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Managing Water in the West

Dam Safety and Security Initiatives

U.S. Department of the Interior
Bureau of Reclamation

Risk

- P (failure) = P (load) x P (response)

- Risk = P (load) x P (response) x loss of life

Early Dam Safety Modifications 1978-1984

- Risk-based approaches not readily available
- PMF's = straight forward analysis, evaluation, modification
- PMF standard presented a moving target
- Earthquake loadings (MCE) subject to change
- Funding Limitations

Late 1980's Concern: Balanced Risk

- Proposing fixes for marginal flood risks
  - Bradbury ($60 million PMF fix)
- Some recognition of seismic risks
- Little emphasis on seepage issues

Mid 1990's: Stepping Up to the Plate

- Agreement among key managers to improve Dam Safety Program
- Program peer review
- **Decision making policy**
- **Evaluation guidelines**
- Trial risk assessments
- BC Hydro technical exchange

Benefits of Risk Based Decisions

- Complies with Federal Guidelines for Dam Safety
- More comprehensive and consistent evaluations - less subjectivity
- Better focus on process of data collection
- Improved consistency in decisions
- Better focus in recommendations
- Better definition of objectives in scoping out work products
- Resource prioritization
- Project Justification

Challenges for Risk Based Decisions

- May not be able to duplicate risk numbers, however experience indicates that the decisions remain the same
- Requires good engineering judgement and experience with risk evaluation process
- Can result in high cost if not focused on decision making

Key Elements of Risk Assessment

- Risk Identification
- Risk Analysis
- Risk Evaluation
- Dam Safety Decision Making

Risk Analysis Process

- Identify Potential Failure Modes
- Construct event tree
- Discuss nodes
- List what's known/unknown
- Estimate probability
- Examine conclusions

Identify Failure Modes

- Static loads
  - Seepage/piping, slope stability, foundation stability, operational problems,
- Floods
  - Overtopping, spillway failure, increased chance of static failure,
- Earthquakes
  - Foundation liquefaction, deformation, cracking, increased chance of static failure

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Estimate Load Probability

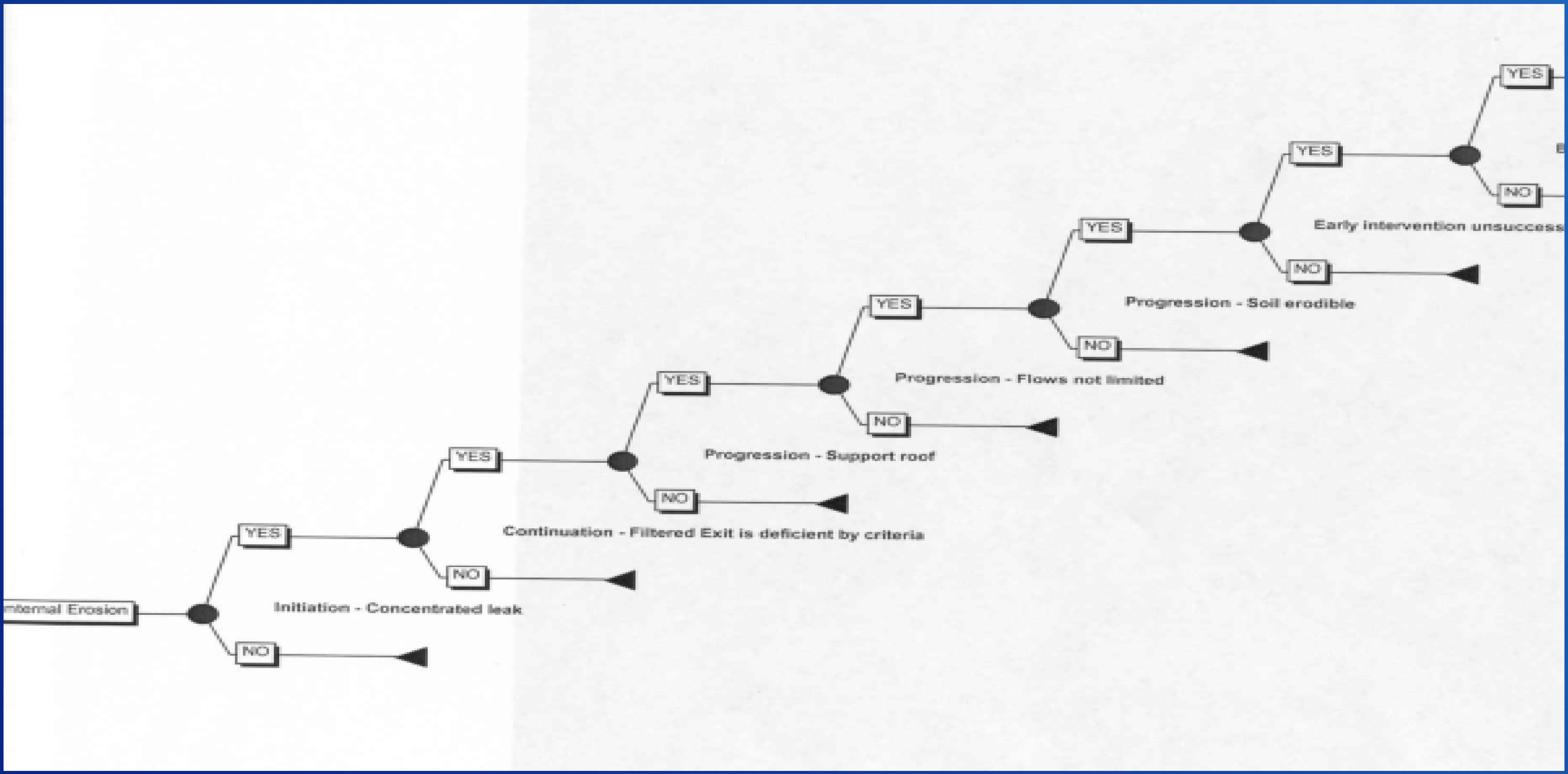
- Look at full range of loading conditions, not just extreme loads

- Provided by specialists
  - Flood frequency analysis
  - Probabilistic seismic hazard analysis

Estimate Response Probabilities

- Usually the most difficult part of the process
- Made by those most familiar with the behavior of the dam
- Break down the overall dam responses into smaller steps that are easier to understand and estimate
- “Toolboxes” being developed

Event Tree Construction



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Estimate Consequences

- Potential loss of life
  - Based primarily on affected downstream population, available warning time, and estimated severity of the flood wave
- Economic
  - Includes downstream damages from failure, loss of infrastructure, lost project benefits, dam replacement costs, etc.

Purpose of Public Protection Guideline document

- Provide safety guidelines to ensure consistent and adequate levels of public protection when evaluating and modifying existing dams and designing new structures
- Define how to incorporate risk-based evaluations into the dam safety decision making process

Risk-based and standards-based approaches

Each a part of the dam safety decision making process

- Risk-based approaches help determine appropriate courses of action
- Standards-based approaches assure sound implementation of those actions

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Results and Decision Making

Results Will Be Used To:

- Determine prudent courses of action
- Identify greatest risks – means to address the risks
- Determine overall priority within Region
- Determine overall priority within Reclamation

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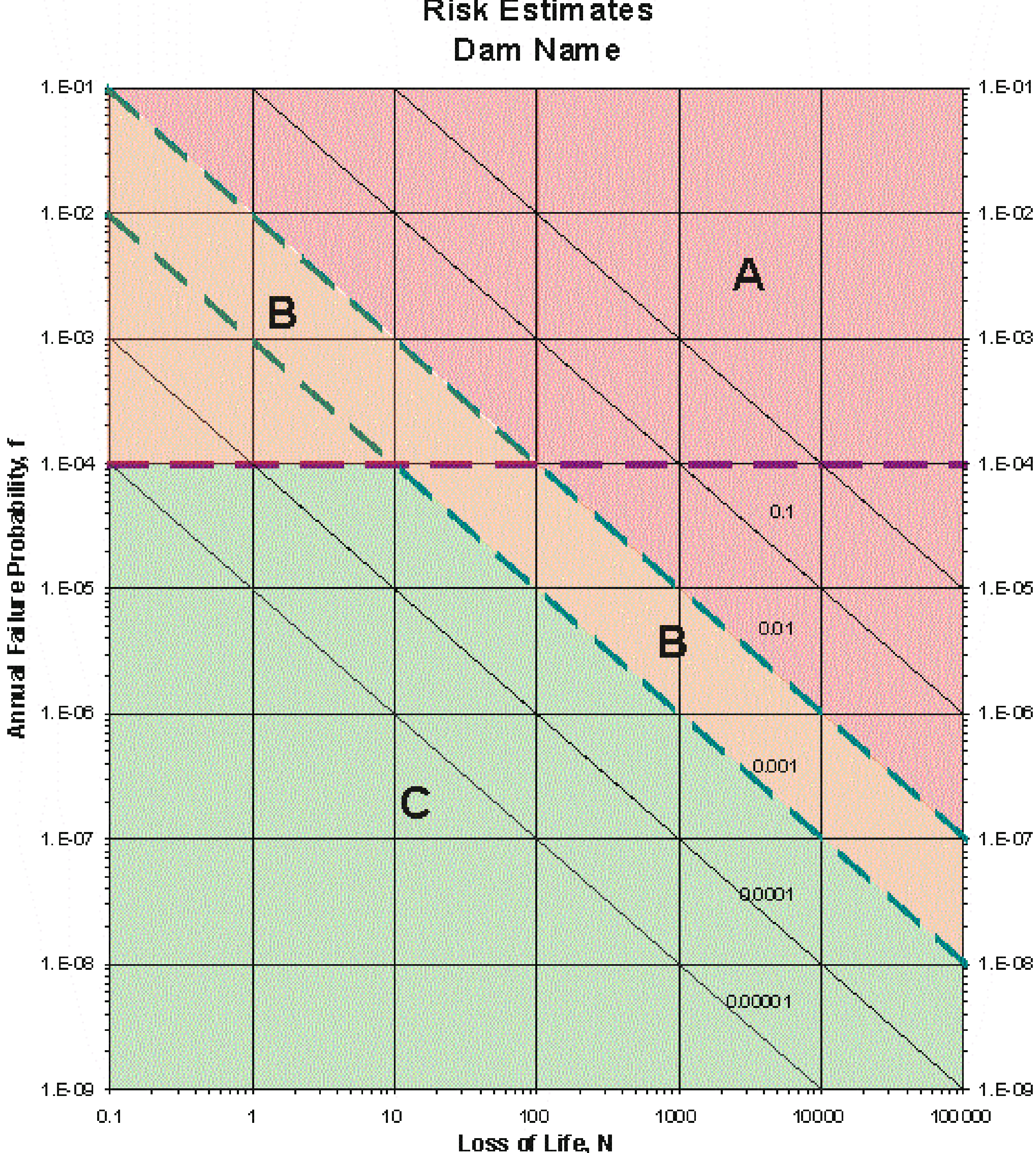

Risk Estimates
Dam Name
Annual Failure Probability, f
Loss of Life, N
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
0.1
1
10
100
1000
10000
100000
A
B
B
C
0.1
0.01
0.001
0.0001
0.00001

Results and Decision Making

- “A’s” needs action immediately – within 90 days
- “B’s” cover a wide variety of actions that may be appropriate. Can be scheduled according to other priorities and funding availability. Risk reduction must be accomplished within 7 years.
- “C’s” The need for actions to reduce risk or conduct studies diminishes. A reasonable and prudent category.

Security Risks

- Threat – Who are the potential aggressors at the dam and what are their typical modes of attack?
- Vulnerabilities – How easily can the facilities at the dam be failed or damaged?
- Consequences – What is the magnitude of life loss, economic damages, lost project benefits, replacement costs, etc., resulting from the attack?

Prioritization process

Risk = (Consequences)(Vulnerabilities)

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Consequences measured by…

- Estimated Life Loss (~70%)
- Powerplant Criticality (~15%)
- Reservoir Capacity (~15%)

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Vulnerability measured by…

- Dam type and height (~70%)
- Size of powerplant (~15%)
- Size of spillway gates or other flow control structures (~15%)

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Priority
(LL+PC+CAP)(SH+PI+DT+SC(Q))

- Relative prioritization can be developed using the scores from this equation if no other evaluations are available.
- This formula is to be used as an initial preliminary assessment of security risks only
- Any dams with high scores should be evaluated using site-specific threats, vulnerabilities, and consequences.

Conclusions

- Reclamation has established risk-based approaches to address dam safety and security aspects of public safety

- Risk based procedures are used to assess safety of Reclamation structures, to aid in making decisions to protect the public, to assist in prioritizing allocation of resources, and to support justification for risk reduction actions where needed.