>
<td>3047</td>
<td>3916</td>
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<tr>
<td></td>
<td>374</td>
<td>331</td>
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<tr>
<td>Height- ft</td>
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<td>76</td>
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<tr>
<td></td>
<td>47</td>
<td>76</td>
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<tr>
<td>Formation Time (hrs)</td>
<td>4.4</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Hydraulics

- HEC RAS 5.0
- 2D Mesh
  - 150 m x 150 m
- Terrain
  - CVFED
  - 1 m resolution
- Manning’s n
  - Based on CVFED
  - Land Use
Mortality

Jonkman et. al.
Mortality
Jonkman et. al.

\[ F_D(h) = 1 \]  

**Breach Zone**

**Rapidly Rising/ Remaining Zones**

\[ F_D(h) = \Phi_N \left( \frac{\ln(h) - \mu}{\sigma} \right) \]  

**Graph:**
- Mortality Fraction \( F_D \) vs. Depth (m)
- Remaining Zone
- Rapidly Rising Zone
Property Damage

Central Valley Flood Protection Plan

![Graph showing the relationship between depth (ft) and property damage (%). The graph includes lines for 1-story, 2-story, Split-Level, and Average properties.]
Things to Note

- Lacking Bathymetric Data
- Downstream Boundary Condition
  - California Delta
- Other Rivers
  - Sacramento River
  - Yolo Bypass
- Not a Comprehensive Floodplain
- Levees Remain Intact
Scenarios

Probable Maximum Flood

Without Auxiliary Spillway

Northern Breach
  - MacDonald
  - Von Thun & Gillette

Southern Breach
  - MacDonald
  - Von Thun & Gillette

With Auxiliary Spillway

No Breach
Results

Floodplain Depth
No Breach

 Depth (Feet)
- < 3.3
- 3.3 - 6.6
- 6.6 - 9.8
- 9.8 - 13.1
- > 13.1
Results

Floodplain Depth
Northern Failure

Depth (Feet)

- < 3.3
- 3.3 - 6.6
- 6.6 - 9.8
- 9.8 - 13.1
- > 13.1
Results

Floodplain Depth
Southern Failure

Depth (Feet)
- < 3.3
- 3.3 - 6.6
- 6.6 - 9.8
- 9.8 - 13.1
- > 13.1
Results

Mortality
No Breach

Does Not Take Evacuation Into Account

% Mort. of People Remaining

- Blue: 0 - 20
- Green: 20 - 40
- Yellow: 40 - 60
- Orange: 60 - 80
- Red: 80 - 100

0 2.5 5 10 Miles
Results

Mortality

North Breach
Results

Mortality

South Breach

Does Not Take Evacuation Into Account
Results

Property Damage
No Breach
Results

Property Damage
North Breach
Results

Property Damage
South Breach
Conclusions

- Flooding Without Breach
- Varying Flood Paths
- High Mortality and Property Damage
  - American River
  - Pocket
  - Natomas
QUESTIONS?