Experiência Internacional sobre a Segurança de Barragens

Apresentado por:

Calvin Creech, PhD, PE

Engenheiro Interdisciplinar e Hidráulico

USACE, Distrito Mobile

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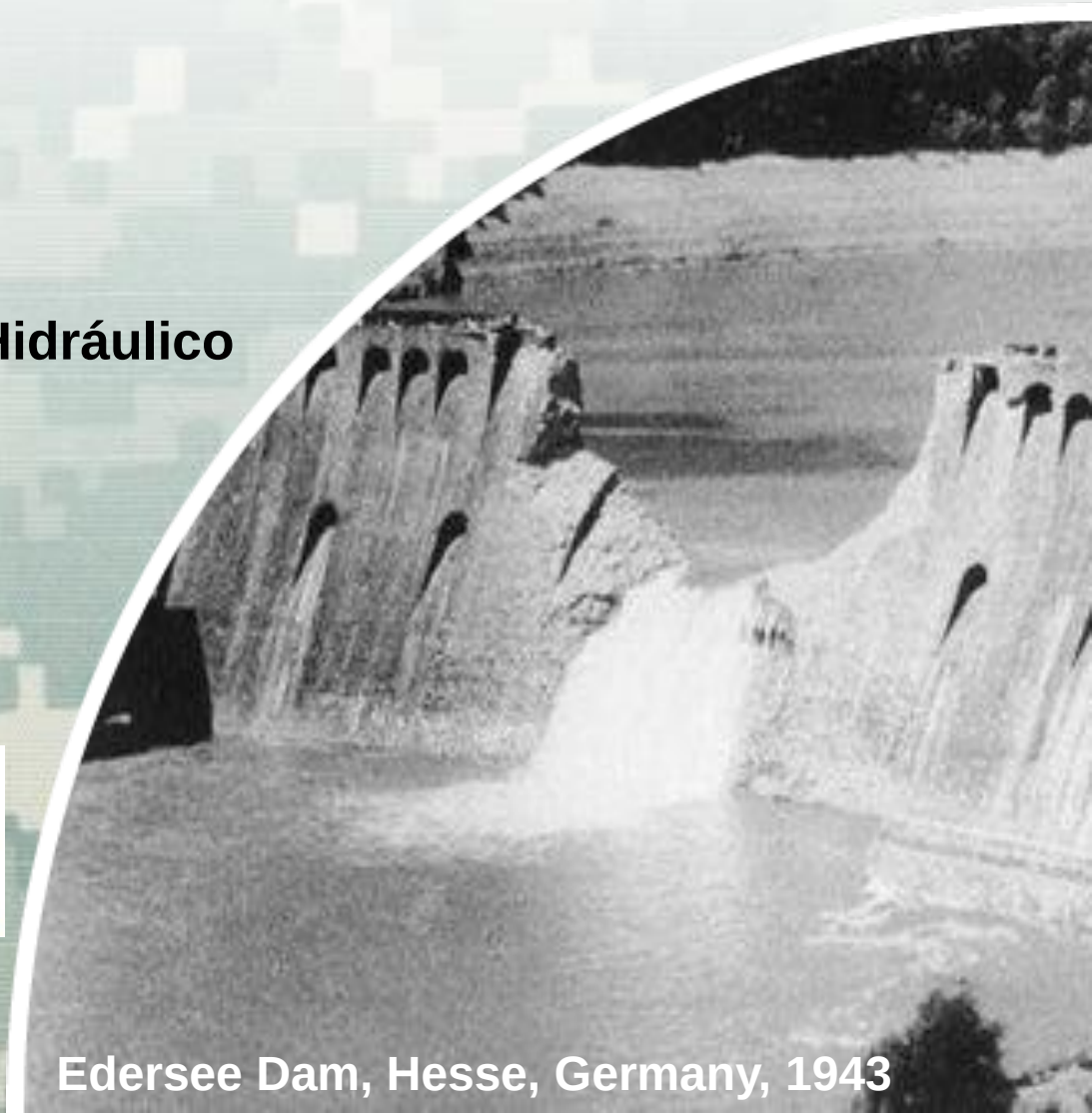
US Army Corps of Engineers
BUILDING STRONG®



Edersee Dam, Hesse, Germany, 1943

Outline

- Introduction
- Dam Safety Program Framework in the United States
- Implementation of the Dam Safety Program in the United States
- Tolerability of Risk Framework

Top 15 Dam Disasters Worldwide

Dam	Country	Year	Cause	Death Toll
Kelly Barnes Dam	United States	1977	Engineering / Rain	39
Lower Otay Dam	United States	1916	Rain	40
Edersee Dam	Germany	1943	Bombed	47-100
Shakidor Dam	Pakistan	2005	Rain	70
Pittston Coal Co. Dam	United States	1972	Engineering / Rain	125
Mill River Dam	United States	1874	Engineering	139
Gleno Dam	Italy	1923	Engineering	356
Malpasset Dam	France	1959	Engineering / Rain	423
Mina Plakalnitsa Dam	Bulgaria	1966	Unknown	~500
Saint Francis Dam	United States	1928	Engineering	600
Pantano de Puentes Dam	Spain	1802	Rain	608
Vajont Dam	Italy	1963	Earthquake	2000
Kaloko Dam	United States	1889	Engineering / Rain	2209
Machchu II Dam	India	1979	Rain	25,000
Banqiao	China	1975	Typhoon	26,000

Dam Safety

The art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment.

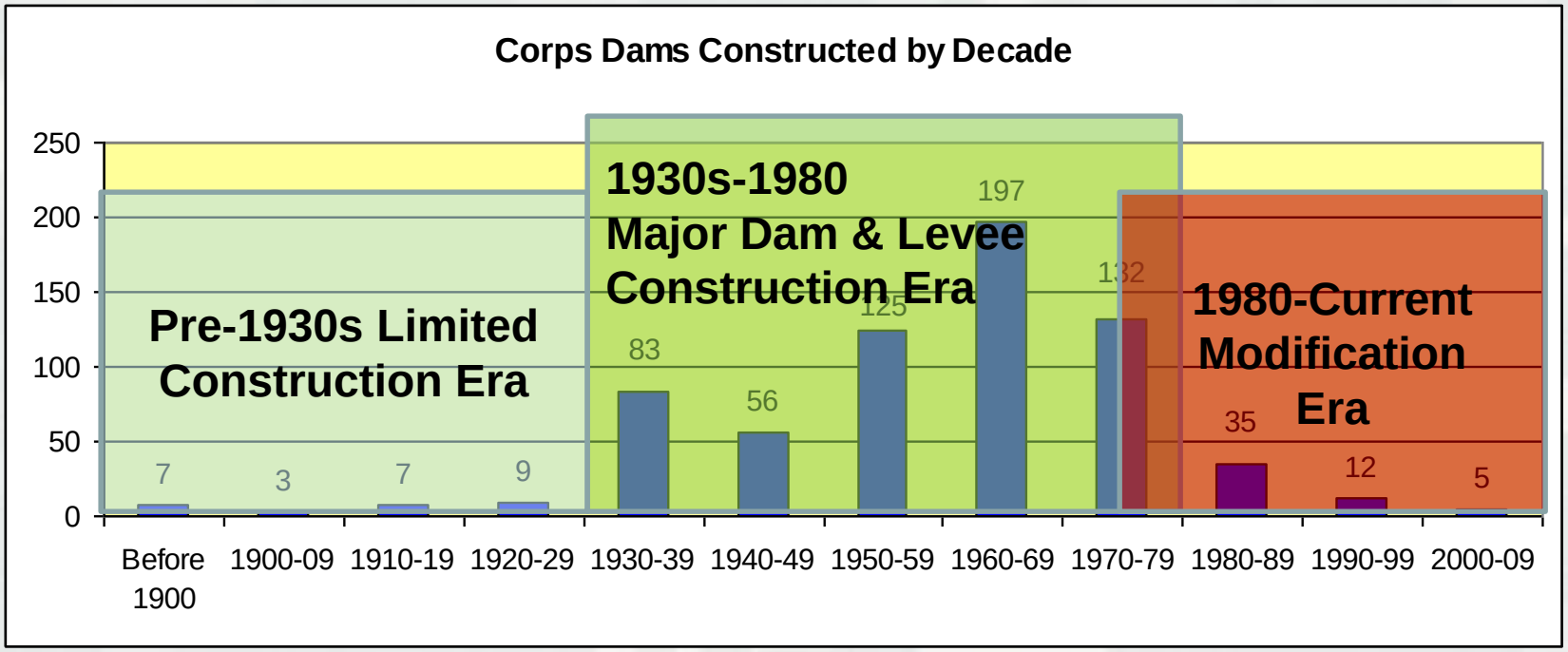
Dam Safety Program

Program to protect life, property, lifelines, and the environment by ensuring that all dams are designed, constructed, regulated, operated, and maintained as safely and effectively as is reasonably practicable.

USACE Civil Works Dams

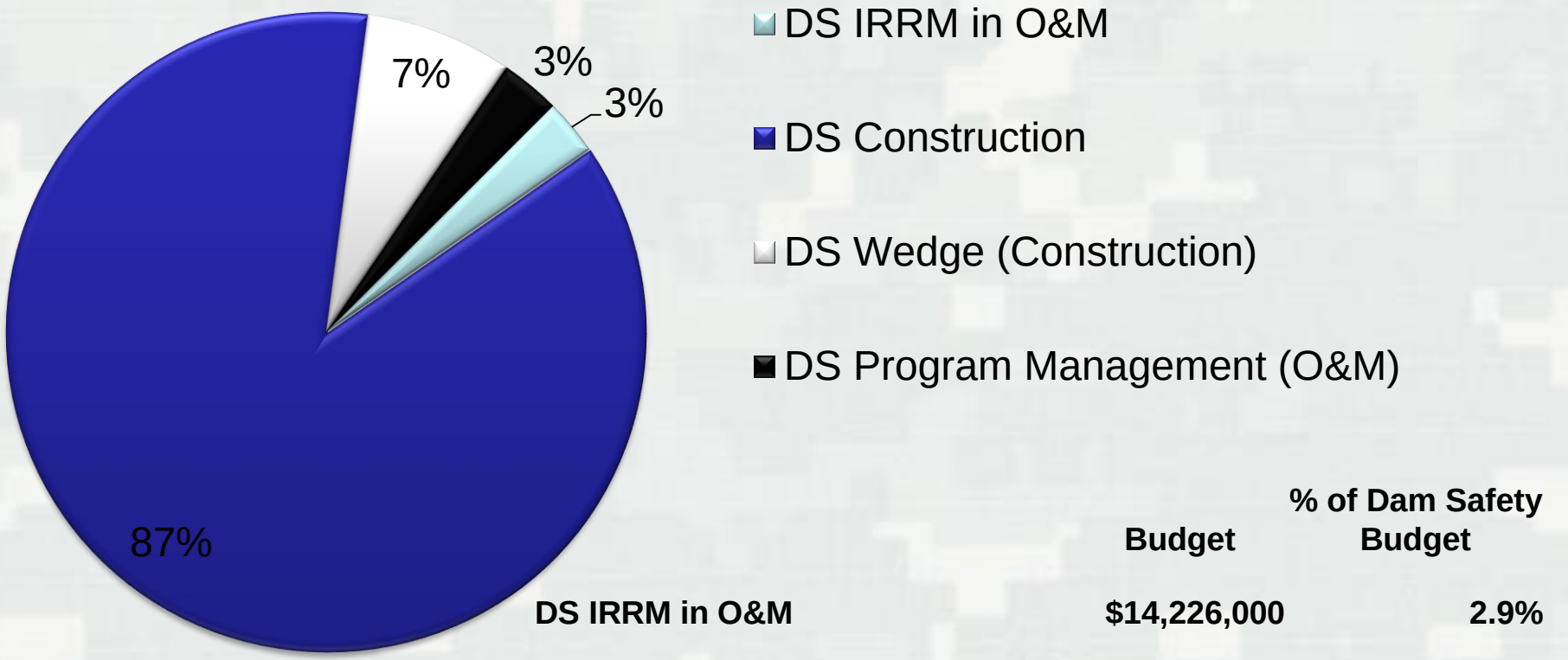
- Over 700 dams
  - **embankment = 86 %**
  - **concrete = 7 %**
  - **combination = 7 %**
- Project purposes include: flood control, navigation, hydropower, water supply, fish & wildlife conservation, recreation
- Median height: 93 feet
- Mean height: 112 feet
- Average age: 55 years
- High Hazard dams: 77 %

History of Dam Construction in USACE



Transitioning from Dam Construction to Dam Modification with New Skills, Practices, and Policies that are Risk Informed.

FY 2012 Dam Safety Budget Summary

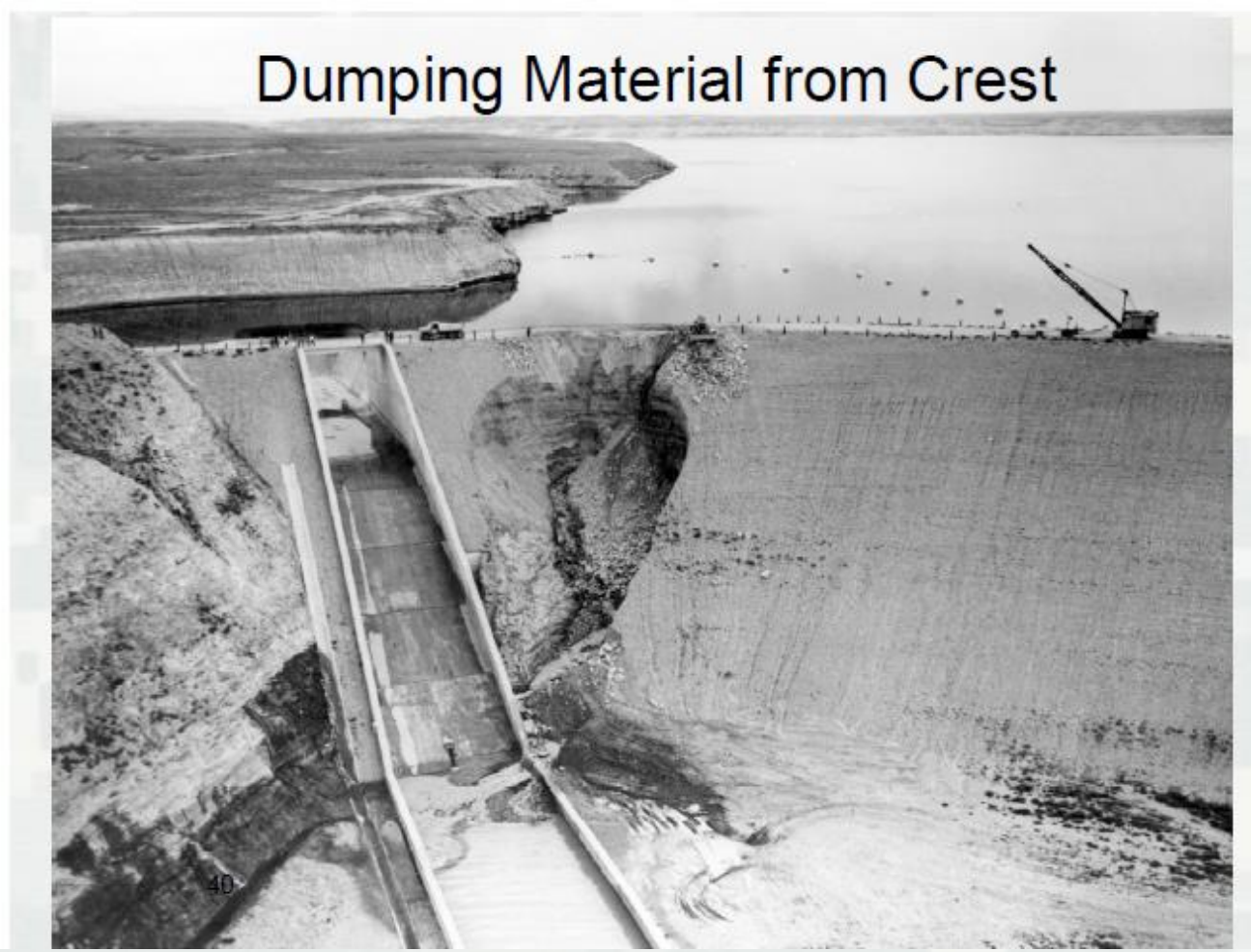


	Budget	% of Dam Safety Budget
DS IRRM in O&M	**$14,226,000**	**2.9%**
DS Construction	**$432,700,000**	**86.7%**
DS Wedge (Construction)	**$37,000,000**	**7.4%**
DS Program Management (O&MRI)	**$15,000,000**	**3.0%**
Dam Safety Budget Total	**$498,926,000**	

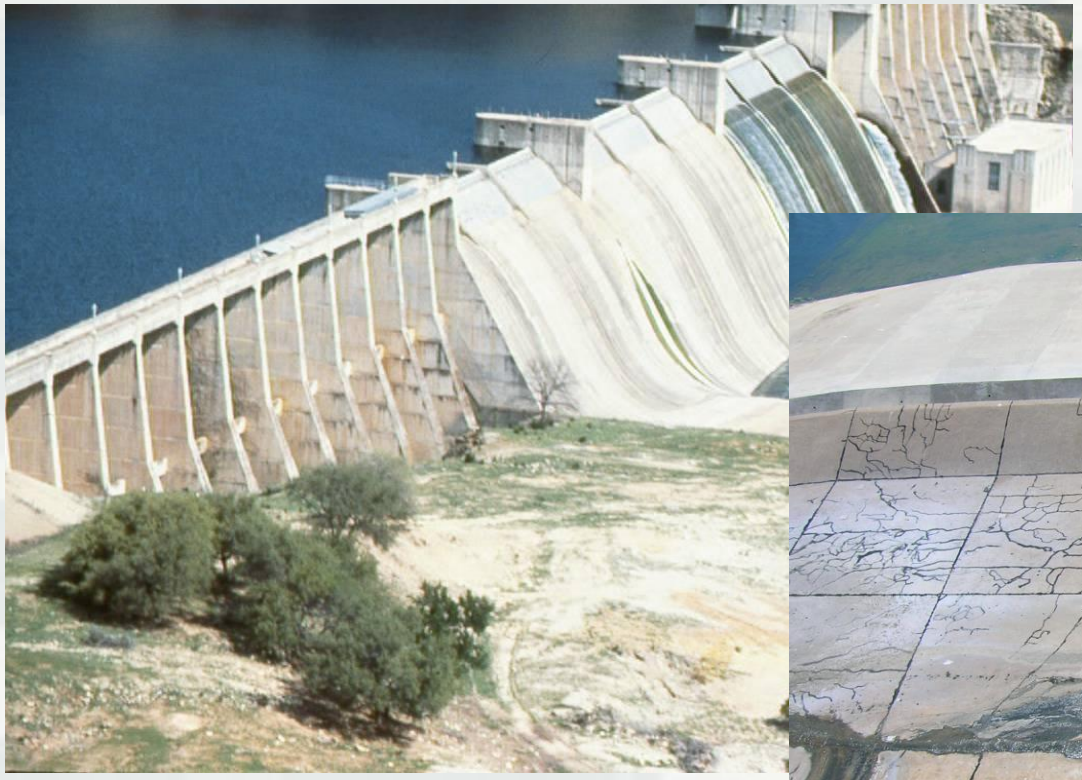
Dam Safety Program Framework in the United States

Federal US Dam Incidents, 1942

Federal US Dam Incidents
Fontenelle Dam Incident 1964



Federal US Incidents, Recent



Surveying results indicated the dam had moved several inches since monitoring began

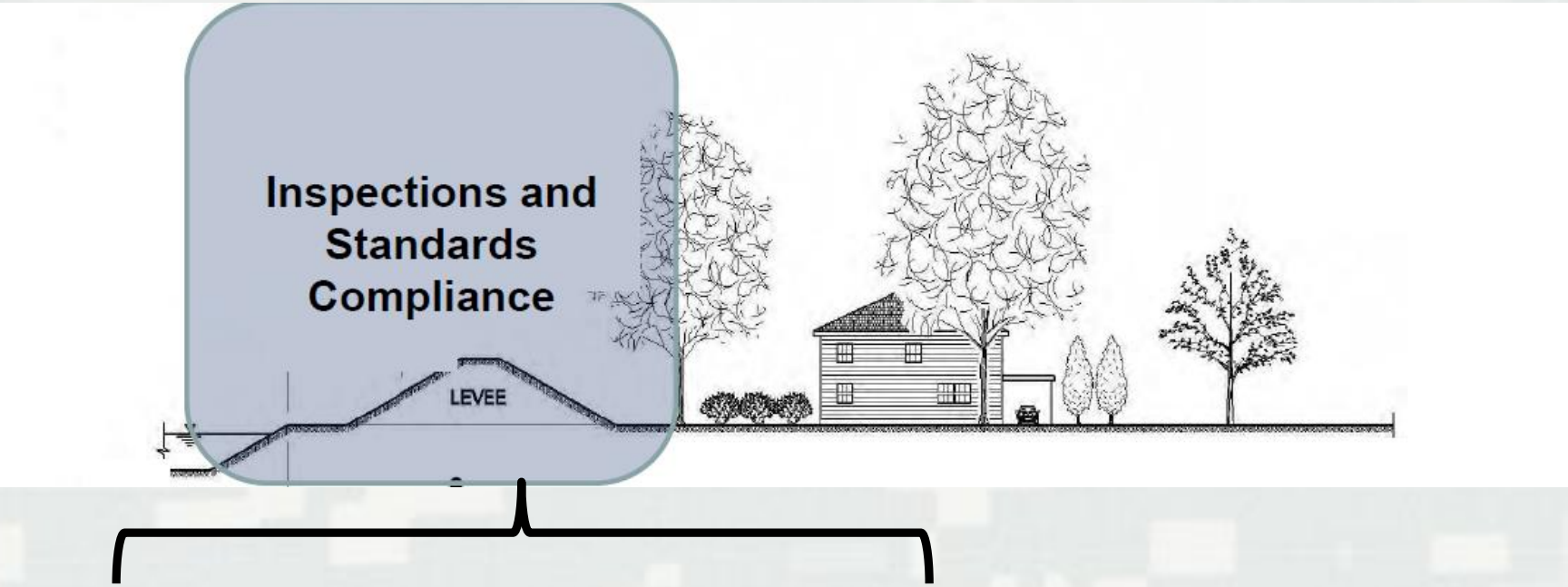
Federal Guidelines for Dam Safety

- Initiated by President Carter in April 1977
- *Ad Hoc* Interagency Committee
- Published in June 1979
- Provide the Standard for Federal Agency Programs
  - Organization Management
  - Technical Management of Design
  - Technical Management of Construction
  - Technical Management of Operations & Maintenance

Transition to Risk-Informed Dam Safety Program

- USACE has moved from a solely standards-based approach for its dam safety program to a dam safety portfolio risk management approach.
  - Standards-based or essential guidelines approach is included in the risk-informed approach.
- One of the bases for a risk-informed decision, and prioritization of the work, is a consideration of meeting tolerable risk guidelines.
  - Other non-quantitative factors will influence practical decision making.

Traditional View of Infrastructure Safety



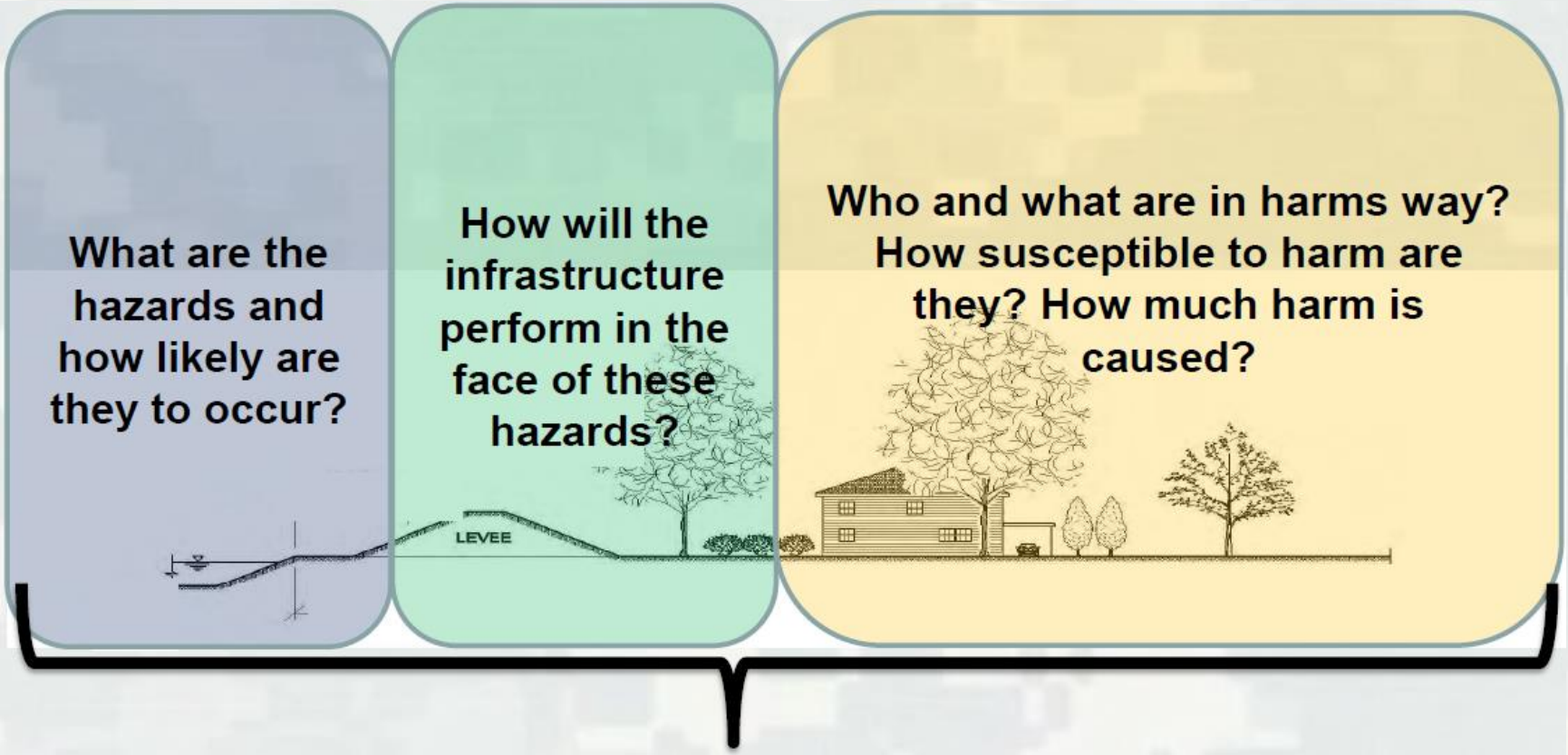
Focused on the Infrastructure (not people)

Focused on Individual Disciplines (not integrated systems)

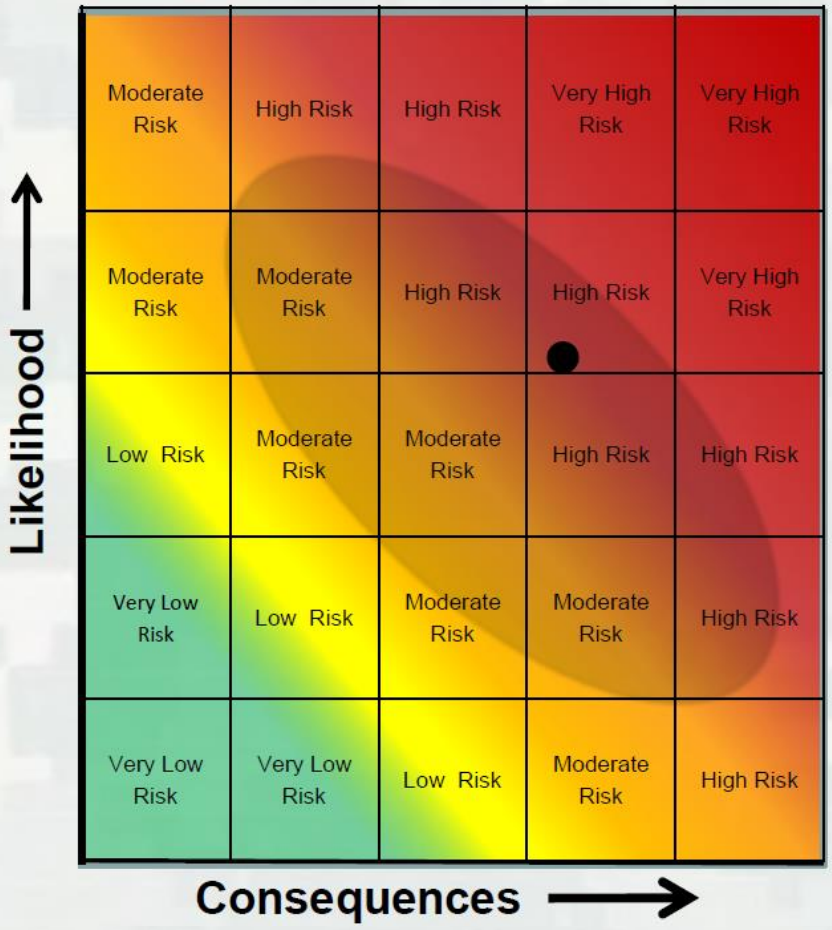
Focused on Design Standards (not expected performance)

Risk Informed View of Infrastructure Safety

Risk = f(Hazard, Performance, Consequences)



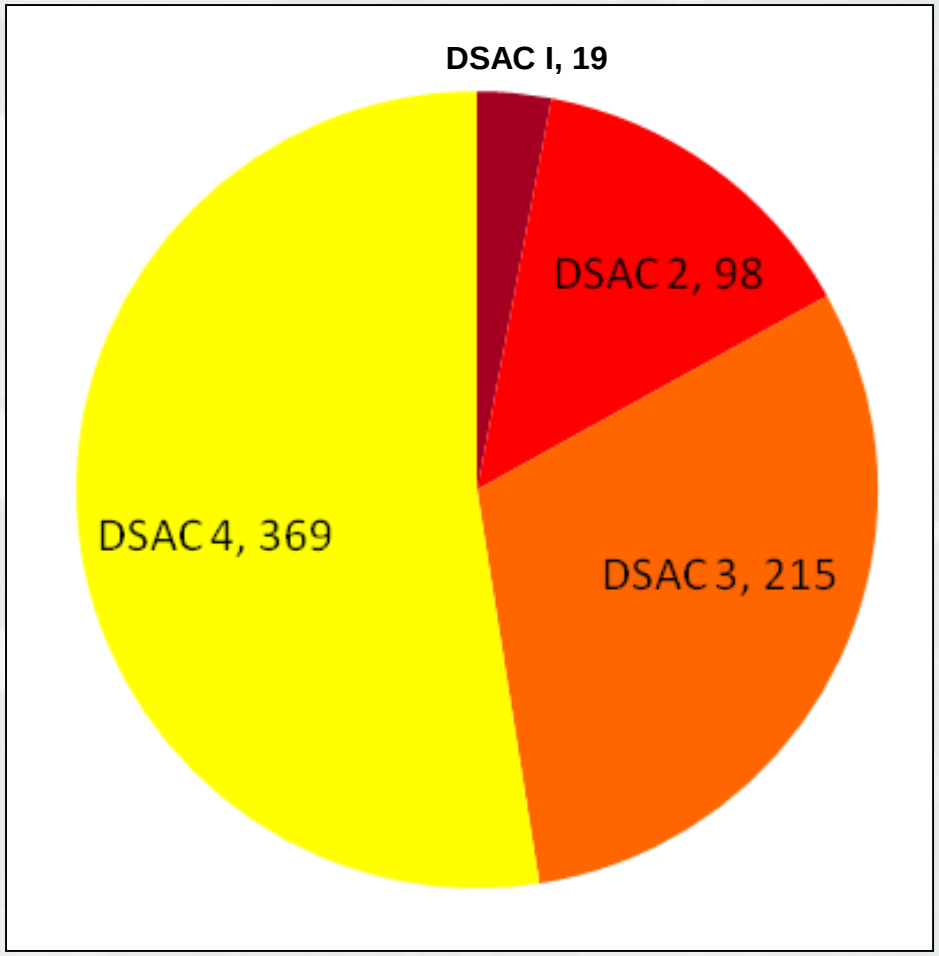
Risk = Improved Communications



- Common Questions:
  - What you Know, What is likely, and What is Possible . . .
  - Where are Risks Relative to Other Systems?
  - What is Source of Risk?
  - What Can be Done
- Realizing Shared Responsibilities

Table 3.1 – USACE Dam Safety Action Classification Table*			
URGENCY OF ACTION		ACTIONS FOR DAMS IN THIS CLASS	CHARACTERISTICS OF THIS CLASS
I VERY HIGH URGENCY		Take immediate action to avoid failure. Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support remediation using all resources and funding necessary. Initiate intensive management and situation reports.	CRITICALLY NEAR FAILURE: Progression toward failure is confirmed to be taking place under normal operations. Dam is almost certain to fail under normal operations from immediately to within a few years without intervention. OR EXTREMELY HIGH INCREMENTAL RISK**: Combination of life or economic consequences with likelihood of failure is very high. USACE considers this level of life-risk to be unacceptable except in extraordinary circumstances.
II HIGH URGENCY		Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as justified. Ensure the 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.	FAILURE INITIATION FORESEEN: For confirmed and unconfirmed 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 INCREMENTAL RISK**: The combination of life or economic consequences with likelihood of failure is high. USACE considers this level of life-risk to be unacceptable except in extraordinary circumstances.
III MODERATE URGENCY		Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as justified. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize investigations to support justification for remediation informed by consequences and other factors.	MODERATE TO HIGH INCREMENTAL RISK**: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is moderate. USACE considers this level of life-risk to be unacceptable except in unusual circumstances.
IV LOW URGENCY		Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.	LOW INCREMENTAL RISK**: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is low and the dam may not meet all essential USACE guidelines. USACE considers this level of life-risk to be in the range of tolerability but the dam does not meet all essential USACE guidelines.
V NORMAL		Continue routine dam safety activities and normal operations, maintenance, monitoring, and evaluation.	VERY LOW INCREMENTAL RISK**: The combination of life, economic, or environmental consequences with likelihood of failure is very low and the dam meets all essential USACE guidelines. USACE considers this level of life-safety risk to be tolerable.
*At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan. ** INCREMENTAL RISK is the risk that exists due to the presence of the dam and this is the risk used to inform the decision on the DSAC assignment. The information presented in this table does not reflect the NON-BREACH RISK associated with the presence of the dam or from operation of the dam.			

USACE Dam Safety Action Classification Dam Portfolio Distribution



- Count as of Sep 2012 is 702 dams at 556 projects

- Sep 2011 was 698 dams at 559 projects.

- DSAC chart is for all dams. Does not include one newly constructed dam that does not have a DSAC value.

- Data Source: DSPMT, 4 Sep 2012

Implementation of the Dam Safety Program

Scope of Risk Assessments

- Risk assessments vary in purpose and therefore in the data required, detail and robustness of analysis, and in uncertainty and confidence in the results:
  - Screening for Portfolio Risk Assessment (SPRA)
  - Interim Risk Reduction Measures Plans (IRRMP)
  - Periodic Assessments (PA)
  - Issue Evaluation Studies (IES)
  - Dam Safety Modification Study (DSMS)
- Level of detail should only be what is needed to justify the decision(s) that will be informed by the risk assessment.

General Steps of a Quantitative Risk Assessment

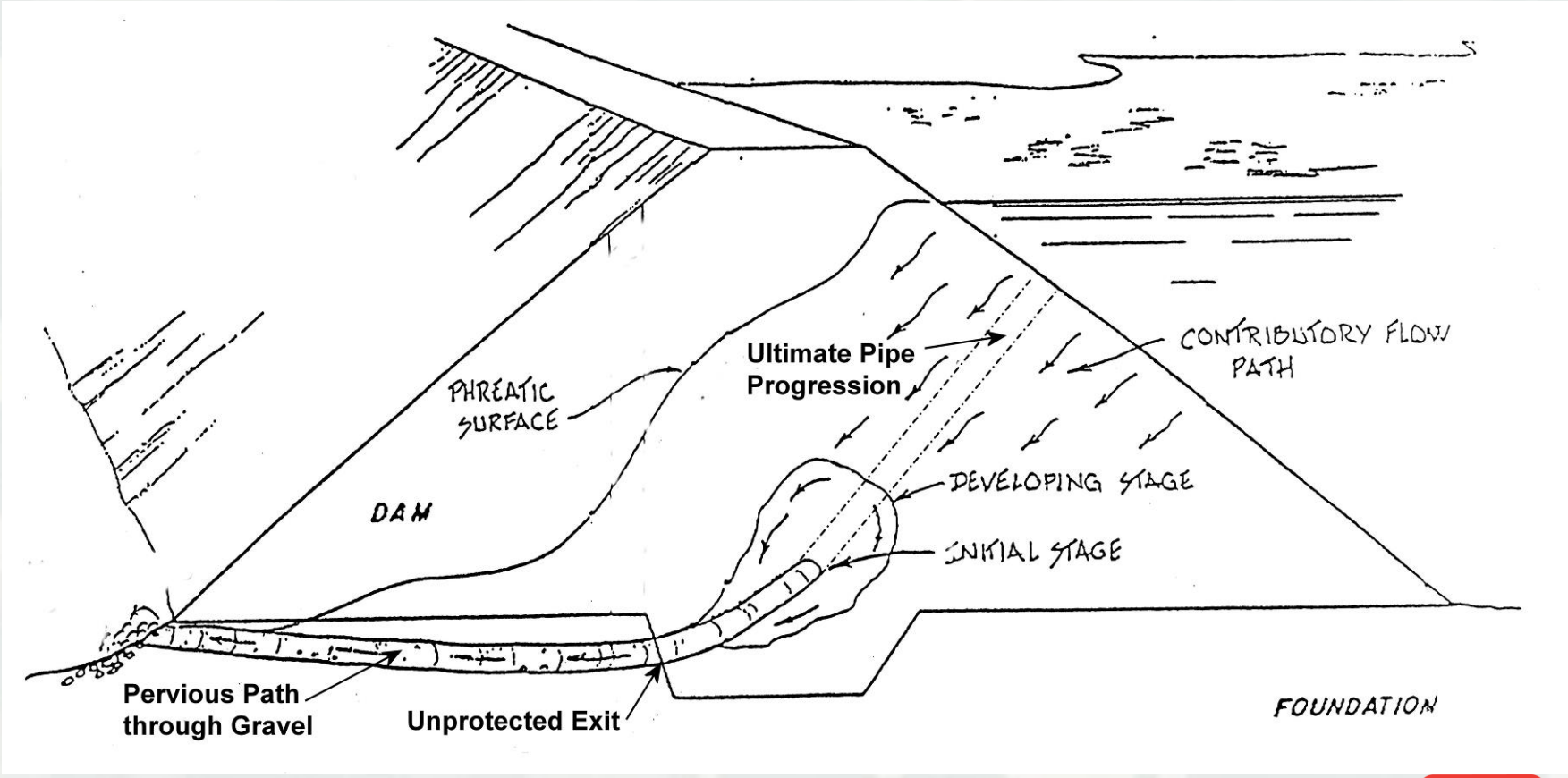
- Perform a potential failure mode analysis.
- Develop event trees for potential failure modes.
- Develop the loading function for each failure mode.
- Determine the conditional probability of failure and system response curve for each failure mode.
- Estimate the consequences.
- Calculate the incremental and non-breach risk.
- Compare the incremental risk to the tolerable risk guidelines.

Potential Failure Modes Analysis

Facilitated process of identifying and fully describing potential failure modes based on a team's understanding of the project's vulnerabilities from a review of existing data and conditions.

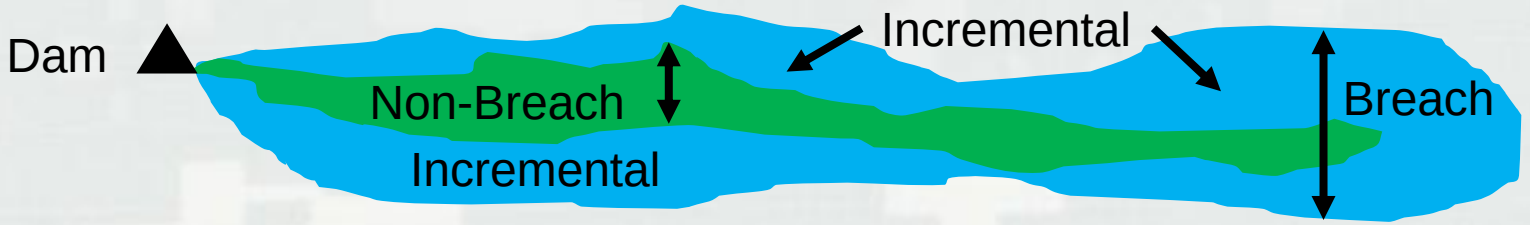
- First, and perhaps the most critical, step in any risk assessment.
- If not done in a diligent and thorough manner, the risk assessment may not be valid.

Sketch of Potential Failure Mode



Incremental Consequences

Incremental consequences	=	Consequences associated with the estimated performance of the project with breach, component malfunction, or misoperation	–	Consequences associated with the estimated performance of the project without breach, component malfunction, or misoperation



Note: Incremental consequences are affected by other factors than shown in this diagram (e.g., differences in depth, travel time, warning time, etc.)

ALARP Considerations

- Disproportion between the sacrifice (money, time, trouble and effort) in implementing the incremental risk-reduction measures and the subsequent risk-reduction achieved.
- Cost-effectiveness of the incremental risk-reduction measures.
- Compliance with essential USACE guidelines.
- Societal concerns as revealed by consultation with the community and other stakeholders.

Perguntas?

Calvin Creech, PhD, PE
email: Calvin.T.Creech@usace.army.mil