Tolerable Risk Guidelines for US Army Corps of Engineers Dams

Society of American Military Engineers

Joint Engineer Training Conference & Expo 2009

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Why Tolerable Risk?

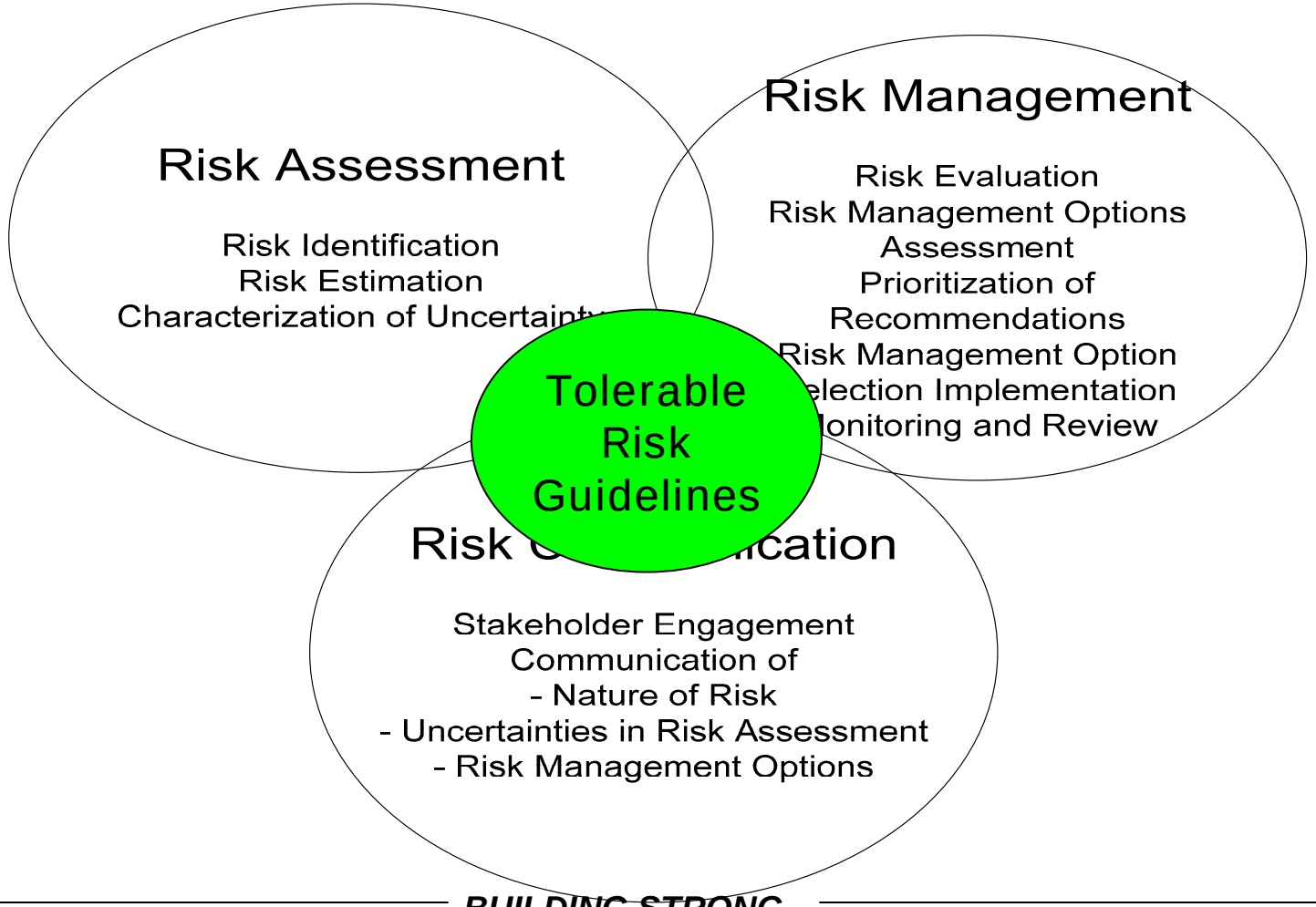
- Support risk informed dam safety program
- Identify, justify, and prioritize decisions
- Communicate risk to stakeholders
- Understand risk in an environment of shared flood risk management responsibilities
- Make better decisions

Dam Safety Defined

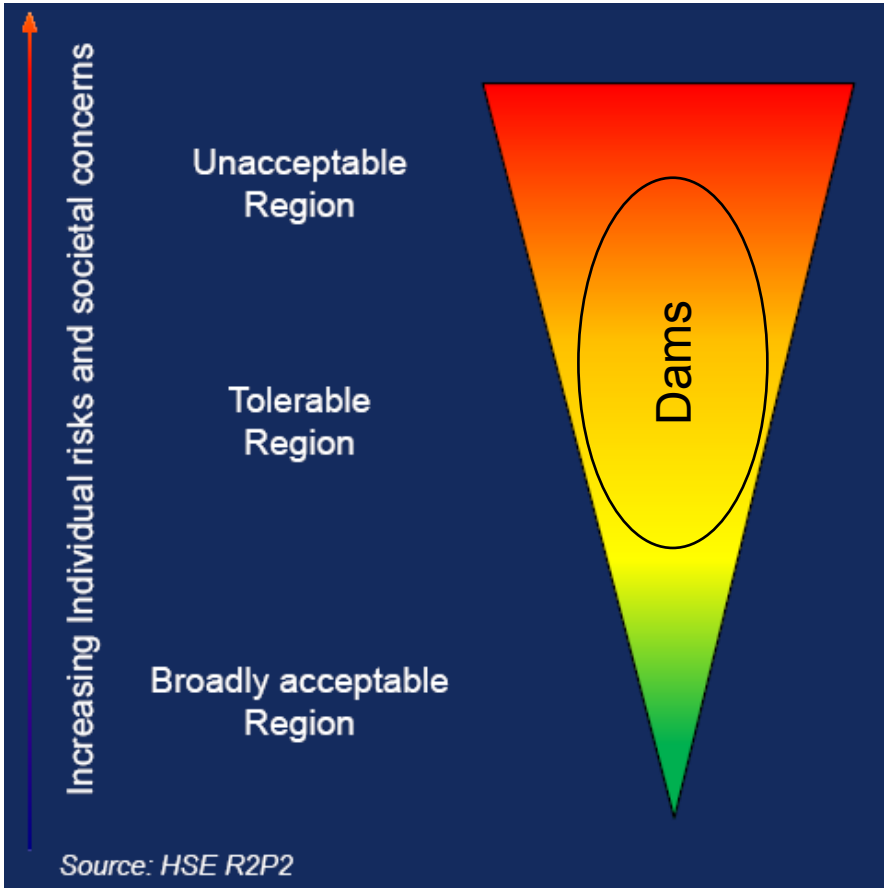
- "Dam safety is the art and science of ensuring the integrity and viability of dams such that they **do not present unacceptable risks to the public, property, and the environment**.
- It requires the collective application of engineering principles and experience, and a **philosophy of risk management** that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction.
- It also includes all actions taken to identify or predict **deficiencies and consequences related to failure**, and to document, publicize, and **reduce, eliminate, or remediate to the extent reasonably possible, any unacceptable risks**"

Federal Guidelines for Dam Safety, Glossary of Terms (FEMA 148), April 2004

Dam Safety Risk Framework



Tolerable Risk Framework



Risk cannot be justified except in extraordinary circumstances

People and society are prepared to tolerate risk in order to secure benefits

Risk regarded as negligible with little or no effort to review, control, or reduce the risk

Tolerable Risk Defined

- "Risk within a range that society can live with so as to **secure certain net benefits**.
- It is a range that we **do not regard as negligible** or as something we might ignore,
- but rather as something we need to **keep under review**
- and **reduce it still further if and as we can**."

Risk Assessment in Dam Safety Management: A Reconnaissance of Benefits, Methods and Current Applications (ICOLD 130), 2005

Tolerable Risk Principles & Considerations

- Equity (Principle)
  - "The right of individuals and society to be protected, and the right that the interests of all are treated with fairness"
- Efficiency (Principle)
  - "The need for society to distribute and use available resources so as to achieve the greatest benefit"
- As Low as Reasonably Practicable (ALARP) (Considerations)
  - Existing good practice
  - Cost effectiveness
  - Disproportionality
  - Societal concerns

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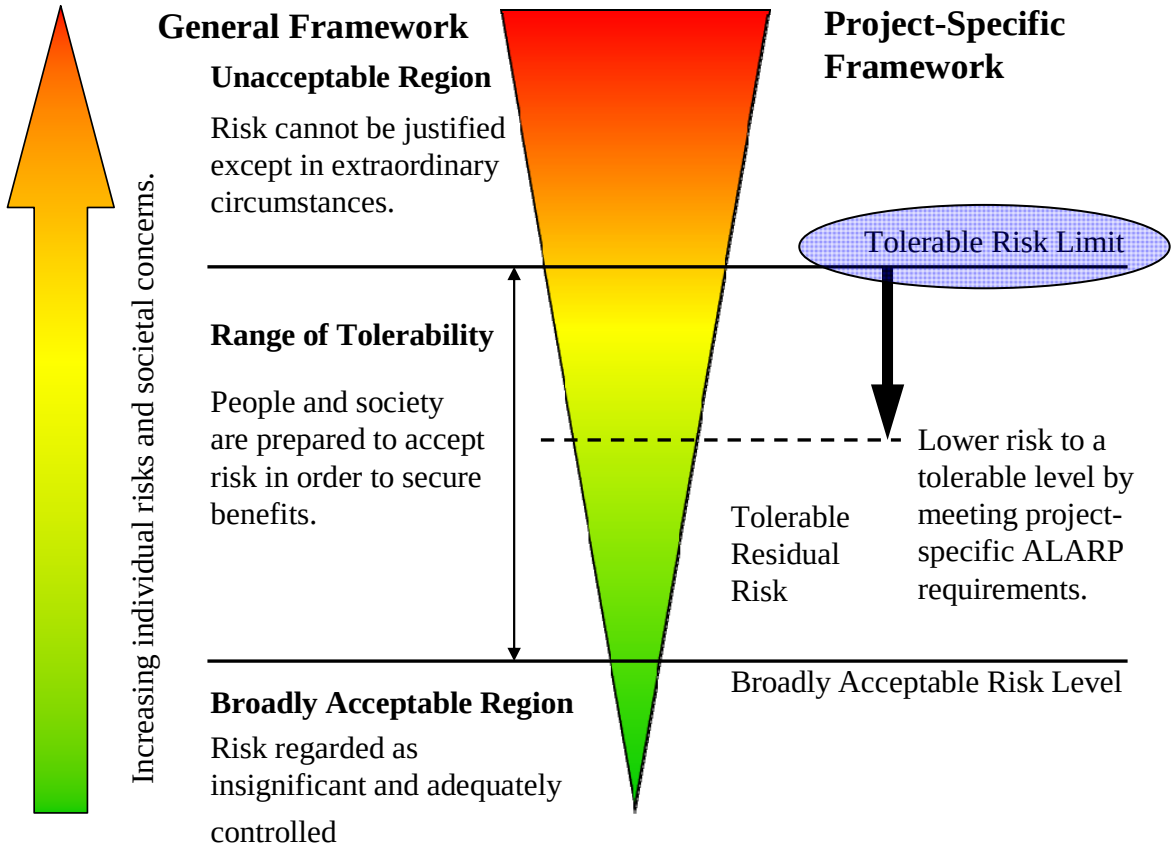
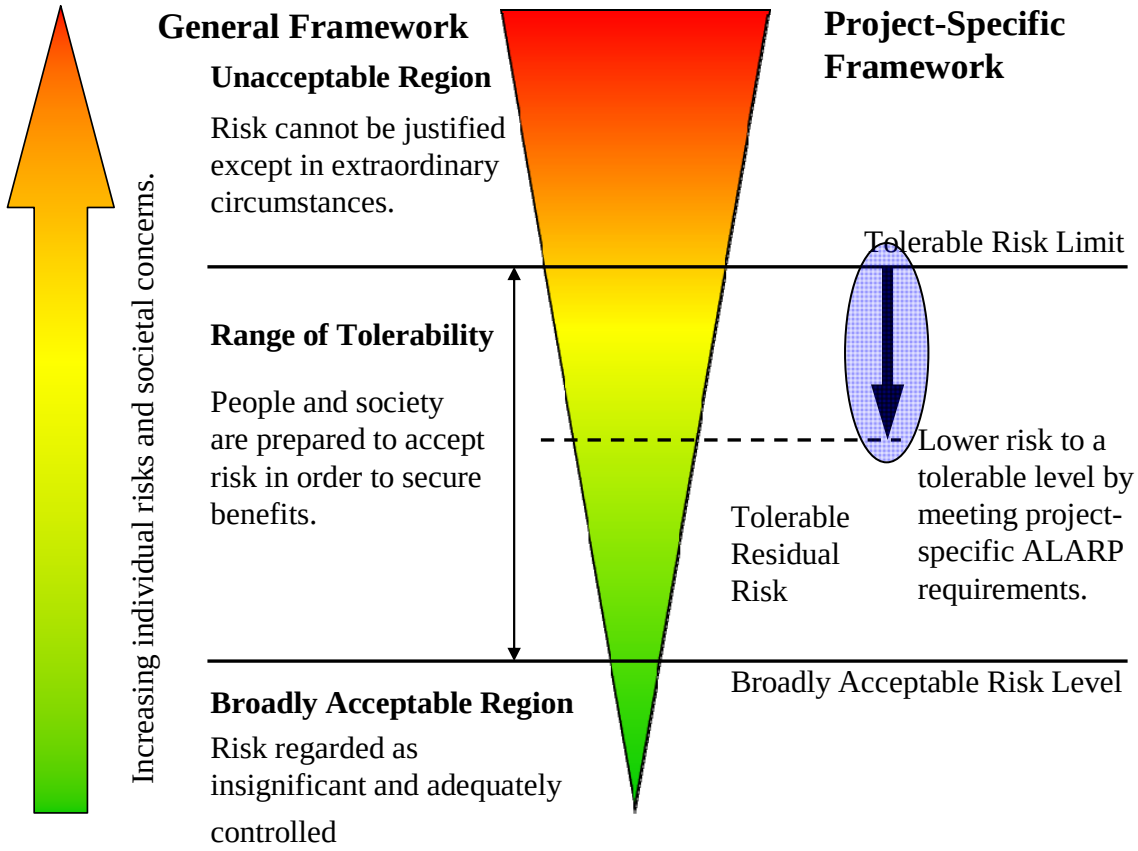
Equity


General Framework
Unacceptable Region
Risk cannot be justified except in extraordinary circumstances.
Project-Specific Framework
Tolerable Risk Limit
Range of Tolerability
People and society are prepared to accept risk in order to secure benefits.
Tolerable Residual Risk
Lower risk to a tolerable level by meeting project-specific ALARP requirements.
Broadly Acceptable Risk Level
Broadly Acceptable Region
Risk regarded as insignificant and adequately controlled
Increasing individual risks and societal concerns.

Efficiency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Broadly Acceptable Risk Level

ALARP Defined

- Risks must be reduced to the tolerable risk limit regardless of cost except in exceptional circumstances
- Risks lower than the tolerable risk limit are tolerable only if further risk reduction is impractical or if the cost is grossly disproportional to the risk reduction achieved.
- Determining that ALARP is satisfied is a matter of judgment.

Basis for USACE Guidelines

- Bureau of Reclamation - “Guidelines for Achieving Public Protection in Dam Safety Decision making” (2003)
- Australian National Committee on Large Dams (ANCOLD) – “Guidelines on Risk Assessment” (2003)
- New South Wales Government Dams Safety Committee – “Risk Management Policy Framework for Dam Safety” (2006)

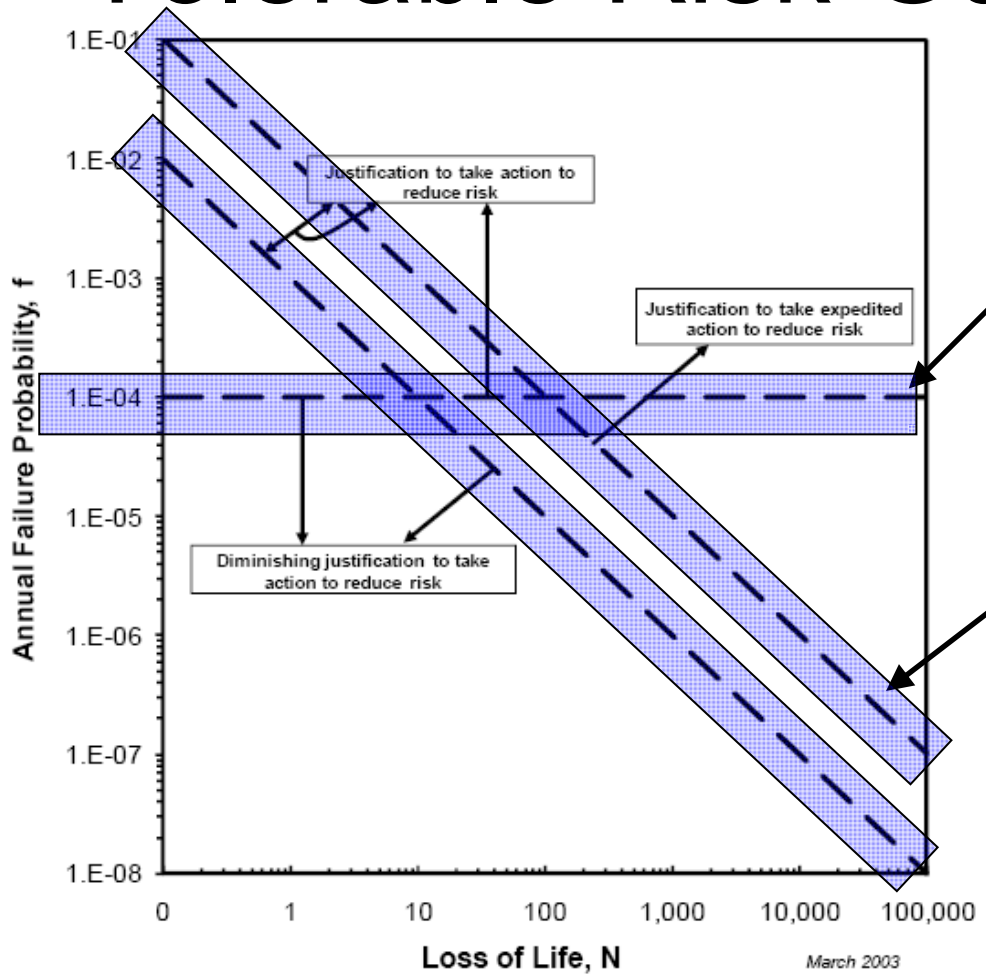
USACE Guidelines

- Life safety
  - Societal
    - Annual Life Loss
    - Probability distribution of life loss
  - Individual
- Performance
  - Annual probability of failure
- Other consequences
  - Economic
  - Environmental

ALARP Considerations

- Cost effectiveness (CSSL)
  - Cost to save a statistical life
- Disproportionality (CSSL / WPT)
  - Willingness to pay to prevent a statistical fatality
- Essential USACE guidelines and best practices
- Consultation with stakeholders

Tolerable Risk Guidelines



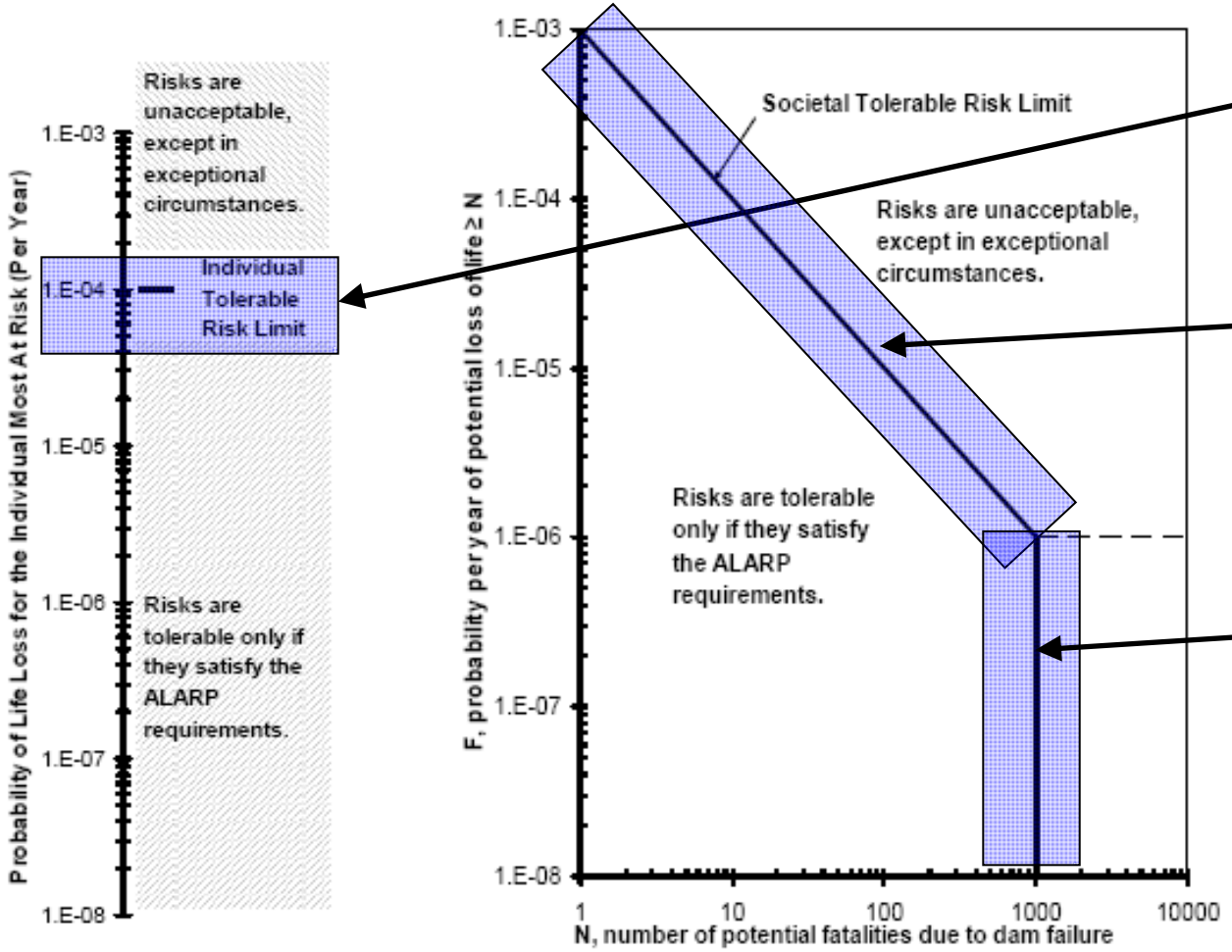
Performance (Annual Probability of Failure)

and

Individual Life Safety

Societal Life Safety (Annual Life Loss)

Tolerable Risk Guidelines



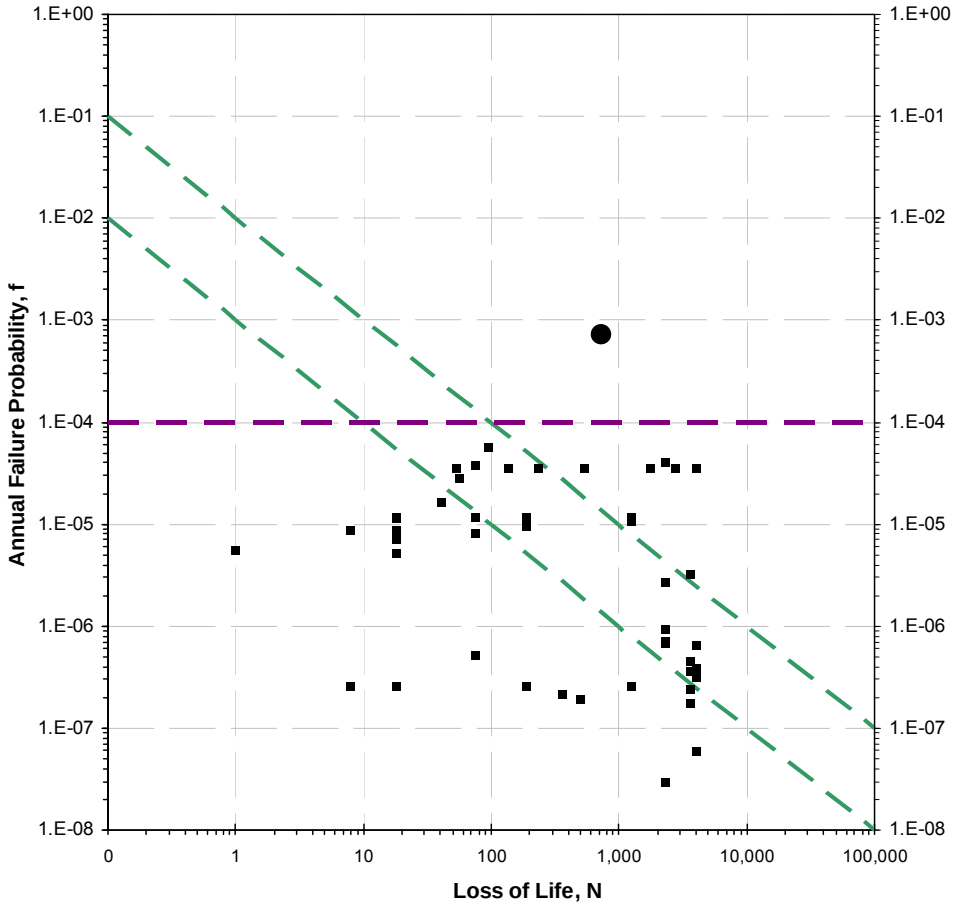
Individual Life Safety (Probability of Life Loss)

Societal Life Safety (Probability Distribution of Life Loss)

Special Consideration for High Consequence Projects (Life Loss > 1000)

f,N Example

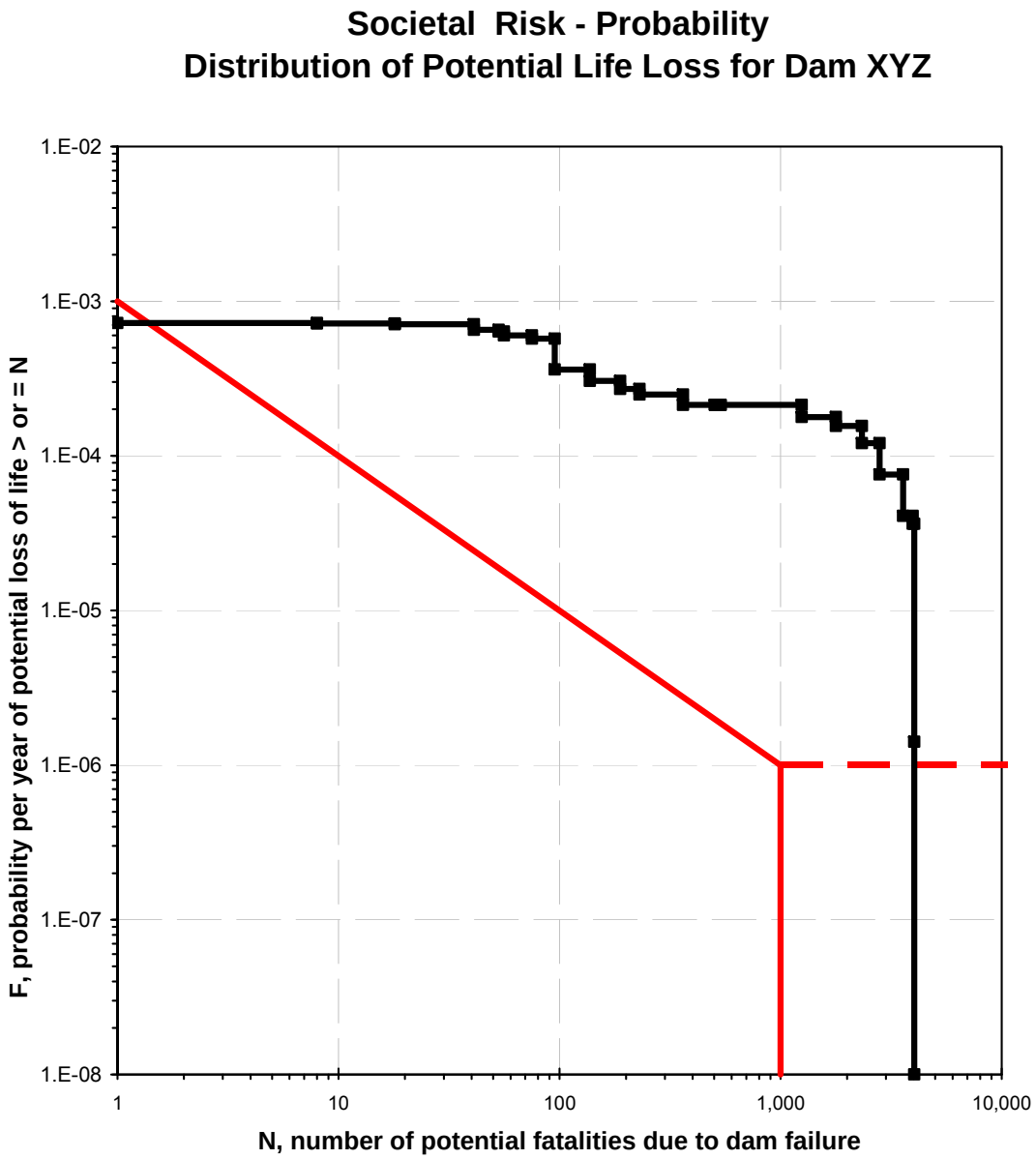
Annualized Probability of Life Loss and Annual Probabiilty of Failure for Dam XYZ



● Expected life loss plotted versus the sum of APF for all failure modes and exposure scenarios

■ f-N pairs

F,N Example


Societal Risk - Probability
Distribution of Potential Life Loss for Dam XYZ
F, probability per year of potential loss of life > or = N
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1
10
100
1,000
10,000
N, number of potential fatalities due to dam failure

Thank you.

Questions?