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USACE Dam Safety Program Screening for Portfolio Risk Analysis (SPRA)

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Outline

- Vision & Strategy
- Dam Safety Program
- USACE Portfolio Risk Management
- Purpose of SPRA
- Information Evaluated
- Consequence Data
- Dam Safety Action Class (DSAC)
- Results



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Vision & Strategy

- Dam Safety Program aligns with USACE Vision
 - Ready, Relevant, Reliable, & Responsive
 - Centrally Led, Decentrally Executed
 - Incorporates Concepts of Risk & Reliability
 - Supports Life Cycle Infrastructure/Asset Management
 - Supports Communities of Practice Concepts
- “...strong dam safety program in compliance with Federal Guidelines for Dam Safety...” ER 1110-2-1156



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Dam Safety Program

- Provide for protection of public safety, property, and the environment
- Allocate limited funds where risk reduction is greatest
- Minimize social disruption and economic and environmental impacts
- Effectively communicate risk
- Rebuild public trust



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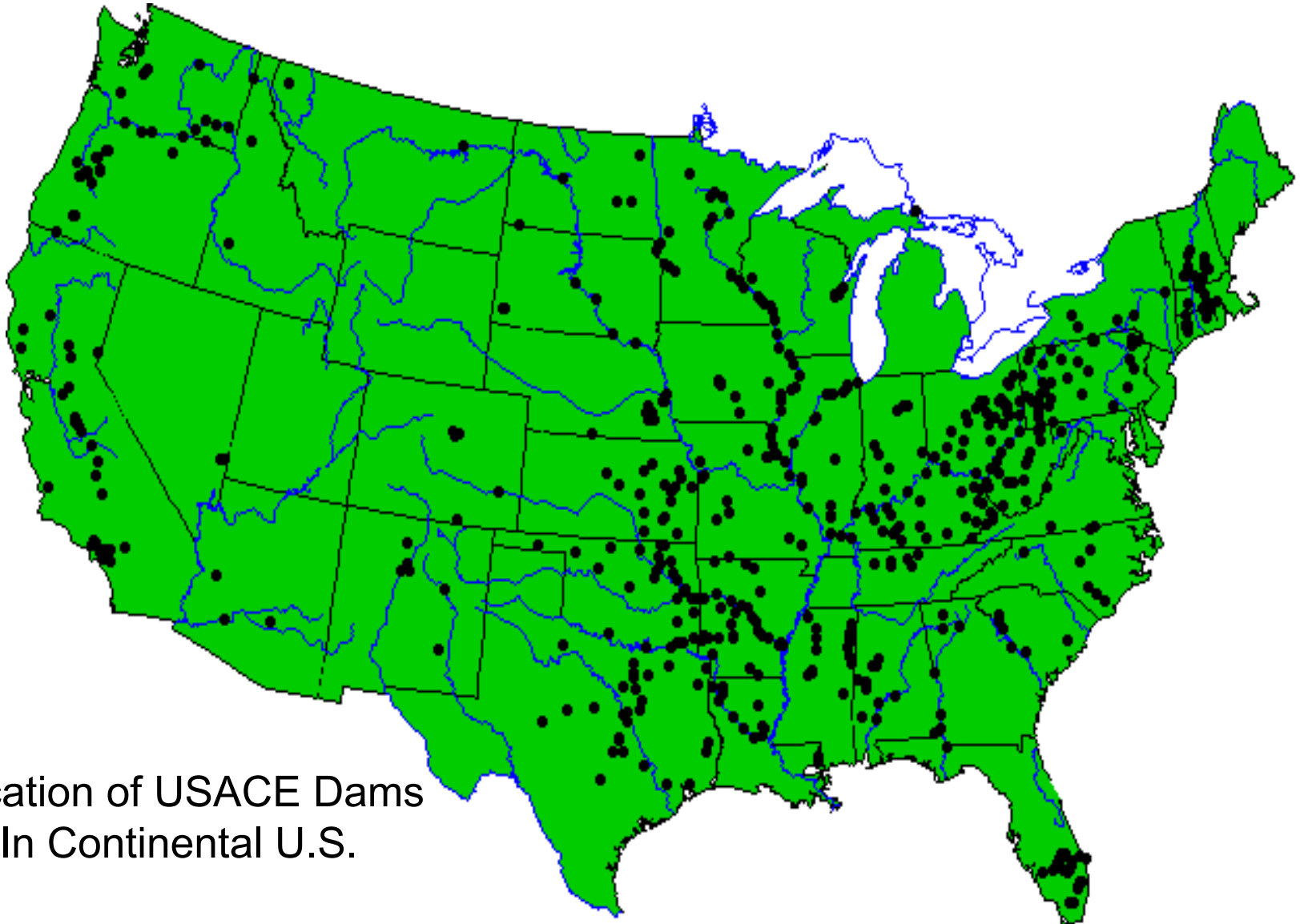
USACE Portfolio

- About 600 Dams across the U.S.
 - Navigation Locks and Dams
 - Flood Control Dams
 - Multi-Purpose Dams – hydropower, flood control, recreation, water supply, navigation
- Composed of rock, earth, concrete, and combinations of these materials
- Variety of spillways, outlet works, etc.
- Some USACE dams have not experienced the original design load (never first filled)



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USACE Portfolio

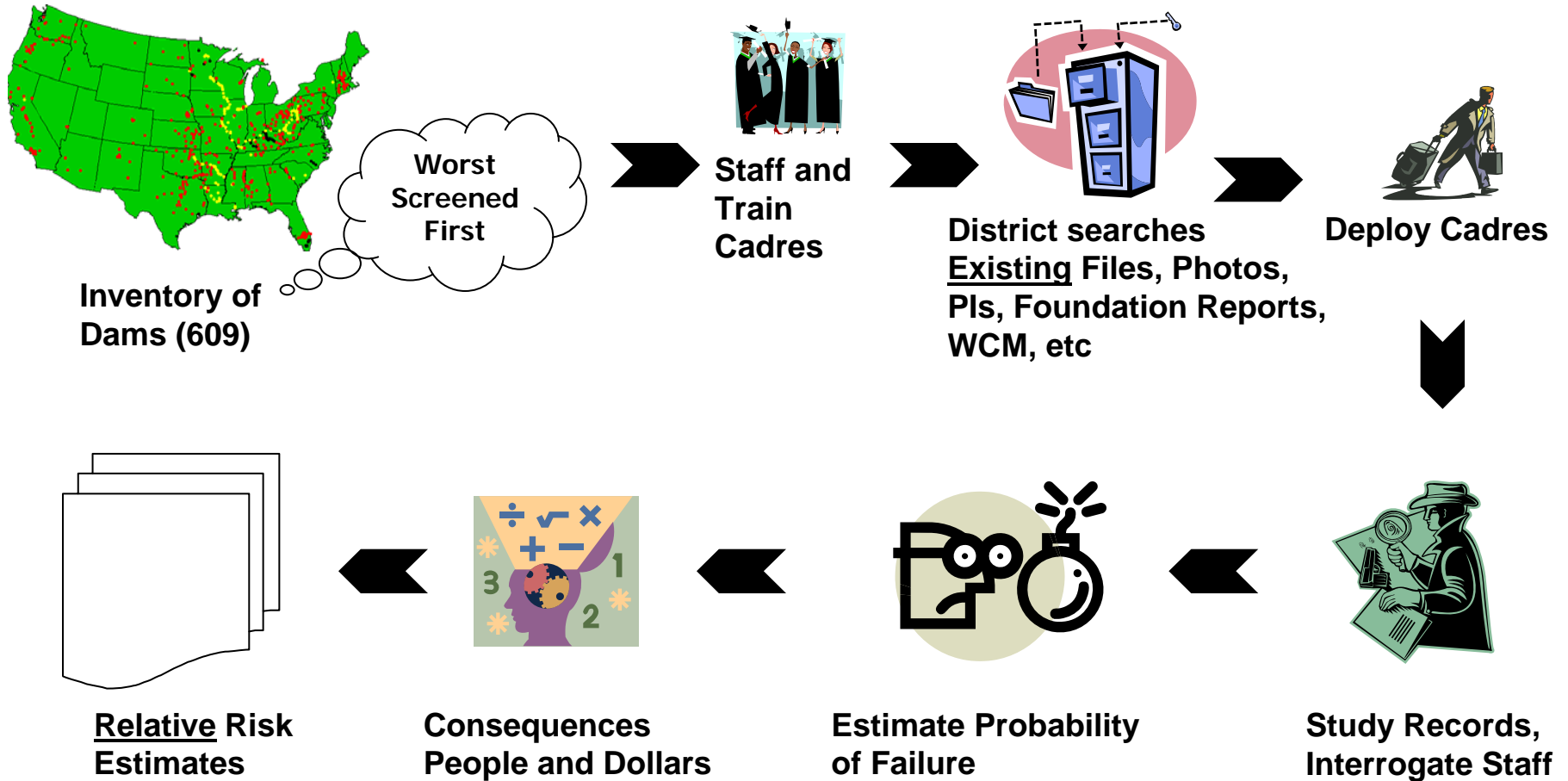


Location of USACE Dams
In Continental U.S.



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Portfolio Risk Management





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Dam Safety SPRA - Purpose

- USACE working towards risk-informed management strategy for Dam Safety – SPRA only the first step in the process
- SPRA has been and will continue to be used to help shape the budget:
 - Investigations/Studies (4 ongoing here in LRH)
 - Remedial Fixes (Interim Risk Reduction Measures)
- All 609 dams will be initially screened using SPRA tool by end of 2009
- Dams are classified according to their relative risks using SPRA findings



Information Evaluated

- SPRA is used to evaluate 3 types of dams
 - Flood Damage Reduction
 - Low-Head Navigation
 - High-Head Navigation
- Evaluation of 28 project features under 5 load cases (3 flood and 2 earthquake)
- Screening results compared to a Baseline Dam – a new dam with the same features all rated as Adequate (i.e. meets current USACE design criteria)



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Information Evaluated (cont'd)

- Concrete Gravity Sections (sliding and/or overturning stability)
- Spillway & Stilling Basin (stability, gate reliability, outlet channel erosion)
- Outlet Works (tower, gate reliability, conduits)
- Embankment (seepage/piping, slope stability, liquefaction, toe erosion from overtopping)
- Foundation (seepage/piping, stability, liquefaction)
- Abutments (seepage/piping, stability, liquefaction)
- Reservoir Rim Performance (low spots, landslides, previous mining activity, etc.)
- Add Other Features As Necessary (saddle dikes, levees, etc.)



Information Evaluated (cont'd)

- Engineering ratings assigned to each project feature based on existing studies, performance data, criteria, project characteristics, and judgment. Associated value for each engineering rating is multiplied by the feature's baseline probability value to model site conditions.
 - Adequate (A)
 - Probably Adequate (PA)
 - Probably Inadequate (PI)
 - Inadequate (I)



Definitions

- **Adequate (A)**: judged to perform well under specified loading condition with a high level of confidence backed up by data, studies, or obvious project characteristics and judged to meet current engineering standards and criteria.
- **Probably Adequate (PA)**: judged to perform well under specified loading with a low level of confidence and may not specifically meet criteria. Requires additional investigation or studies to confirm adequacy.
- **Probably Inadequate (PI)**: judged to not perform well under specified loading with a low level of confidence and requires additional studies and investigations to confirm. Judged to not meet current criteria.
- **Inadequate (I)**: judged to not perform well under specified loading with a high level of confidence. Physical signs of distress are present. Analysis indicates factor of safety near limit state.



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Engineering Rating Summary

Feature	Normal Water Level	50% Exceedence Duration Water Level with OBE	50% Exceedence Duration Water Level with MDE	Unusual (100yr)	Extreme (500yr)
Concrete Structures – Rock Foundation					
External Stability	A	A	A	A	A
Internal Stability	A	A	A	A	A
Foundation Stability – under dam	A	A	A	A	A
Scour Protection	A	A	A	A	A
Foundation -Seepage & Piping	A	A	A	A	A
Abutment Foundation Stability	A	A	A	A	A
Concrete Structures – Pile Foundation					
Foundation Seepage & Piping (Incl. upstream cutoff) 1	NA	NA	NA	NA	NA
Foundation Liquefaction	NA	NA	NA	NA	NA
External Stability1	NA	NA	NA	NA	NA
Foundation Stability (Incl. pile capacity) 1	NA	NA	NA	NA	NA
Internal Stability	NA	NA	NA	NA	NA
Scour Protection	NA	NA	NA	NA	NA
.....Void.....	NA	NA	NA	NA	NA
Abutment Foundation Stability1	NA	NA	NA	NA	NA
Gates & Gate Structure					
Spillway gate(s) failure 2	PA	A	A	A	A
Spillway gate piers – structural capacity	PA	A	A	A	A
Gates – Electrical/Mechanical	PI	A	A	A	A
Lock gates (struct/elect/mech)	PA	A	A	A	A
.....Void.....	NA	NA	NA	NA	NA
Embankment & Closure Dikes					
Embankment Seepage & Piping	PI	A	A	PI	PI
Embankment Stability and/or Liquefaction	A	A	A	A	A
Erosion: Toe, Surface & Crest	A	A	A	A	A
Abutments Seepage & Piping	NA	NA	NA	NA	NA
Abutments Stability and/or Liquefaction	NA	NA	NA	NA	NA
Foundation Seepage & Piping	A	A	A	A	A
Foundation Stability and/or Liquefaction	A	A	A	A	A
Emergency Closure Systems					
Service bridge,	A	A	A	A	A
Crane & Power	NA	NA	NA	NA	NA
Bulkheads	A	A	A	A	A
.....Void.....	NA	NA	NA	NA	NA
Other Features					
Feature 1	NA	NA	NA	NA	NA
Feature 2	NA	NA	NA	NA	NA
Feature 3	NA	NA	NA	NA	NA
Feature 4	NA	NA	NA	NA	NA



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Consequence Data

There are four primary categories of estimates of potential consequences:

- Loss of Life
- Property Damage
- Foregone Project Benefits
- Repair Costs



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Consequence Data (cont'd)

- Loss of Life
 - PAR within inundation zone
 - Fatality rate from modified Graham's chart used to estimate LOL
- Economic Damage
 - Property Damage within inundation zone
 - Loss of Project Purpose
 - Repair Costs



Consequence Data (cont'd)

- Annualized Life Risk is compared to Annualized Baseline Life Risk to bin into relative DSAC categories for Flood Risk Management projects
- Annualized Economic Risks used to bin into relative DSAC categories for Navigation projects



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sPRA Consequence Worksheet

1. Damages - use District estimates when available; document in write-up

Type	Measure to use if better data do not exist
a. Residential Structures and Contents	Structure 75% Census Median Housing Value; Content 50% of Residential Structure
b. Non Residential Structures and Contents	Structure estimated as 33% of Residential; Content 100% of Non Residential Structure
c. Agricultural Crop Damage	\$100 per acre basic crops; \$200 per acre specialty crops
d. Roads and Bridges	Estimated as 25% of Commercial Structure
e. Recreation Facilities	Include if available
f. Environmental Impacts	Include if available
g. Other Impacts	Include if available

2. Lost Benefits - use District estimates when available; document in write-up

Project Purpose	Foregone Benefit (indexed to 2005\$)	Measure to use if better data do not exist
a. Navigation	Transportation Savings	Annual Tons X Avg. Savings Per Ton
b. Flood Risk Management	Flood Damage Protection	Average annual damages prevented
c. Hydropower	Mwh Output	\$40 per Mwh or \$0.04 per Kwh
d. Water Supply	Price of least cost alternative	\$60 per acre foot of use
e. Recreation	Recreation visitation	\$7 per visit; and 80% loss of loss visitation \$\$
f. Fish & Wildlife	Environmental Value	District estimate - if available

3. Repair - cadre estimate

	Measure
a. Time to repair - no more than 3 years	Cadre estimate
b. Embankment Dam replacement assumed 80% of original adjusted to 2005 \$	Cadre estimate
c. Interest During Construction included	Calculated from cadre cost/time estimate



Fatality Rates Table

Event	Valley	Emergency	Arrival	Fatality
Normal	Narrow = N	Action	Time	Rate
Unusual	Wide = W	Plan		
PMF	Special = S	Y / N		
N	N	Y	< .25 hrs	0.3000
N	N	Y	>=.25 hrs - <1hr	0.0050
N	N	Y	>=1hr - <24 hrs	0.0020
N	N	N	< .25 hrs	0.3000
N	N	N	>=.25 hrs - <1hr	0.0100
N	N	N	>=1hr - <24 hrs	0.0050
U	N	Y	< .25 hrs	0.5000
U	N	Y	>=.25 hrs - <1hr	0.0200
U	N	Y	>=1hr - <24 hrs	0.0100
U	N	N	< .25 hrs	0.5000
U	N	N	>=.25 hrs - <1hr	0.0500
U	N	N	>=1hr - <24 hrs	0.0300
P	N	Y	< .25 hrs	0.7500
P	N	Y	>=.25 hrs - <1hr	0.0400
P	N	Y	>=1hr - <24 hrs	0.0200
P	N	N	< .25 hrs	0.7500
P	N	N	>=.25 hrs - <1hr	0.0800
P	N	N	>=1hr - <24 hrs	0.0600
N	W	Y	< .25 hrs	0.3000
N	W	Y	>=.25 hrs - <1hr	0.0010
N	W	Y	>=1hr - <24 hrs	0.0001
N	W	Y	>24 hrs	0.0001
N	W	N	< .25 hrs	0.3000
N	W	N	>=.25 hrs - <1hr	0.0040
N	W	N	>=1hr - <24 hrs	0.0002

Event	Valley	Emergency	Arrival	Fatality
Normal	Narrow = N	Action	Time	Rate
Unusual	Wide = W	Plan		
PMF	Special = S	Y / N		
N	W	N	>24 hrs	0.0001
U	W	Y	< .25 hrs	0.5000
U	W	Y	>=.25 hrs - <1hr	0.0020
U	W	Y	>=1hr - <24 hrs	0.0002
U	W	Y	>24 hrs	0.0001
U	W	N	< .25 hrs	0.5000
U	W	N	>=.25 hrs - <1hr	0.0080
U	W	N	>=1hr - <24 hrs	0.0003
U	W	N	>24 hrs	0.0002
P	W	Y	< .25 hrs	0.7500
P	W	Y	>=.25 hrs - <1hr	0.0040
P	W	Y	>=1hr - <24 hrs	0.0004
P	W	Y	>24 hrs	0.0002
P	W	N	< .25 hrs	0.7500
P	W	N	>=.25 hrs - <1hr	0.0150
P	W	N	>=1hr - <24 hrs	0.0006
P	W	N	>24 hrs	0.0003
N	S	Y	>=1hr - <24 hrs	0.0002
N	S	N	>=1hr - <24 hrs	0.0005
U	S	Y	>=1hr - <24 hrs	0.0020
U	S	N	>=1hr - <24 hrs	0.0030
P	S	Y	>=1hr - <24 hrs	0.0040
P	S	N	>=1hr - <24 hrs	0.0060



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PMF Fail Consequences

\$ - PMF Fail Total Economic Consequences

Spillway Crest or Spillway Gates Elevation		0.0
Outlet Works Invert Elevation		0.0
PMF Fail LOL		0.00
PMF Fail Economic Consequences	\$	-
PMF No Fail LOL		0.00
PMF No Fail Economic Consequences	\$	-

Fail	Pool Elevation	Water Depth	Depth Ratios	From Population Worksheet		Consequences
				PAR	LOL	
PMF	1.0	1.0	1.0000	-	0.00	\$ -
6 month - 50% exceedence	0.0	0.0	0.0000	-	0.00	\$ -
10 yr - Sunny Day - Normal	0.0	0.0	0.0000	-	0.00	\$ -
300 yr - Unusual	0.0	0.0	0.0000	-	0.00	\$ -
No Fail	Pool Elevation	Water Depth in Spillway				
PMF	1.0	1.0		-	0.00	\$ -
300 Yr	0.0	0.0		-	0.00	\$ -



PMF Fail Consequences (cont'd)

Discharges (if no other info available)

PMF Fail	17 cfs	discharge = $(16.6 * (\$21 * .3048)^{1.95}) * 3.2808^3$
300 Yr Fail	- cfs	discharge = $(16.6 * (\$24 * .3048)^{1.95}) * 3.2808^3$
PMF No Fail Discharge	0 cfs	from cadre H&H
300 Yr No Fail Discharge	0 cfs	from cadre H&H

0.0000 PMF no-fail/PMF fail discharge ratio

0.0000 300 Yr no-fail/300 Yr fail discharge ratio



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Problems with SPRA Consequence Data

- Outdated project purpose economics
- Inconsistent data between Districts
- Old/Outdated inundation mapping
- Unequal application of Graham fatality rates
- Extrapolation based on discharge and water depth ratios is crude



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Improvements with PRA Consequence Data

- Updated project purpose economics
- Consistency between Districts
- GIS developed inundation mapping and census data
- Consistent Graham application
- Improved models for better consequence estimates for each load/event (no longer extrapolate)



DSAC Ratings

- Based upon a combination of annualized loss of life (or annualized economic damages) and the engineering ratings (likelihood for poor performance).
- Recommendations are made by the Cadre but are QC reviewed and must be approved by the Senior Oversight Group (SOG) before being finalized.



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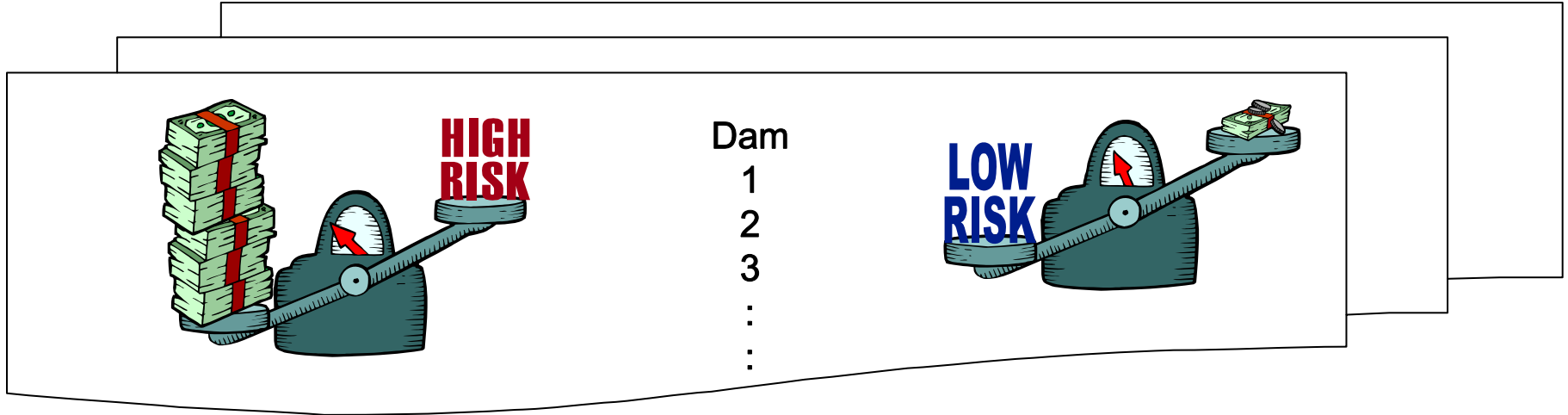
Dam Safety Portfolio Risk Management

- Senior Oversight Group – consists primarily of Community of Practice Technical Leaders and Business Line Managers from HQ, USACE, regional experts on dam safety, and select members from the three subordinate teams – they are led by the HQ, USACE Special Assistant for Dam Safety.
- Methodology Team – primarily staffed by Senior Technical Experts assigned to the Engineering Risk and Reliability Directory of Expertise and augmented with members from private industry and HQ, USACE.
- Policy and Procedures (P&P) Team – Staffed by interdisciplinary Senior Technical Experts from throughout USACE. They work in tandem with the Methodology Team and are led by a District Dam Safety Officer.
- Cadres - Staffed by technical specialists from throughout USACE. These risk cadres perform Screening for Portfolio Risk Analysis (SPRA) at the USACE Districts and other investigations/analysis for the dam safety program.



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SPRA Results



Evaluate Risk



Dam Safety Action Classification

Class I
Urgent and Compelling

Class II
Urgent

Class III
High Priority

Class IV
Priority

Class V
Normal



Table 1 USACE Dam Safety Action Classification Table*

Dam Safety Action Class	Characteristics of this class	Actions for dams in this class
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 (Adequately 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



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Dam Safety Action Class	Reasons to adjust classification		
I URGENT AND COMPELLING (Unsafe)		To Class 2 <ul style="list-style-type: none"> • External Peer Review does not support DSAC. • Studies and Investigations do not support suspected defect or failure mode. Extreme risk is not supported 	
II URGENT (Unsafe or Potentially Unsafe)		To Class 1 <ul style="list-style-type: none"> • Progression toward failure is confirmed or supported by field observations (boils, excessive seepage, deformation, sink holes, etc) 	Class 3 <ul style="list-style-type: none"> • Primary deficiency is in the extreme loading events. • History to indicate good performance at unusual loading range.
III HIGH PRIORITY (Conditionally Unsafe)		Class 2 <ul style="list-style-type: none"> • Field observations indicate signs of distress for unusual loading (Seepage & Piping) • Project has high component risk • Cadre belief that the dam has credible failure modes that could initiate under unusual loading that is supported by a review of construction records and project documents. • Effectiveness of prior repairs are questionable • Site seismicity is believed to be significantly higher than original design basis. 	Class 4 <ul style="list-style-type: none"> • Deficiencies are at extreme loading events • Low component risk
IV PRIORITY (Marginally Safe)		To Class 3 <ul style="list-style-type: none"> • Increasing piezometric pressure over time • Project has high component risk 	
V NORMAL (Safe)		N/A	

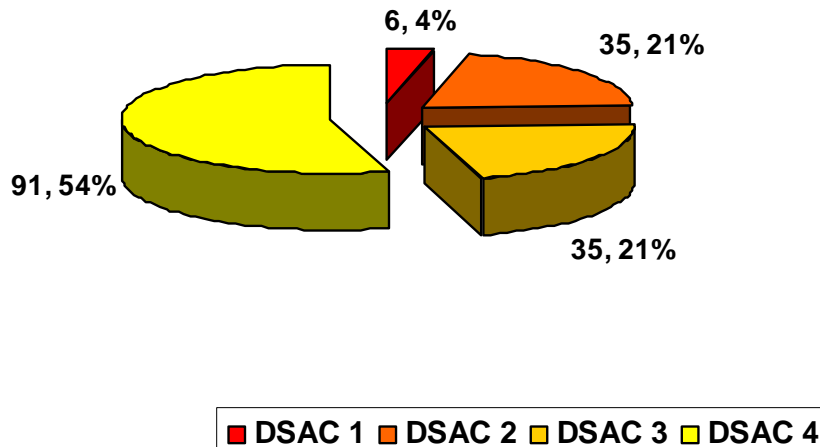


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Screening Portfolio Risk Analysis

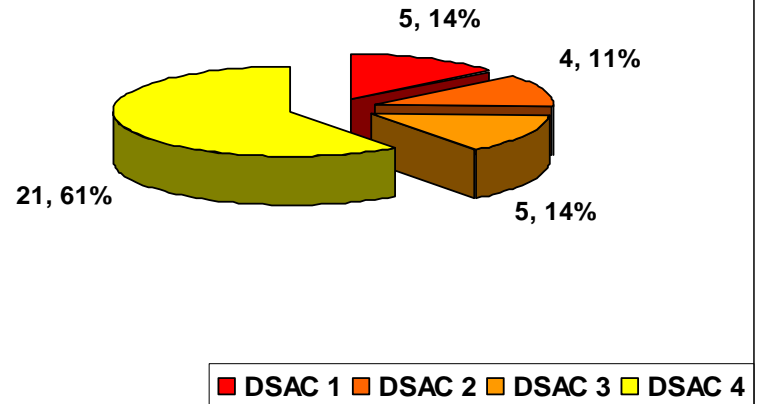
Findings: 202 of 609 Projects

Flood Damage Reduction Projects



167 FDR Projects

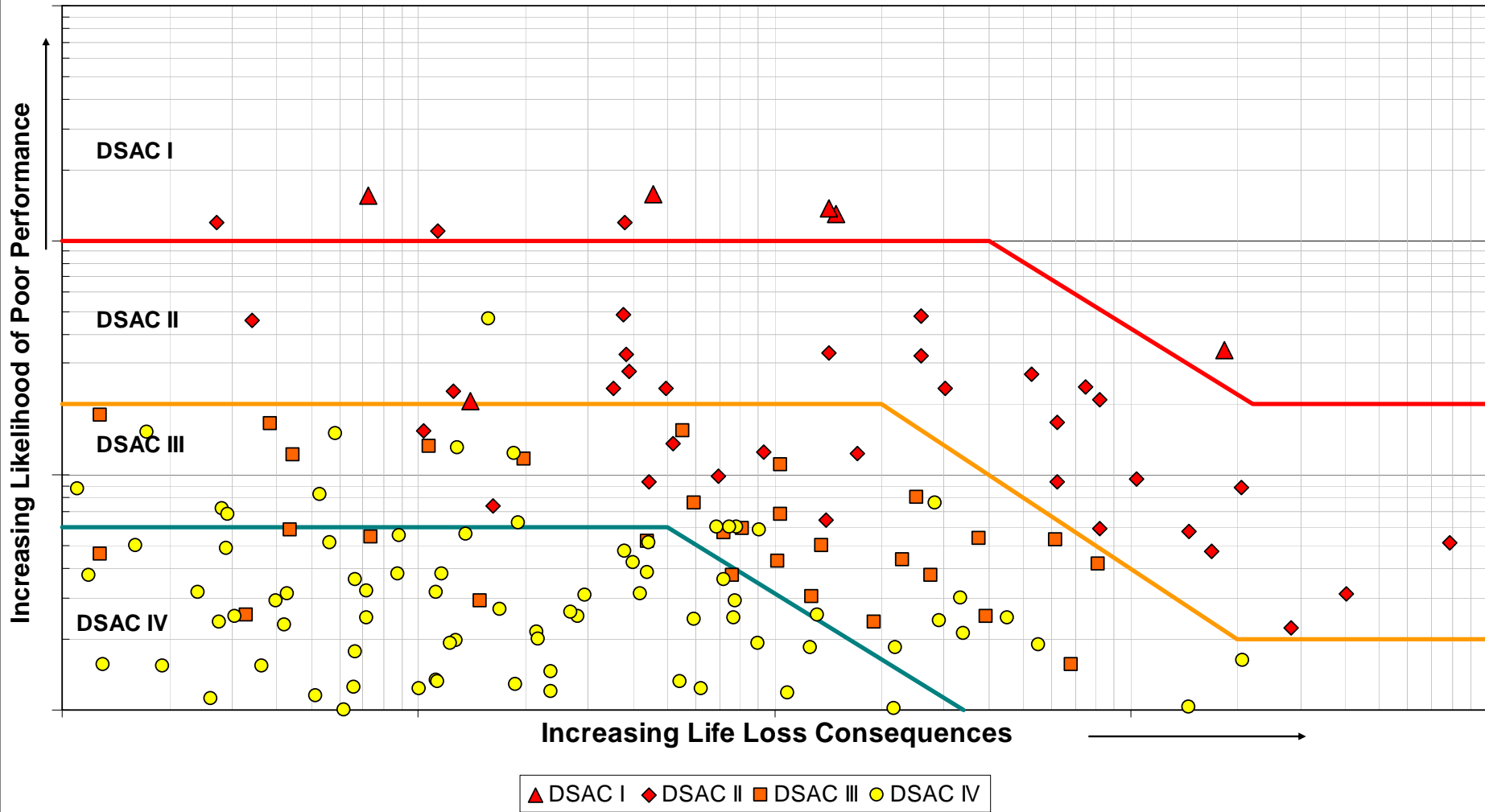
Navigation Dams



35 Navigation Projects

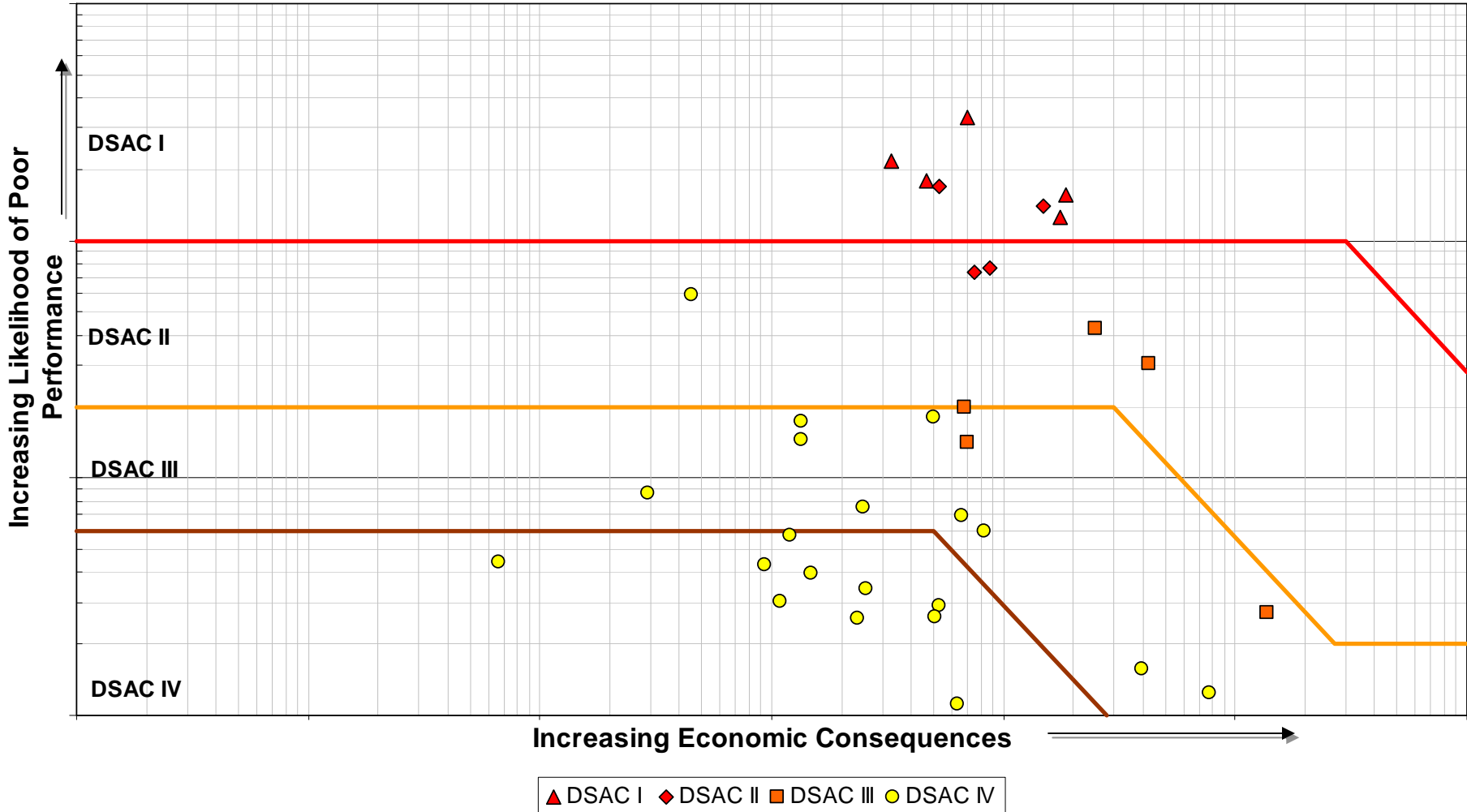


Flood Damage Reduction Dams Screened between FY 05-07





Navigation Dams Screened between FY 05-07





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Screening Results

- Looked for data consistency
 - Reasonable, Minor Variations
 - No Cadre Biases Observed
- Significant rigor for screening level
 - 8 man-days per project average effort
 - Thousands of individual judgments
- Do results make sense test?
 - Engineering standpoint
 - Risk/Reliability perspective
 - Life Loss and Economic Consequence



Screening Results (cont'd)

- Relative Life Risks are well correlated with relative Economic Risks
- Seepage & Piping: greatest risks primarily due to occurrence at normal pools, higher fatality rate, and uncertainty
- Extreme Events (Seismic/Hydrologic) generally yield lower relative risks
- Navigation Projects: very low relative Life Risks, but high relative Economic Risks



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Screening Results (cont'd)

- Risks Regionally Influenced:

Geography:

- Narrow Valleys
- Population Centers

Geology:

- Seismically Active Zones
- Karst and Glacial Foundations

Project Age & Purpose

Regional Availability of Resources



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Levels of Risk Analysis/Assessment

SPRA	Based on available information, Preliminary DSAC Classification, 2005-2009
Type 1	Periodic Assessments (PA) will be conducted for all dams on a 5 to 10 year cycle. The PA will consist of a periodic inspection, a potential failure mode analysis, and scripted risk analysis tools based on existing data and minimum of additional new data. The primary purpose of the PA is to confirm the DSAC of a project; justify interim risk reduction measures; provide initial input for quantitative risk reporting; identify needed preliminary dam safety studies; prioritize preliminary dam safety studies; identify operations and maintenance, monitoring, emergency action plan, training and other recurrent needs; and confirm essential USACE dam safety guidelines are met and determine if residual risks are tolerable to confirm DSAC V.
Type 2	Issue Evaluation (IE) supports Preliminary Dam Safety studies and is performed using available and additional data as justified by the decision to be made. The Issue Evaluation will use the Corps of Engineers Dam Safety Risk Assessment tools which will provide increased robustness of and confidence in the output over PA. The primary purpose of the Issue Evaluation is to investigate unconfirmed dam safety issues and to confirm dam safety issues do or do not exist, identify or verify the need for potential risk reduction measures, prioritize dam safety modification studies, and confirm essential USACE dam safety guidelines are met and determine if residual risks are tolerable to confirm DSAC V.
Type 3	The Dam Safety Modification (DSM) studies leading to definitive decisions and documentation to justify dam safety actions to achieve reduction in Life, Economic, Societal, and Environmental risk. Additional data will be gathered as justified by the decision to be made. The DSM will use the Corps of Engineers Dam Safety Risk Assessment tools which will provide results of increased robustness of and confidence in the output over IE. The primary purpose of the DSM is the identification, evaluation, justification, and recommendation of long-term risk reduction remedial measures.



What's Next ?

- Carry on with SPRA to completion in 2009
- Developing more robust engineering and economic tools for the next (PRA) phase (Methodology Team)
- Overhaul Dam Safety Program Based On Risk (Policy Team)
- Update Consequence Data, Improve Methods and Develop Models



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Questions?