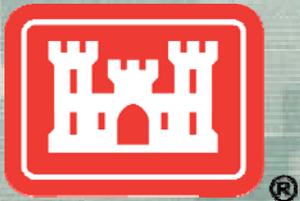


Lessons in Implementing Risk Concepts in Dam Safety

Eric Halpin, PE
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United States

June 2010



US Army Corps of Engineers
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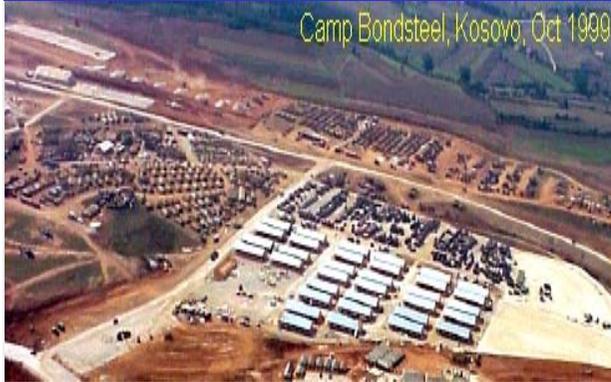
Topics

- 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



Real Estate



Acquire, Manage & Dispose

- DOD Recruiting Facilities
- Contingency Operations

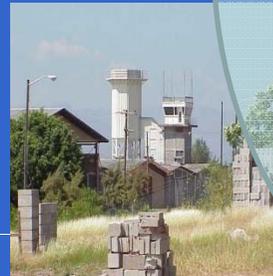
Homeland Security



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

Interagency Support

- DOD
- Federal
- State
- Local
- International



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



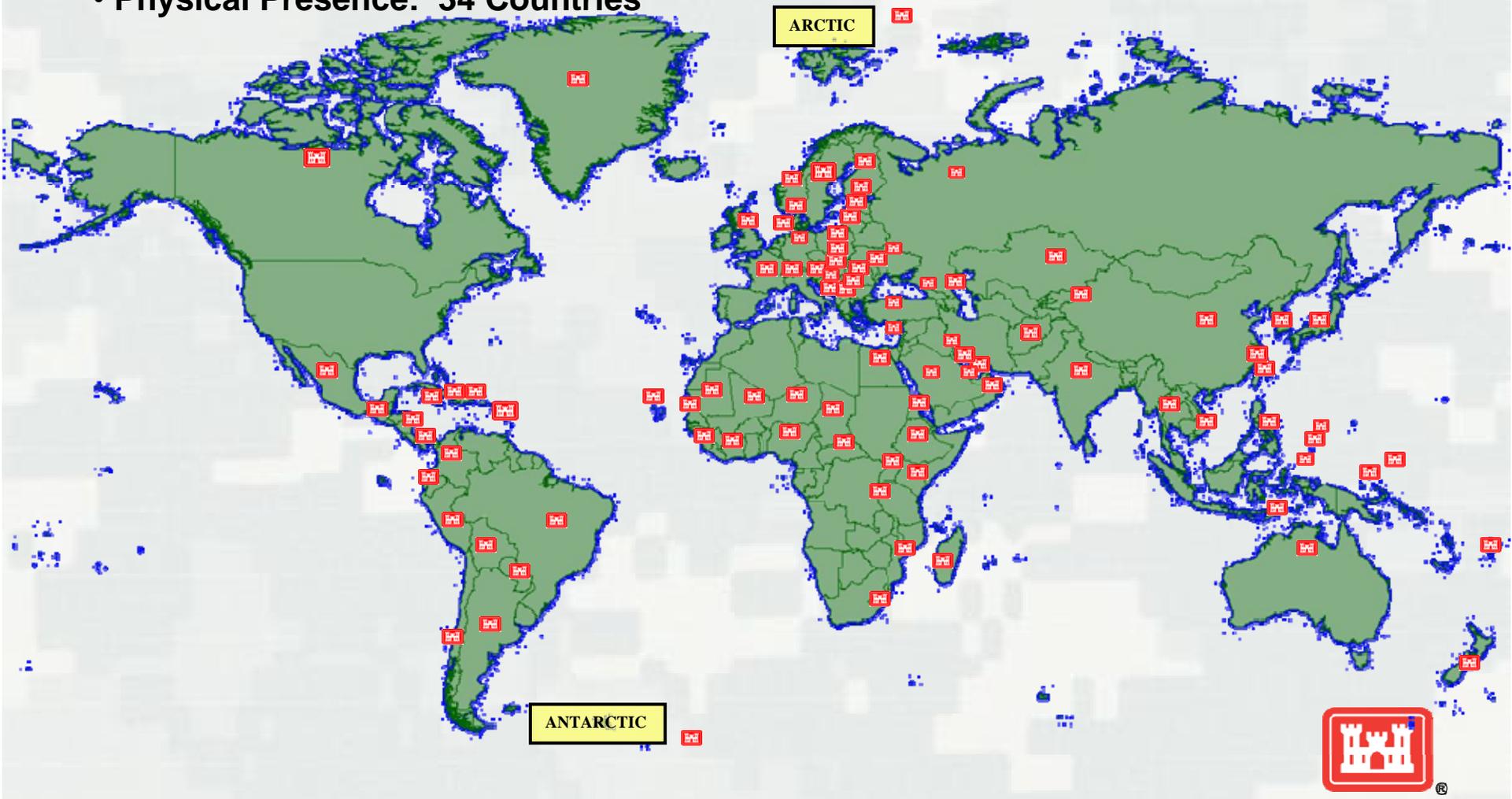
\$48B 2009 Investments; 36,000 Employees



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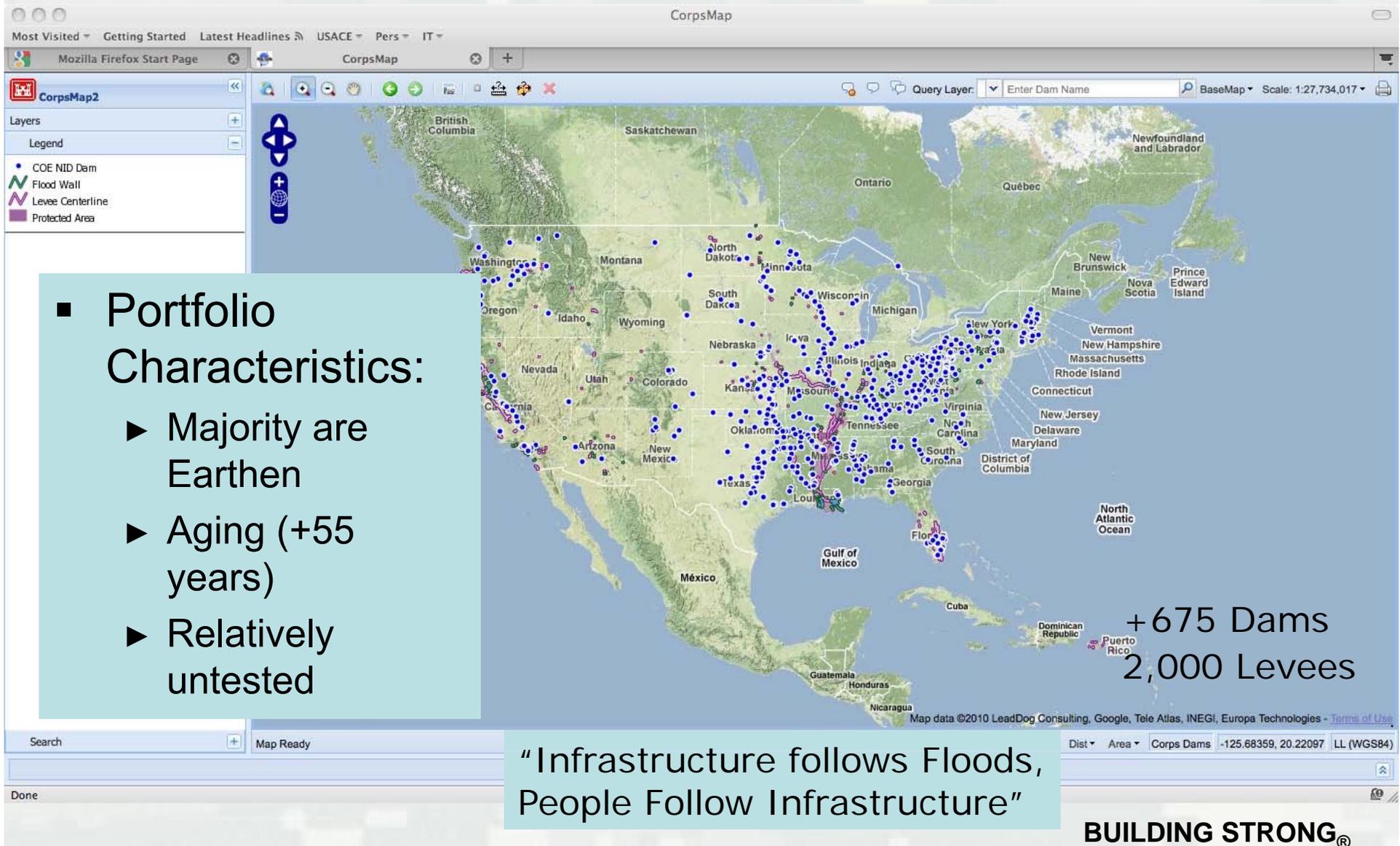
US Army Corps of Engineers Global Engagement

- Engagement: 100+ Countries
- Physical Presence: 34 Countries



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Corps of Engineers Infrastructure



Risk Assessment in Dam Safety

Lessons



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Potential Failure Mode Analysis



PFMA Team, Isabella Dam, California

- Completely Rethinking Infrastructure from...
 - ▶ How to analyze and design components to
 - ▶ How do they perform as a system?
- Invaluable in Understanding
 - ▶ Credible Faults
 - ▶ Likelihood

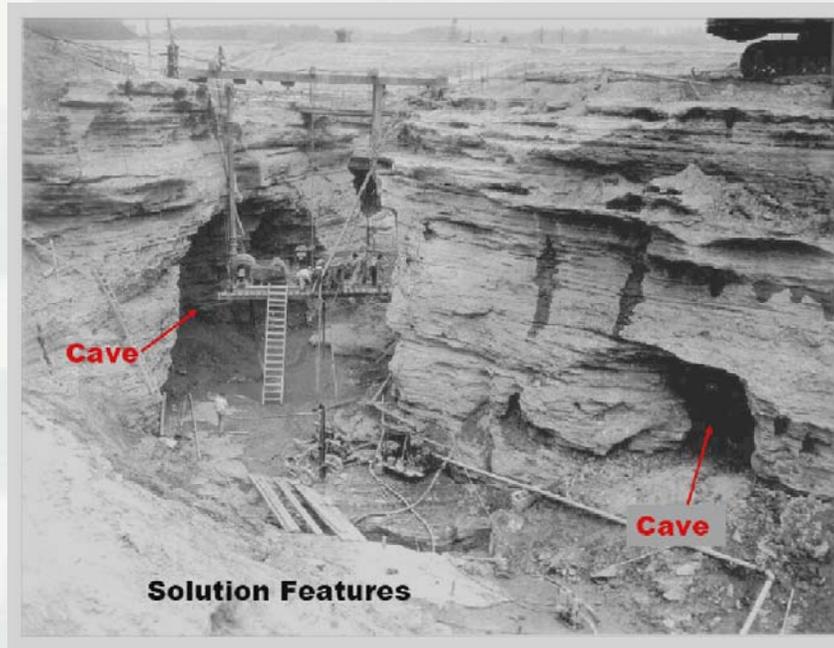


Type of Risk Analysis

- 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

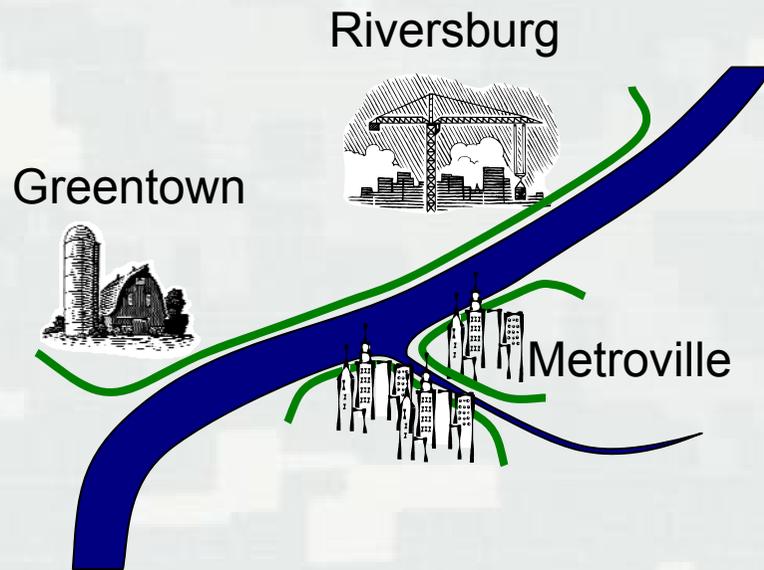


Wolf Creek Dam, Kentucky
During Construction
Karst Cave Features

- 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!



Risk and Systems Approaches



This diagram shows one levee "project" and three levee systems

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

Addresses Complexity Equitably



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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

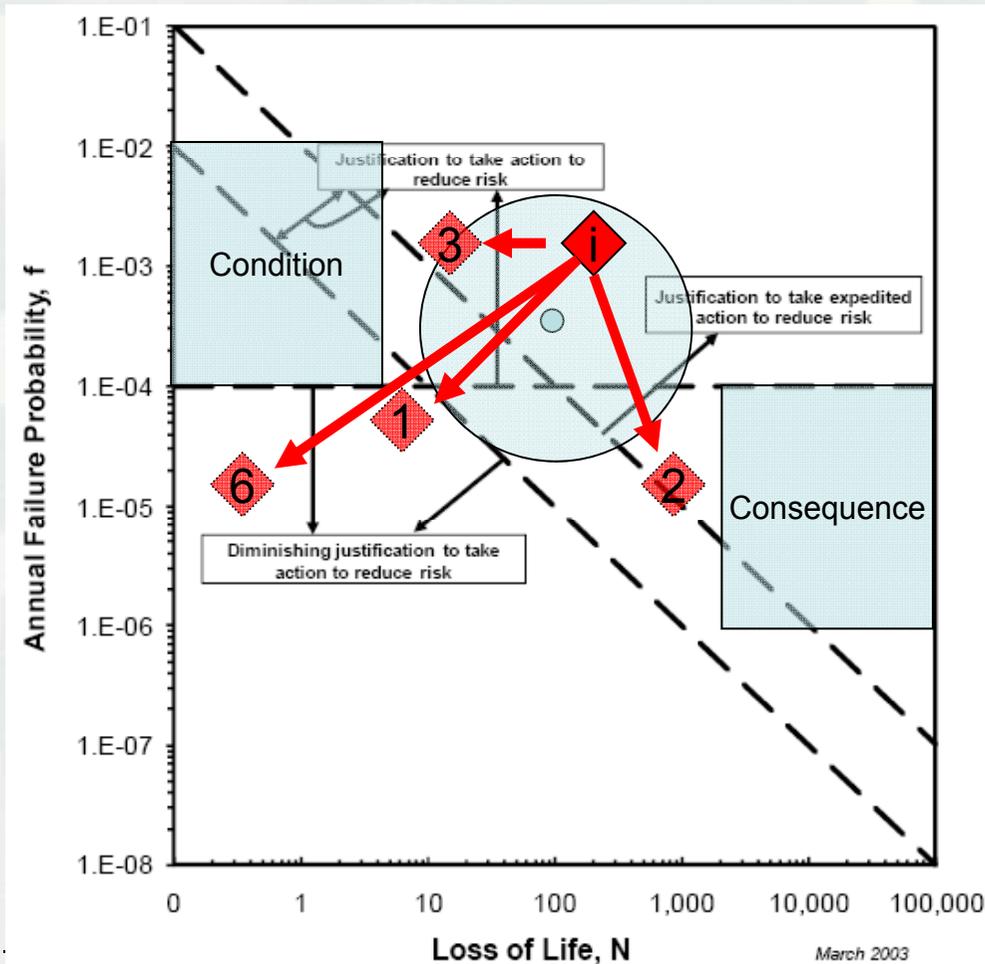
- ***Match Level of Effort with Type of Decision to be Made!***



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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



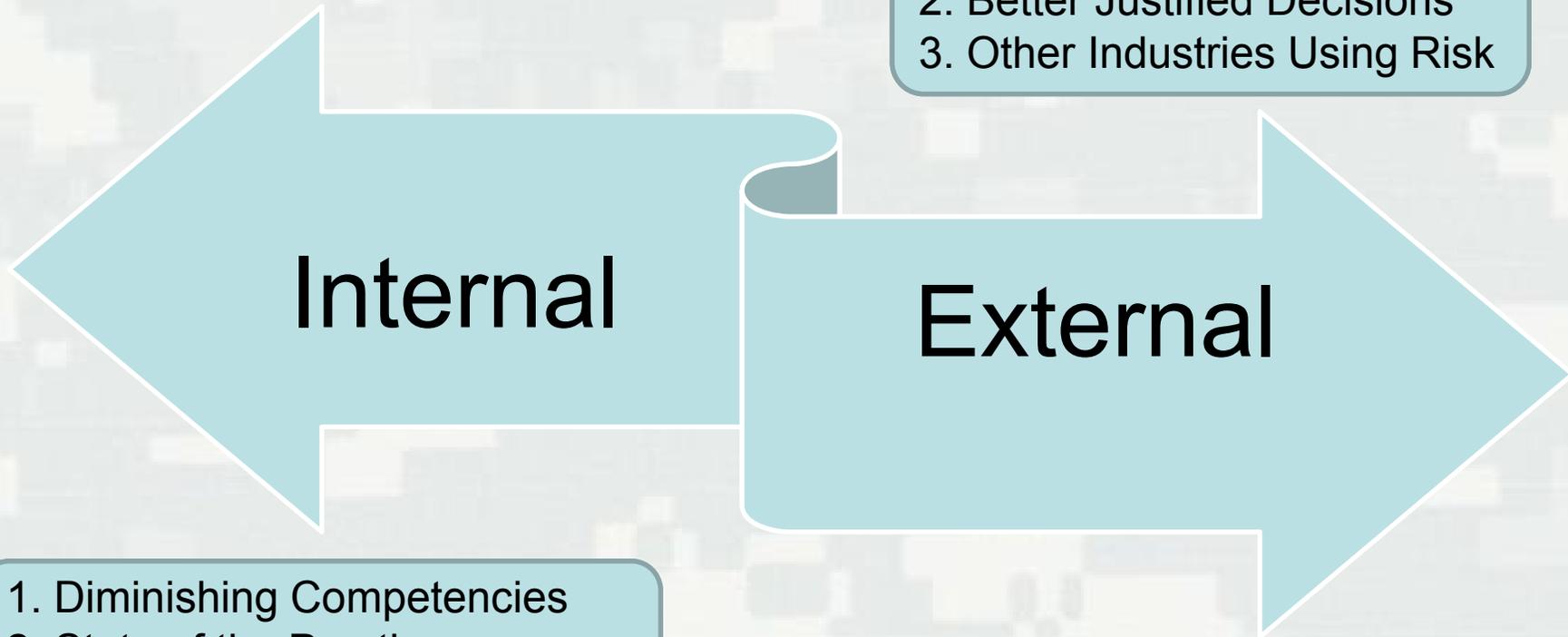
Risk Management in Dam Safety

Lessons



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Motivation for Change

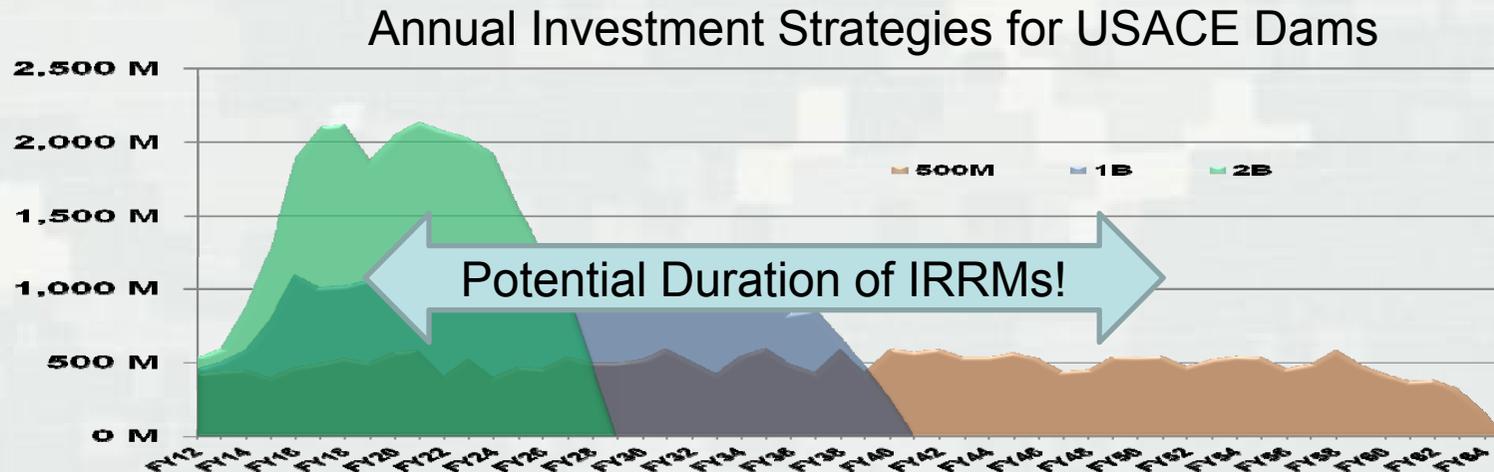


1. Funding Shortfalls
2. Better Justified Decisions
3. Other Industries Using Risk

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



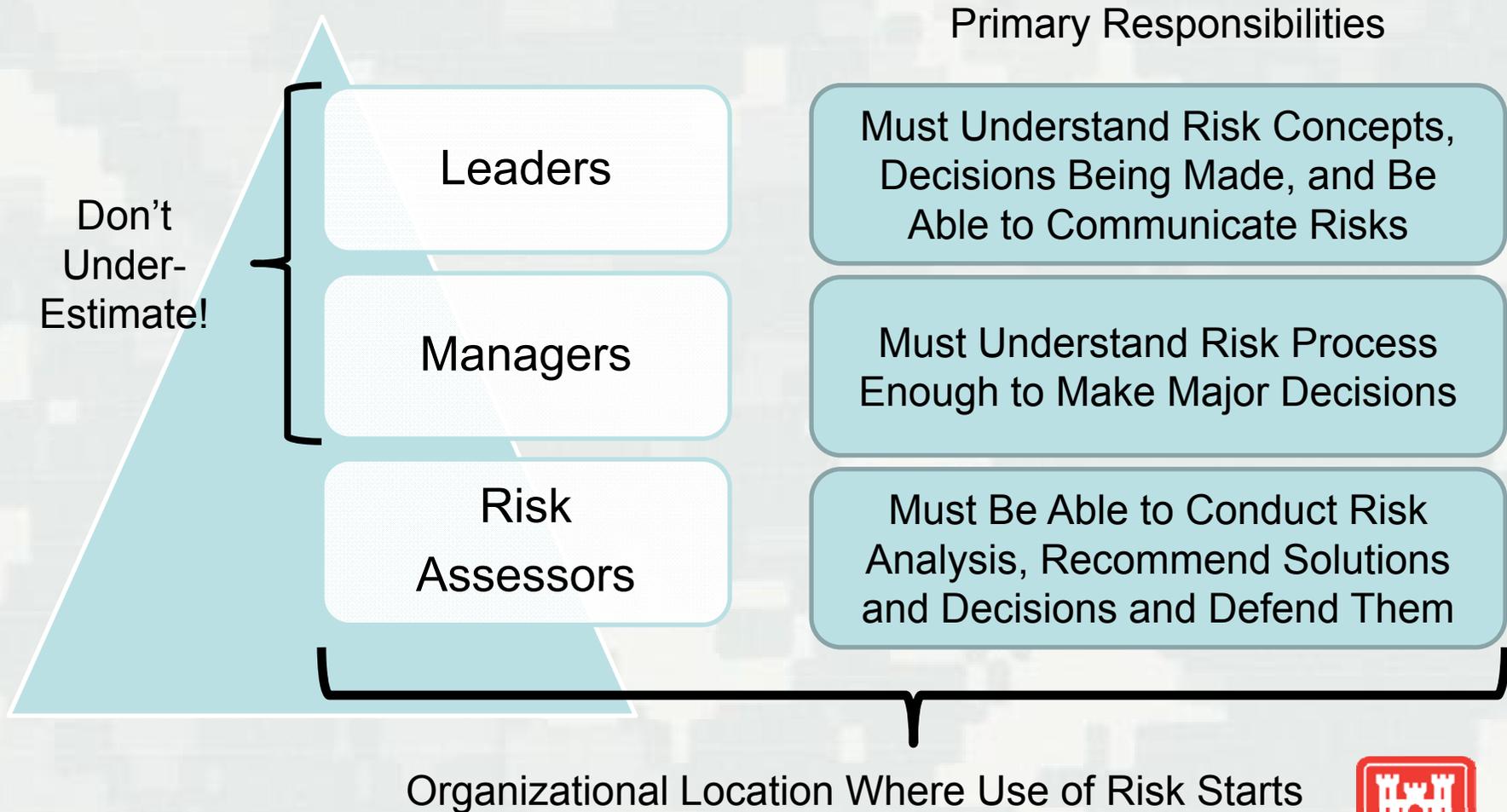
Interim Risk Reduction Measures



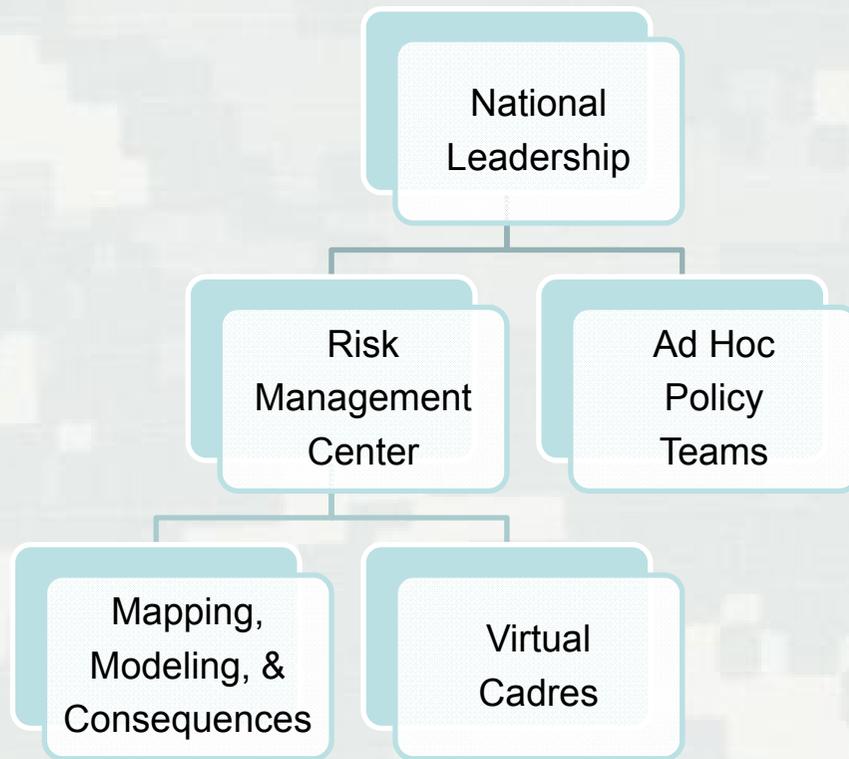
- IRRMs are a strategic response to size of our dam safety challenges
- Actions include: reservoir restrictions, increased inspections, temporary structural measures
- What we never considered: Outlet Capacity



Organizational Learning



Building and Sustaining the Bench of Risk Competencies

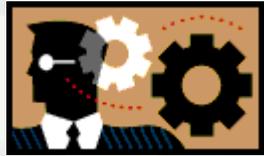


- Office Consolidation
- Broad Recruitment
- Good Documentation:
 - ▶ Policy
 - ▶ Procedures
 - Best Practices
 - Manuals
- Annual Training
- Reviews:
 - ▶ Quality & Consistency
 - ▶ Independent, Peer

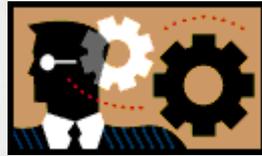


Creating a Risk Generalist

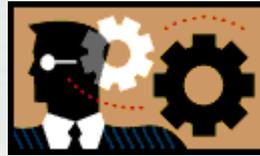
Traditional Specialists



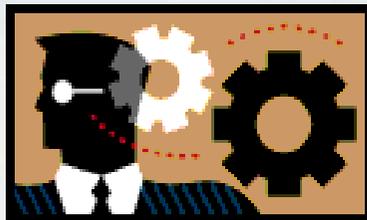
Geotechnical



Hydraulic



Risk



New Generalist

- Risk Demands a New, Non-Traditional System Oriented Professional
- Skills:
 - ▶ Multiple Disciplines
 - ▶ Analytical and Subjective
 - ▶ Uncertainty
 - ▶ Decision Oriented



Building 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



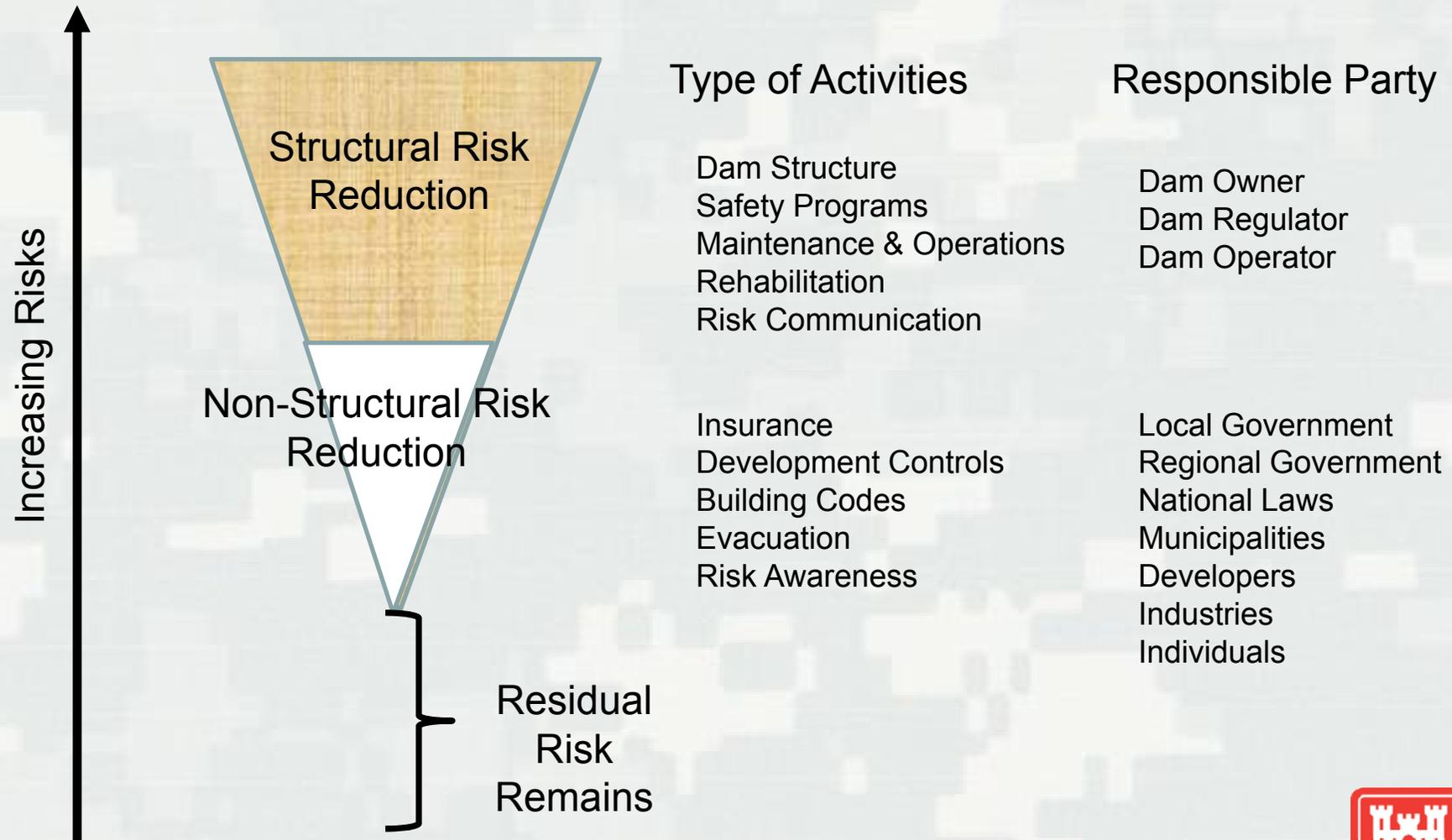
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Disciplined Consistency

USACE Dam Safety Action Classification Table*			
Dam Safety Action Class	Characteristics of this class	Actions for dams in this class	
Risk Characterization	I URGENT AND COMPELLING (Unsafe)	CRITICALLY NEAR FAILURE 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. OR EXTREMELY HIGH RISK Combination of life or economic consequences with probability of failure is extremely high.	Take immediate action to avoid failure. Validate classification through an external peer review. Implement interim risk reduction measures, including operational restrictions, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support justification for remediation using all resources and funding necessary. Initiate intensive management and situation reports.
	II URGENT (Unsafe or Potentially Unsafe)	FAILURE INITIATION FORESEEN For confirmed (unsafe) and unconfirmed (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. OR VERY HIGH RISK The combination of life or economic consequences with probability of failure is very high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current, and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite confirmation of classification. Give very high priority for investigations to support justification for remediation.
	III HIGH PRIORITY (Conditionally Unsafe)	SIGNIFICANTLY INADEQUATE OR MODERATE TO HIGH RISK For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is moderate to high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize for investigations to support justification for remediation considering consequences and other factors.
	IV PRIORITY (Marginally Safe)	INADEQUATE WITH LOW RISK 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.	Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but no plan for risk reduction measures at this time.
	V NORMAL (Safe)	ADEQUATELY SAFE AND RESIDUAL RISK IS CONSIDERED TOLERABLE. Dam is considered safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues.	Continue routine dam safety activities, normal operation, and maintenance.

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

Shared Responsibilities



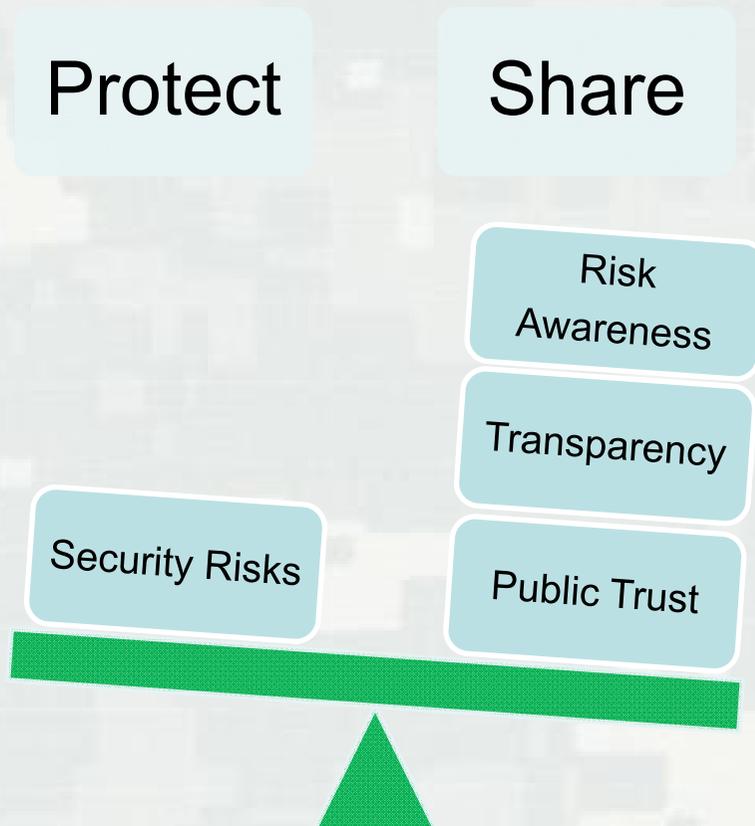
Communicating Risks



- 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



Thundermist Dam, New England
2010 Flood Releases

- 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



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



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