Innovative Technologies in Water Management

• How is dam safety an innovative technology?

• How is dam safety relevant in the current drought?
Governor's Water Action Plan

STORAGE is a key component:

“The bottom line is we need to increase our state’s storage capacity, whether surface or groundwater; whether big or small.”

Big: Sites Reservoir and Temperance Flats Reservoir
Small: Ensure full use of existing capacity and dam raises
Small Scale Storage

• Most dams reaching 50-yr design life
• Neglecting regular maintenance can lead to more serious problems...
• ...Which can lead to a mandated restriction in storage
• 56 dams are currently under restrictions due to dam safety issues
• 470,000 AF of lost storage

Data provided by D. Gutierrez, Chief of the DSOD

Camanche Reservoir, EBMUD
Total Storage 417,000 AF
Small Scale Storage Advantages

- Existing facilities with sunk capital costs
- Fewer environmental and permitting obstacles
- Minimal real estate acquisition impacts
- Existing internal knowledge of operations and maintenance
- Opportunity to improve recreational activities
- Requires development AND implementation of comprehensive Dam Safety Program
Comprehensive Dam Safety Program

- Construction history
- Performance history
- Instrumentation
- Reporting procedures
- Instrumentation thresholds
- Inundation mapping
- Energy Action Plans
- Institutional knowledge
- Relationship with regulator

Construction of San Pablo Dam, photo from EBMUD
Regulators and Risk

- Indirect Risk Evaluation
  - Maximum credible earthquake
  - Probable Maximum Flood
    - With some statistical considerations
  - Design/retrofit to specified level
  - Moving towards more formal risk based approaches

- Risk Informed Decision Making (RIDM)
  - Probabilistic seismic hazard analysis (PSHA)
  - Probable Maximum Flood
  - Probability of failure
  - Consequence of failure
  - Risk reduction measures
The Two Components of Risk

#1 – Probability of Failure
Define potential failure modes

#2 – Consequence of Failure
Loss of life
Economic loss
Operations, irrigation, generation
Environmental loss
Loss to infrastructure
Loss of public trust

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DSOD Consequence-Hazard Matrix
Risk Analysis - Scalable

- DSOD: “Indirect” evaluation of risk
- FERC: PFMA – qualitative expert elicitation
  - Category I – Highlighted
  - Category II – Considered but not highlighted
  - Category III – More information needed to classify
  - Category IV – Ruled out
- USACE/BOR/NRC – Quantitative risk analysis
  - Calculation of probability and consequence
  - Even these calculations can be scalable
USACE Tolerable Risk

- 1 in 10,000 of 10 fatalities
- 1 in 100,000 of 100 fatalities
- > 1,000 fatalities could only be acceptable if a careful evaluation of tradeoff and costs is performed
Define Potential Failure Modes

PFM 1 – Overtopping and erosion leading to breach

PFM 2 – Earthquake causing liquefaction leading to dam failure

PFM 3 – Plane crashing and destroying dam

Probability of Failure
AFE: 7E-5 (1 in 15,000)

Probability of Failure
AFE: 5E-6 (1 in 200,000)

Probability of Failure
AFE: 1E-6 (1 in 1,000,000)
Not All Failures Are Created Equally

Consequence of Failure: **Low**
- Forecast rain
- Operational controls
- Erosion can be slow failure
- FERC Category I

Consequence of Failure: **Moderate**
- No warning
- Piping, seepage leading to breach may take minutes to hours
- FERC Category II

Consequence of Failure: **High**
- No warning
- No time for evacuation
- FERC Category IV
F-N Plot of Risk
Consistent Risk
Dam A

Ground Motions for Design

$M_{7.5}$ at 5 km, Hayward Fault

PGA = 0.73g ($84^{th}$% deterministic)

High slip rate fault

Hazard Curve (USGS, 2008)

PGA: 0.73g – 885 yr return period
Dam B

Ground Motions for Design

**M**6.5 at 10 km, Foothills Fault system

PGA = 0.40g (84\textsuperscript{th} % deterministic)

Low slip rate fault

Hazard Curve (USGS, 2008)

PGA: 0.40g – 32,000 yr return period

885 yr RP: ~0.10g
Consistent Risk??
Risk Reduction

• Reduce probability of failure
  • Retrofit

• Reduce consequences
  • Improved evacuation plan
  • Improved instrumentation
  • Downstream floodwalls/levees
Benefits of Risk Analysis

• Can start simple and grow in complexity
• Allows for consistent regulatory oversight across large portfolios
• Allows for more rational decision making and CIP prioritization
• Helps communication with policy makers and public
• Demonstrates benefit of both reducing the probability of failure (retrofit), and reducing losses (downstream modifications, updated EAP, cooperation with downstream emergency responders)
Innovative Technologies in Water Management

• How is dam safety an innovative technology?
  • FERC has adopted risk based approaches
  • Many states have adopted risk based approaches
  • DSOD is slowly moving towards risk

• Why is dam safety relevant in the current drought?
  • Risk based approach could benefit MCWRA members
  • Reduced seismic and hydrologic demands
  • Level playing field with rest of state
  • Return existing storage capacity
Innovative Technologies in Water Management

• Policy makers need to understand risk
• Policy makers need to encourage regulators to adopt risk
• Technical staff need to communicate the concepts of risk to non-technical policy makers
Thank you.

Contact me with your questions:

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