Risk-Based Priority System

BACKGROUND

- **33 US Code §467f-2(f) states:** “The Administrator, in consultation with the Board, shall develop a risk-based priority system for use in identifying eligible high hazard potential dams for which grants may be made under this section.”
- **Objective:** Develop a risk-based priority system that will provide justification on which projects are selected by states to move forward (assuming funding will not cover all projects).

OVERALL PROCESS (PRE-APPLICATION)

Establishes number of eligible dams used to compute “need-based” portion of funding (2/3)

INITIAL ELIGIBILITY SCREENING (STATES)

Initial Screening

- **In a state with a state dam safety program**
- **High Hazard**
- **Has an Emergency Action Plan**
- **Fails to meet minimum state dam safety standards**
- **Poses unacceptable risk (as defined by FEMA)**

Note: cannot include federally sponsored dams, dams build under the authority of the Secretary of Agriculture, or licensed hydroelectric dams

Pre-Application Process

Recruit eligible sponsors based on eligible dams and identify potential projects. Potential construction projects must eliminate unacceptable risk. Potential planning projects must have the objective of eliminating unacceptable risk.

Submit Applications

Is the funding adequate to fund all projects?

Refer to flowchart on Risk Priortization Process on Page 2

Implement Projects

Assess Damages Avoided by Project and Summarize in Project Closeout documents.

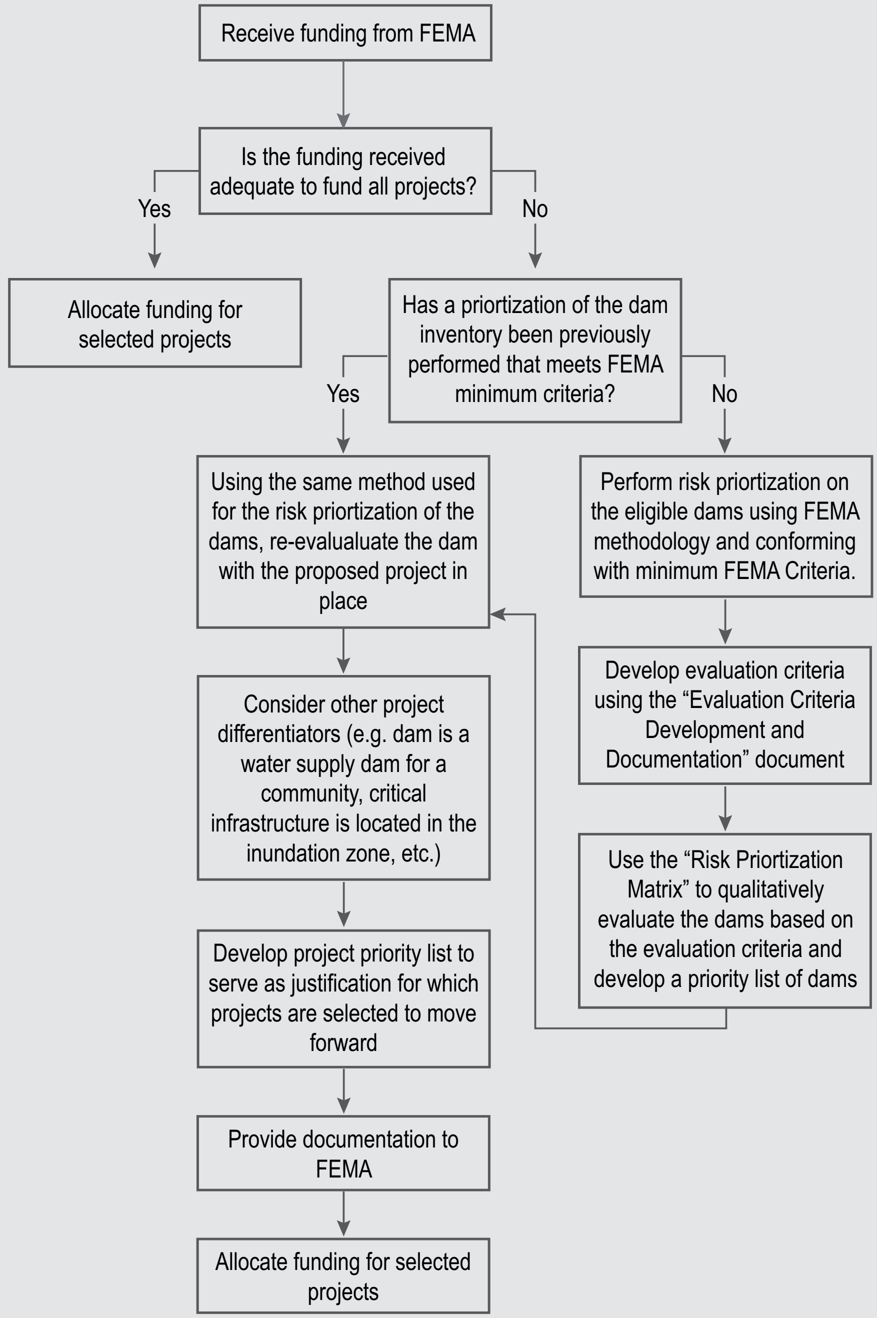
Post-Project Implementation

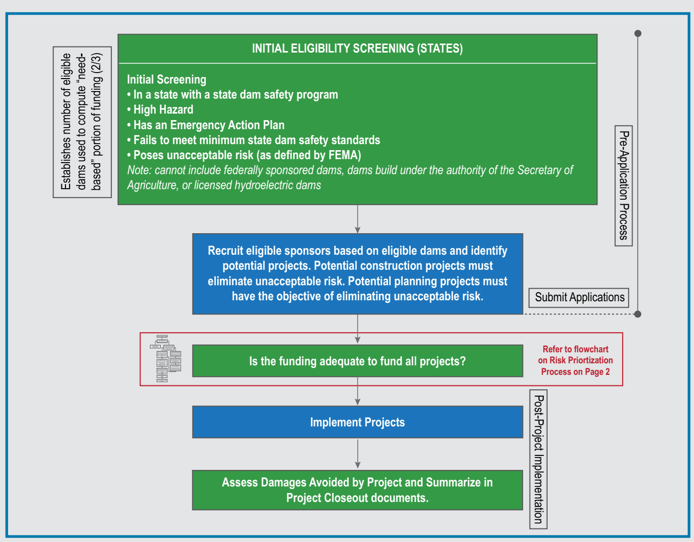
MINIMUM CRITERIA

- Evaluates static, hydrologic, and seismic failure modes
  - Evaluation of hydraulic failure mode should consider (where applicable)
    - Percentage of the required inflow design flood that the dam can pass safely through its spillways (both capacity and erosion resistance of the spillways should be considered).
    - Whether or not overtopping of the dam has been reported or observed.
    - Spillway redundancy
    - Condition of the spillways
    - Non-routine operational issues
  - Evaluation of static failure mode should consider (where applicable):
    - Whether the dam meets state-required static stability criteria (or federal criteria if no state criteria exists)
    - Dam safety observations (e.g. settlement, cracking, depressions/sinkholes, slumps/sloughs)
    - Past seepage history
    - Instrumentation readings
    - Known design and/or construction issues (e.g. outdated design features, lack of filter compatibility, non-functioning elements)
    - Non-routine operational issues
  - Evaluation of seismic failure mode should consider (where applicable):
    - Whether the dam meets state-required seismic stability criteria (or federal criteria if no state criteria exists)
    - Proximity of the dam to a high-risk seismic zone
    - Whether the embankment or the foundation is comprised of liquefiable materials
- Method should evaluate downstream consequences resulting from a breach event. This should consider (where applicable):
  - Estimation of population at risk (PAR) during a dam breach
  - Estimation of warning time for the nearest PAR
  - Loss of benefits associated with the dam no longer functioning (e.g. water supply dam)
  - Number of critical facilities (hospitals, fire stations, police stations, emergency operation centers, and schools) within the inundation zone
  - Extent of economic/environmental impacts that could occur due to a breach event
  - Whether the EAP is current and has been recently exercised
- Method complies with FEMA's "Federal Guidelines for Dam Safety Risk Management" (FEMA, 2015) for screening-level risk analysis as follows:
  - Identifies potential failure modes
  - Develops relative risk estimates for each dam in a way that enables the relative risk among the dams to be evaluated and priorities for further study or remediation to be established.
  - Can be quantitative or qualitative
- Method is objective and reproducible. It is noted that some subjectivity is likely to exist with any prioritization method, however this should be limited to the extent possible.
- Where calculations or numerical estimates are included as inputs into the method, the process to evaluate these estimates is consistent across the dam inventory (e.g. is computed for the same failure scenarios and estimated in the same way for each dam considered).
- Method includes documentation on all assumptions used in the process.

*Method is screening-level, qualitative, allows for **relative** ranking of dams/projects.*

RISK PRIORITIZATION PROCESS



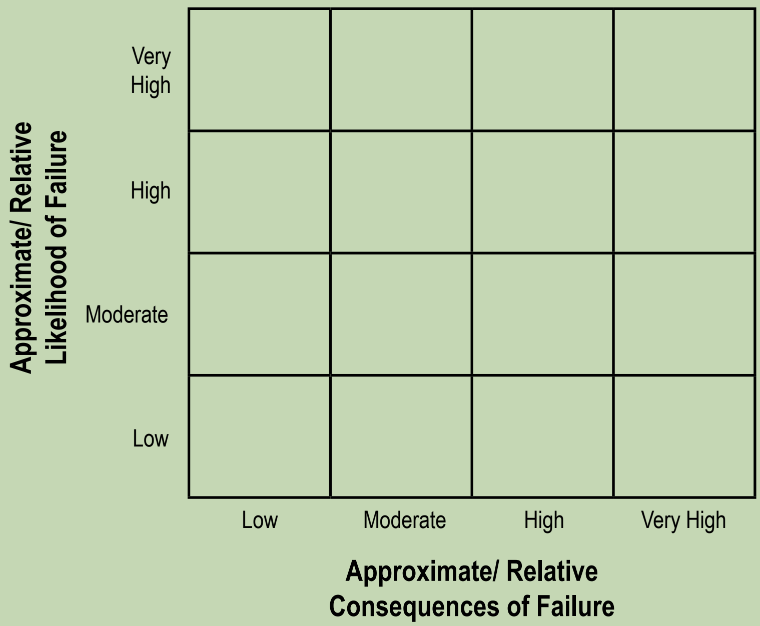


*See page 1 to view enlarged overview process graphic.

SCREENING-LEVEL RISK PRIORITIZATION METHODOLOGY

- Define and document criteria and considerations
- Evaluate dams based on this criteria
- Establish “tie-breakers”: for dams that are within the same category
- Perform same process on dam projects to evaluate risk reduction and prioritize projects

RISK PRIORITIZATION MATRIX



CRITERIA DEFINITION

- States would define criteria they would use to evaluate static, hydrologic, and seismic risk.
- Criteria should include/address static. hydrologic and seismic factors (see table).
- States would also define criteria they would use to evaluate downstream consequences.
- Criteria should include/address:
  - Population at Risk (PAR)
  - Warning Time
  - Economic Losses
  - Environmental Losses
- Criteria defined should also include any additional considerations that will be evaluated

Static	Hydrologic	Seismic
• Static factors of safety (when known) • Dam condition (based on recent dam safety observations and their severity) • Past seepage history • Instrumentation readings (if available) • Known design/construction deficiencies • Non-routine operational issues	• Dam/Spillway Capacity • Condition of spillways • Previous hydrologic performance • Non-routine operational issues	• Seismic factors of safety (when known) • Proximity to high risk seismic zones • Liquefaction potential (embankment and foundation)

ADDITIONAL CONSIDERATIONS

- Not directly used in original ranking of the dam
- May be related to knowledge that is available for only some of the dams within the inventory
- Examples may include:
  - Results of engineering studies/analyses
  - Past performance or deficiencies at the dam
  - Unique consequences associated with dam failure
- Additional considerations can be used to adjust the ranking of the dam (depending on whether these are likely to contribute to failure/increase consequences or prevent failure/decrease consequences)

EXAMPLE (FAILURE MODES)

Probability of occurrence is consistent across failure modes.

		Static Failure Mode Criteria	Hydrologic Failure Mode Criteria	Seismic Failure Mode Criteria
Very High	~ AEP > 1:10	Static Factor of Safety < 1 OR Most recent inspection indicates severe deficiencies that are likely to cause failure of the dam in the short-term (within the next 10 years)	Dam can pass less than a 10-year storm without overtopping (unless dam is designed to overtop)	Seismic Factor of Safety < 1 for ground motions with an annual probability of exceedance of 1 in 10 years OR 2% Probability of Exceedance in 50 years peak ground acceleration (PGA) > 0.6
High	~ AEP 1:10 - 1:1,00	1.1 > Stats Factor of Safety >1 OR Most recent inspection indicates one or more major deficiencies related to dam condition	Dam can pass between a 10-year and a 100-year storm without overtopping (unless dam is designed to overtop)	Seismic Factor of Safety <1 for operating basis earthquake OR 0.3 < 2% Probability of Exceedance in 50 years peak ground acceleration (PGA) > 0.6
Moderate	~ AEP 1:100 - 1:1,000	1.2 > Static Factor of Safety > 1.1 OR Most recent inspection indicates no significant deficiencies related to dam condition	Dam can pass between a 100-year and 1,000-year storm without overtopping (unless dam is designed to overtop)	Seismic Factor of Safety > 1 for operating basis earthquake OR 0.2 < 2% Probability of exceedance in 50 years peak ground acceleration (PGA) > 0.3
Low	~ AEP < 1:1000	1.5 > Static Factor of Safety > 1.2 OR Most recent inspection indicates no significant deficiencies related to dam condition	Dam can pass between a 1,000-year and a PMP storm without overtopping (unless dam is designed to overtop)	Seismic Factor of Safety > 1.1 for minimum design earthquake OR 2% Probability of Exceedance in 50 years peak ground acceleration (PGA) < 0.2
Additional Considerations		Persistent dam safety issues noted in past inspections that have not been addressed over the years, past seepage history, instrumentation readings, known design and/or construction deficiencies, and non-routine operational issues	Spillway redundancy, condition of the spillways, whether the dam has previously overtopped, and non-routine operational issues	Whether the embankment and/or foundation is comprised of liquefiable materials

Define other considerations that will factor into the final ranking.

Numerical values defined

EXAMPLE (Consequences)

	Population at Risk (PAR) and Warning Time	Economic Losses	Environmental Losses
Very High	PAR > 100 and warning time is not sufficient to evacuate the majority of the persons from the inundation area	Exceed $1 Billion	losses would likely be severe and permanent
High	PAR > 100 and warning time is considered sufficient to evacuate some of the persons from the inundation area	$100 Million - $1 Billion	losses are expected to be significant and could be remediated, but would take many years
Moderate	PAR 10-100 and warning time and warning time is considered sufficient to evaluate the majority of persons from the inundation area	$10 Million - $100 Million	losses could be remediate, but would take several years
Low	PAR 1-10 and warning time is considered sufficient to evacuate most persons from the inundation area	Less than $10 Million	losses could be sustained as a result, but remediation is possible
Additional Considerations	number of critical facilities (such as hospitals, fire stations, police stations, nursing homes/ elderly care facilities, emergency operation centers, and schools) within the inundation zone and whether the EAP is current and has been recently exercised		

Define other considerations that will factor into the final ranking.

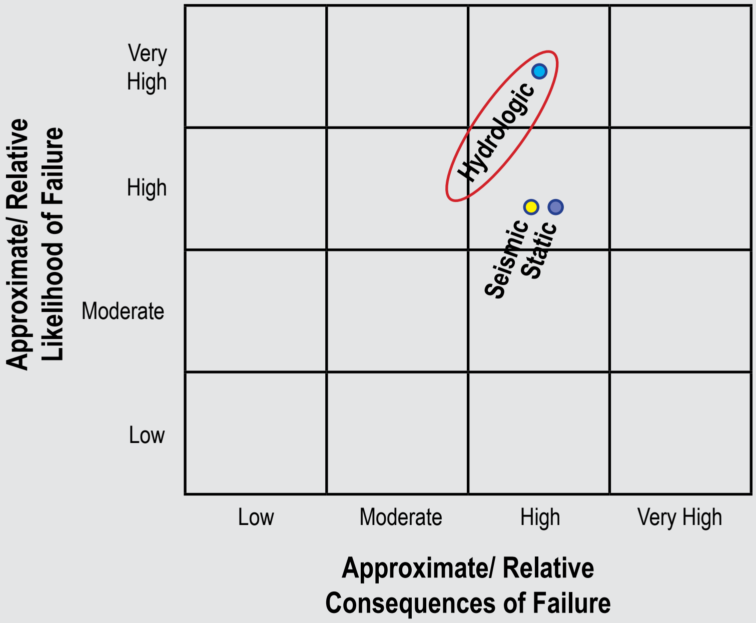
Numerical values defined

- States use the risk prioritization matrix in combination with the criteria to score the dams.
- This is performed for each failure mode (e.g. static, hydrologic, seismic).
- Use the most severe combination **if seismic, hydrologic, and static are viewed to have relatively equal likelihoods of failure**.

EXAMPLE 1

- Relative likelihood of failure equivalent
- Consequences are similar across each failure scenario
- Hydrologic failure is found to be most critical.

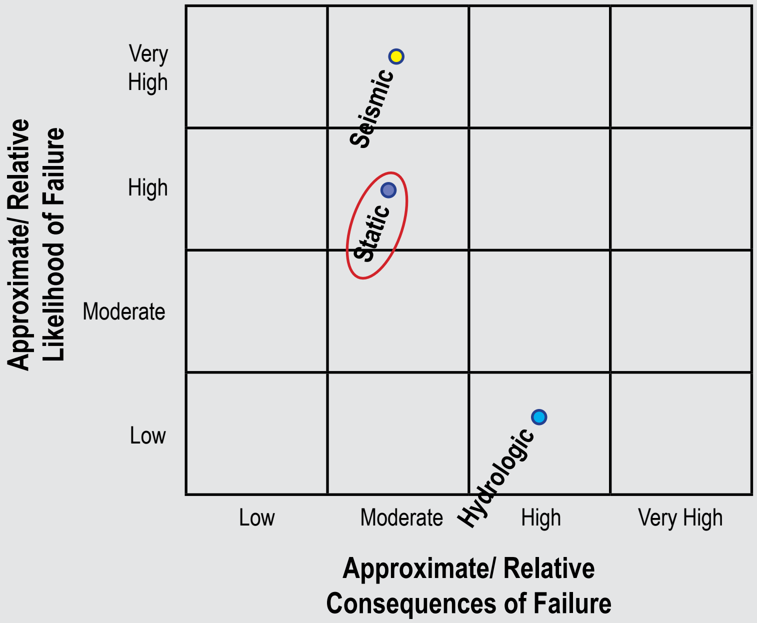
DAM A – RISK EVALUATION



EXAMPLE 2

- Relative likelihood of failure not equivalent
- Consequences are found to be higher for hydrologic failure scenario
- Seismic failure initially found to be most critical (based on the combination of consequences and likelihood of failure), however probability of a seismic event is considered more remote – Static failure chosen as most critical. (Note: this should be evaluated on a case-by-case basis)

DAM B – RISK EVALUATION



"TIE-BREAKERS"

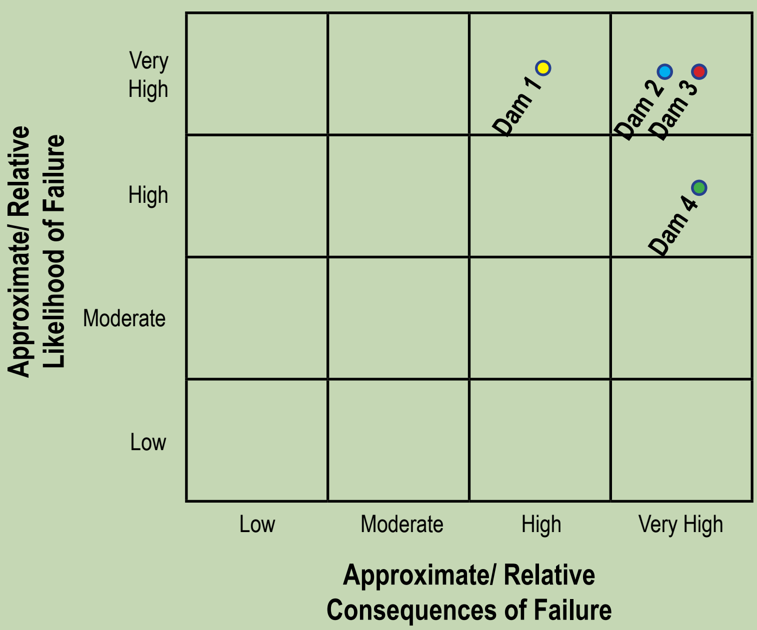
- "Tie-Breakers" or "differentiators" can be used to distinguish between dams that rank equivalently on the risk prioritization matrix.
- Can include:
  - Critical infrastructure (hospitals, emergency management centers, schools, etc.) in inundation zone
  - Dam is considered a valuable asset to the community
  - Dam is multi-function (e.g. flood control and water supply)

EXAMPLE 3

- Dams 3 and 2 and Dams 1 and 4 have the same prioritization.
- Dam 3 is judged to be more critical than Dam 2 because there is a school in the inundation area directly downstream of the dam.
- Dam 1 is prioritized higher than Dam 4 because the population at risk is smaller, but closer to the dam.

Dam	Category	Ranking	Justification
Dam 2	Very High - Very High	1	School within inundation zone
Dam 3	Very High - Very High	2	No critical infrastructure within inundation zone
Dam 1	High - Very High	3	Smaller PAR than Dam 4, but considerable PAR very close to dam and has a higher failure potential
Dam 4	Very High - High	4	PAR is larger than Dam 1, but several miles downstream

STATE A – RISK EVALUATION



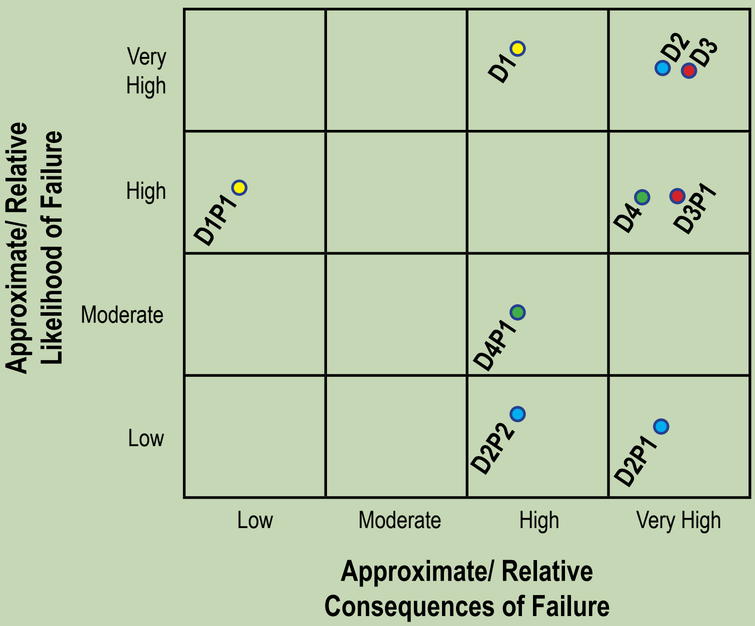
PROJECT EVALUATION

- Dams are re-evaluated with proposed project in place
- Reduction in risk is used to rank projects (along with other project factors)
- Justification should be provided
- For projects that address a specific failure mode, the ranking of the dam related to that failure mode should be used to assess the risk reduction.
- To evaluate planning studies/non-capital projects, the ranking of the dam should be considered along with other project factors.

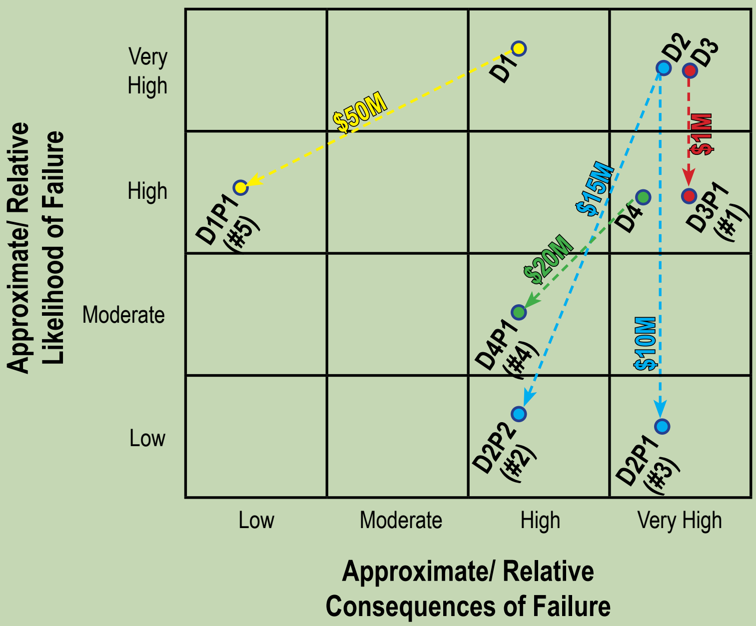
EXAMPLE 4

- D = Dam, P = Project
- Each dam has one project except for Dam 2, which has two projects.
- Dam 2 Project 1 involves capital improvements.
- Dam 2 Project 2 involves capital improvements in addition to purchasing a large residential area in the dam breach inundation zone

STATE A – PROJECT EVALUATION



STATE A – PROJECT EVALUATION



Project	Risk Reduction	Cost	Rank	Justification
Dam 3 Project 1	**Very High – Very High** to **Very High – High**	$1 M	1	Reduces risk associated with one of the “riskiest” dams for relatively low cost
Dam 2 Project 2	**Very High – Very High** to **High – Low**	$15 M	2	Dam 2 projects both provide significant risk reduction for relatively low cost. D2P2 was ranked higher because of a large reduction in downstream PAR.
Dam 2 Project 1	**Very High – Very High** to **Very High –Low**	$10 M	3	Provides a significant reduction in risk for relatively low cost
Dam 4 Project 1	**Very High - High** to **High – Moderate**	$20 M	4	Significant risk reduction, but larger cost than other projects.
Dam 1 Project 1	**High – Very High** to **Low – High**	$50 M	5	Significant risk reduction, but very large cost.

OVERALL DAM RISK REDUCTION

- The projects selected for funding must address all deficiencies and bring the overall dam in compliance with state dam safety regulations

OR

- A phased plan must be provided to show how the risk associated with other failure modes will be addressed
  - “no regret projects”- what is proposed does not have to be undone or fixed to address other known deficiencies
  - future phases could be eligible for grant funding subject to reprioritization and FEMA’s annual appropriation