Lessons in Implementing Risk Concepts in Dam Safety

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Topics

- US Army Corps of Engineers Background
- Lessons in Risk Assessment
  - Philosophy
- Lessons in Risk Management
  - Decision Making
  - Policy
- Lessons in Risk Communication
Military Programs
- Military Construction
- Base Operations
- Environmental Support
- Geospatial Engineering

Homeland Security
- Critical Infrastructure Protection
- The Infrastructure Security Partnership
- Contingency and Disaster Operations

Research & Development
- Military Engineering
- Terrain & Geospatial
- Structures
- Environment
- Water Resources

Civil Works
- Navigation, Hydropower
- Flood control, Shore Protection
- Water Supply, Regulatory
- Recreation, Disaster Response
- Environmental Restoration

Interagency Support
- DOD
- Federal
- State
- Local
- International

Real Estate
- Acquire, Manage & Dispose
- DOD Recruiting Facilities
- Contingency Operations

$48B 2009 Investments; 36,000 Employees

BUILDING STRONG®
US Army Corps of Engineers
Global Engagement

• Engagement: 100+ Countries
• Physical Presence: 34 Countries
Corps of Engineers Infrastructure

- **Portfolio Characteristics:**
  - Majority are Earthen
  - Aging (+55 years)
  - Relatively untested

“Infrastructure follows Floods, People Follow Infrastructure”

+ 675 Dams
+ 2,000 Levees

BUILDING STRONG®
Risk Assessment in Dam Safety

Lessons
Potential Failure Mode Analysis

- Completely Rethinking Infrastructure from…
  - How to analyze and design components to
  - How do they perform as a system?

- Invaluable in Understanding
  - Credible Faults
  - Likelihood
Type of Risk Analysis

- **Scripted Approaches:**
  - Relative
  - Repeatable Numbers
  - Crude Risk Characterization
  - Good Safety Program Starting Point
  - Portfolio Insight

- **Unscripted Approaches:**
  - Explicit
  - Repeatable Decisions
  - Appropriate for Use with Tolerable Risk Guidelines
  - Good Safety Program Sustainment
  - Project Insight
Internal Erosion $P_f$

- Dominant Failure Mode in Our Portfolio
- Least Well Understood
- Modified S&P Toolbox (Foster, Fell, et al):
  - Balance of Experiential, Analytical, and Expert Elicitation
  - Cannot be Fully Prescriptive!

Wolf Creek Dam, Kentucky During Construction Karst Cave Features
Risk and Systems Approaches

- Systems within Single Projects
- Systems among Multiple Projects:
  - Dams
  - Levees
- Physical and Human Systems

Addresses Complexity Equitably
Level of Effort in Risk Analysis

- **SPRA**
  - Screening Portfolio Risk Assessment
  - Relative Risks, Initial Characterization
  - What Deserves Further Study?
  - Entire Portfolio
  - One Day
  - ~$15,000 USD

- **IES**
  - Issue Evaluation Study
  - Explicit Risks, TRG Application
  - Where is Rehab Investment Justified?
  - 90 Days
  - ~$250,000 USD

- **DSMS**
  - Dam Safety Modification Study
  - Explicit Risks
  - Alternative Analysis
  - What is amount and urgency of Investment?
  - 1-2 Years
  - ~$2,000,000 USD

**Match Level of Effort with Type of Decision to be Made!**
Tolerable Risk Guidelines
“Making Better Decisions”

- More than a Number
- Making decisions with large uncertainties
- Prioritizing between condition driven and consequence driven risks
- Understanding Shared Responsibilities
Risk Management in Dam Safety

Lessons
Motivation for Change

Internal

1. Diminishing Competencies
2. State of the Practice
3. Expectations of Leadership

External

1. Funding Shortfalls
2. Better Justified Decisions
3. Other Industries Using Risk
Portfolio Risk Management

- Routine Activities are **Decentrally** Managed:
  - Inspections
  - Instrumentation
  - Screening Risk Assessments

- Non-Routine Activities are **Centrally** Managed:
  - Priorities & Queues
  - Staging
  - Investments
Interim Risk Reduction Measures

IRRMs are a strategic response to size of our dam safety challenges

- Actions include: reservoir restrictions, increased inspections, temporary structural measures
- What we never considered: Outlet Capacity
Organizational Learning

Primary Responsibilities

- Leaders
  - Must Understand Risk Concepts, Decisions Being Made, and Be Able to Communicate Risks

- Managers
  - Must Understand Risk Process Enough to Make Major Decisions

- Risk Assessors
  - Must Be Able to Conduct Risk Analysis, Recommend Solutions and Decisions and Defend Them

Don’t Under-Estimate!

Organizational Location Where Use of Risk Starts

BUILDING STRONG®
Building and Sustaining the Bench of Risk Competencies

- Office Consolidation
- Broad Recruitment
- Good Documentation:
  - Policy
  - Procedures
    - Best Practices
    - Manuals
- Annual Training
- Reviews:
  - Quality & Consistency
  - Independent, Peer
Creating a Risk Generalist

Traditional Specialists

- Geotechnical
- Hydraulic
- Risk

New Generalist

- Risk Demands a New, Non-Traditional System Oriented Professional

Skills:
- Multiple Disciplines
- Analytical and Subjective
- Uncertainty
- Decision Oriented

BUILDING STRONG®
Building the Safety Case

- Documenting the Logic and Reasoning ("Why" and "How")
- No Simple Numerical Solutions
- Supports the Recommended Decision
- Withstands Peer Review
Risk Communication in Dam Safety

Lessons
Disciplined Consistency

<table>
<thead>
<tr>
<th>Dam Safety Action Class</th>
<th>Characteristics of this class</th>
<th>Actions for dams in this class</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>CRITICALLY NEAR FAILURE</td>
<td>Take immediate action to avoid failure.</td>
</tr>
<tr>
<td>URGENT AND COMPELLING</td>
<td>Progression toward failure is confirmed to be taking place under normal operations. Almost certain to fail under normal operations from immediately to within a few years without intervention.</td>
<td>Validate classification through an external peer review.</td>
</tr>
<tr>
<td>(Unsafe)</td>
<td>OR EXTREMELY HIGH RISK</td>
<td>Implement interim risk reduction measures, including operational restrictions, and ensure that emergency action plan is current and functionally tested for initiating event.</td>
</tr>
<tr>
<td></td>
<td>Combination of life or economic consequences with probability of failure is extremely high.</td>
<td>Conduct heightened monitoring and evaluation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expedite investigations to support justification for remediation using all resources and funding necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Initiate intensive management and situation reports.</td>
</tr>
<tr>
<td>II</td>
<td>FAILURE INITIATION UNSEEN</td>
<td>Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current, and functionally tested for initiating event.</td>
</tr>
<tr>
<td>URGENT</td>
<td>For confirmed (unsafe) and confirmed (potentially unsafe) dam safety issues, failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety.</td>
<td>Conduct heightened monitoring and evaluation.</td>
</tr>
<tr>
<td>(Unsafe Potentially</td>
<td>OR VERY HIGH RISK</td>
<td>Expedite confirmation of classification. Give very high priority for investigations to support justification for remediation.</td>
</tr>
<tr>
<td>Unsafe)</td>
<td>The combination of life or economic consequences with probability of failure is very high.</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>SIGNIFICANTLY INADEQUATE</td>
<td>Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current, and functionally tested for initiating event.</td>
</tr>
<tr>
<td>HIGH PRIORITY</td>
<td>OR MODERATE TO HIGH RISK</td>
<td>Conduct heightened monitoring and evaluation. Prioritize for investigations to support justification for remediation considering consequences and other factors.</td>
</tr>
<tr>
<td>(Conditionally Unsafe)</td>
<td>For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is moderate to high.</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>INADEQUATE WITH LOW RISK</td>
<td>Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but no plan for risk reduction measures at this time.</td>
</tr>
<tr>
<td>PRIORITIZED</td>
<td>For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is low and may not meet all essential USACE guidelines.</td>
<td></td>
</tr>
<tr>
<td>(Marginal Safe)</td>
<td>ADEQUATELY SAFE</td>
<td>Continue routine dam safety activities, normal operation, and maintenance.</td>
</tr>
<tr>
<td>V</td>
<td>Dam is considered safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues. AND RESIDUAL RISK IS CONSIDERED TOLERABLE</td>
<td></td>
</tr>
<tr>
<td>NORMAL</td>
<td>(Safe)</td>
<td></td>
</tr>
</tbody>
</table>

* At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan.
Shared Responsibilities

**Type of Activities**

- **Structural Risk Reduction**
  - Dam Structure
  - Safety Programs
  - Maintenance & Operations
  - Rehabilitation
  - Risk Communication
  - Responsible Party: Dam Owner, Dam Regulator, Dam Operator

- **Non-Structural Risk Reduction**
  - Insurance
  - Development Controls
  - Building Codes
  - Evacuation
  - Risk Awareness

**Residual Risk Remains**
Communicating Risks

- Public’s Understanding is Binary (Not Probabilistic)
- Communication:
  - Support for Decisions
  - Influence Behavior but Don’t Panic
  - Consistent Message = trust, credibility
Information Accessibility

- Balance Benefits of Sharing with Safeguarding Information
- Evolving Policy with Competing Position-Based Opinions
- Overcome by Technology?
Unsafe Dams and Flood Risks

- Operations of Unsafe Dams in Flood Events:
  - Risk of Failure versus Known Induced Downstream Damage
  - Outlet Capacity Generally Lacking
  - Legal Authority?
  - Primarily Managed with Non-Structural Measures

Thundermist Dam, New England 2010 Flood Releases
Findings After Using Risk Concepts

**Benefits**
- Understanding of Risks Greatly Improved
- Better Decisions
- More Effective Communication

**“Eye-Openers”**
- Standards Based Approach Inadequate
- Problems are Larger than we Thought
- Risks are Not Intuitive
- Risks are Not Evenly Distributed
- It’s a marathon, not a Sprint!
Thank You

Discussion & Questions