USACE Dam Safety Program
Current Approach & Methodology

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New England District
Corps of Engineers Dam Safety Program

**Flood Damage Reduction Dams Through March 2009 SOG**
- 157, 55%
- 45, 16%
- 75, 26%

**Navigation Dams Through March 2009 SOG**
- 43, 46%
- 21, 22%
- 24, 25%

**287 FDR Projects**

**95 Navigation Projects**
USACE Dams

- 654 Projects across the country
- 31 flood damage reduction dams in New England constructed in the 1940s-1960s (as well as over 47 levee projects); Prompted by major flooding of the 1930s
Traditional Approach

- Funding through the Operation & Maintenance program has been used by the districts to evaluate ongoing issues. Funding has been provided to repair and address issues as they have arisen.

  - **Advantage:** Local knowledge of the dams and their day to day performance

  - **Disadvantage:** Limits on funding and the lack of a centralized standardized approach have meant that some significant/high risk issues have had to await funding, while other, perhaps less significant, have been addressed; ‘Squeaky wheel gets the oil’.

  - **Result:** Funding was not used optimally to buy down risk.
New Vision & Strategy

• Risk & Reliability-based approach adopted since early 2000s. Flood damage to levees during the Katrina disaster gave new urgency to addressing the aging infrastructure Corps portfolio of dams and levees.

• A risk-based approach ensures funding is directed to reduce risk in the most cost efficient manner.

• Program is centrally led, regionally executed; ‘best of both worlds’
Risk

- What’s wrong?
- How likely is it to occur?
- What are the consequences?
Definition

• **Risk = Probability X Consequence**
  
  - Loading Event Probability
  - Potential Failure Mode
  - Probability of Failure
  - Loss of Life
  - Economic Damage
  - Other Consequences
Program Components

- Screening Portfolio Risk Assessment (SPRA)
  - Assigns relative risk to entire USACE dam portfolio

- Issue Evaluation Studies (IES)
  - Detailed look at each dam to ascertain actual level of risk & consequences

- Periodic Assessments (PA) – includes periodic inspections
  - Continually re-assess risk based on performance
BUILDING STRONG

US Army Corps of Engineers

SPRA

Inventory of Dams (654)

SPRA (Worst First)

Staff and Train Cadres

Search Files, data Photos, etc

Deploy Cadres

Risk Estimates

Consequences People and dollars

Estimate Probability of failure

Study Records, Interview Staff
Information Evaluated for a Dam

- SPRA is Setup to Evaluate Two Types of USACE Dams
  - Flood Control
  - Navigation
- Five Load Cases Evaluated in SPRA
  - Normal (1-yr to 10-yr)
  - Seismic Unusual (OBE, 145-yr Event)
  - Seismic Extreme (MDE)
  - Hydrologic Unusual (10-yr to 300-yr Event)
  - Hydrologic Extreme (300-yr to PMF)
- Evaluation of 28 Project Features Under Five Load Cases
Information Evaluated (continued)

- Example Features Evaluated for a Dam
  - Concrete Gravity Sections (Stability)
  - Spillway & Stilling Basin (Stability, Gates, Erosion)
  - Outlet Works (Tower, Gates, Conduit Performance)
  - Embankment (Seepage/Piping, Stability, Liquefaction, Erosion)
  - Foundation (Seepage/Piping, Stability, Liquefaction)
  - Abutments (Seepage/Piping, Stability, Liquefaction)
Information Evaluated (continued)

- 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.
  - 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
SPRA Results: Classifications

Evaluate Risk

Dam Safety Action Classification (DSAC)

Class 1: Urgent and Compelling
Class 2: Urgent
Class 3: High Priority
Class 4: Priority
Class 5: Normal
## Table 3.1 USACE Dam Safety Action Classification Table*  6 May 2008 version

<table>
<thead>
<tr>
<th>Dam Safety Action Class</th>
<th>Characteristics of this class</th>
<th>Actions for dams in this class</th>
</tr>
</thead>
</table>
| **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  
The 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, economic, or environmental 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, economic, or environmental 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  
Dam is considered safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues.  
AND RESIDUAL RISK IS CONSIDERED TOLERABLE. | 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
DSAC Rating Starts the Process

Figure 3.1  3 Feb 2009

Screening for Portfolio Risk Analysis (SPRA) (One time only)

Dam Safety Action Classification (DSAC) (D 1a)

All Dams

Yes

Routine dam safety activities, Periodic Inspections, Periodic Assessments, normal DSM, and implement lessons learned

No

Incident triggers DSAC Review? (D 1d)

Yes

DSAC II, III, or IV

For DSAC II, III, or IV dams are Modification Studies Justified? (D 3)

No

Yes

DSAC II, III, or IV

Develop and Implement IRRM Plan for DSAC II (D 2a)

Develop and Implement IRRM Plan for DSAC I (D 2a)

Develop and Implement IRRM Plan DSAC III (D 2a)

No

Heightened Monitoring for DSAC IV (D 2b)

No

Prioritize and Schedule Issue Evaluation Studies (P 1)

Resource Queue

Issue Evaluation Studies

Review DSAC and modify as appropriate, Review and modify IRRM Plan, (D 1c)

DSAC I

No

Prioritize and Schedule Modification Studies (P 2)

Resource Queue

Prepare Project Management Plan

Yes

Corps Accepts as DSAC I? (D 1b)

Develop and Implement IRRM Plan for DSAC III (D 2a)

No

Prioritize and Schedule Modification Studies

Resource Queue

Yes

Yes

Resource Queue

Implement Decision

Review DSAC and modify as appropriate, Review and modify IRRM Plan, (D 1c)

Dam Safety Modification Studies

Decision document*

Yes

No Action Required.

No

Report Approved? (D 3)

Yes

Yes, Action Required

No

Prioritize Projects for Funding (P 3)

DSAC IV

No

DSAC III
Example SPRA: Hopkinton Lake Dam; Merrimack River Basin
Engineering Assessments: Hopkinton

Probably Inadequate:

- Embankment – Embankment, Seepage & Piping
  - Extreme
- Embankment – Foundation Stability & Liquefaction
  - MDE
- Embankment – Abutment Stability & Liquefaction
  - MDE
- Dike H2 Embankment – Foundation Stability & Liquefaction
  - Extreme
- Dike H2 Embankment – Seepage & Piping
  - Extreme
- Dike H3 Embankment – Seepage & Piping
  - Extreme
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<th>50% Exceedence Duration Normal Water Level with OBE</th>
<th>50% Exceedence Duration Normal Water Level with MDE</th>
<th>Unusual (300yr)</th>
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**Summary Ratings: Hopkinton**
## Recommendations: Hopkinton

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<tr>
<th>DSPMT Code</th>
<th>Description</th>
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<tr>
<td>2</td>
<td>Perform seepage analysis and investigate the need for piezometers in Dikes H-2 and H-3. Currently there is no monitoring of these structures. Also perform seepage to determine the need for piezometers at the railroad embankment that was left in place during construction on the left bank of the main dam.</td>
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<td>3</td>
<td>Update stability analysis for each structure (main dam, dike H-2 and H-3) for each case; sudden drawdown, steady state seepage and seismic.</td>
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<td>3</td>
<td>Perform or update Hydraulic Steel Structure inspections in accordance with ER 1110-2-8157, Responsibility of Hydraulic Steel Structures; and EM 1110-2-8157, Inspection, Evaluation and Repair of Hydraulic Steel Structures</td>
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After SPRA

- DSAC 1 dams will receive immediate funding to repair
- DSAC II and III dams will receive funding to perform Issue Evaluation Studies (IES) to determine best course of action
ISSUE EVALUATION STUDIES
Corps of Engineers Dam Safety Portfolio Risk Management Process

Issue Evaluation Study
Issue Evaluation Studies
Purpose & Objectives

• Determine the nature of the dam safety issue and the degree of urgency for action within the context of the entire USACE inventory of dams.

• Focus on project specific potential failure modes when evaluating risk.

• Guide the selection, and gauge the effectiveness, of Interim Risk Reduction Measures (IRRM).

• Justify the need for Dam Safety Modification Studies.
Focus

- Use existing project data (studies, analysis, performance data).
- Update consequence estimates using existing Census data and updated mapping and dam failure models provided by the Modeling, Mapping, and Consequence (MMC) Center.
- Perform a baseline risk estimate which includes as many significant potential failure modes (PFM) necessary to determine if Dam Safety Modification Studies and/or DSAC reviews are warranted.
- Recommend Phase 2 studies when the existing data produces a high level of uncertainty or low level of confidence in the risk estimate.
- The effectiveness of existing Interim Risk Reduction Measures (IRRM’s) and the need for additional IRRM’s.
IES - Time Line

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<th>Cadre</th>
<th>PFMA</th>
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Initiation of Phase 2 (if Required)

6 Months

Initiation of Phase 2 (if Required)
Overall PFMA Process

1) Assemble team and gather all background information.
2) Conduct site visit and interview field personnel.
3) Review all available background information.
4) Review loading conditions and baseline consequences.
5) Brainstorm “candidate” potential failure modes and failure scenarios.
6) Categorize failure modes as “credible” or “non-credible”.
7) Prioritize “significant” failure modes from the listing of “credible” failure modes for discussion and evaluation.
Recent Example IES: Ball Mountain Dam
DSAC II (urgent or potentially unsafe)
Issue Evaluation Study
May-September 2009