U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT

2016 LEVEE SAFETY MEETING

"SHARED RISKS, SHARED SOLUTIONS"

Sheraton Louisville Riverside Hotel,
Jeffersonville, IN

9-10 February 2016

AGENDA

Tuesday 9 February 2016

9:00 to 9:15	Opening Remarks - Day 1	Colonel Christopher Beck, P.E., Commander, Louisville District
9:15 to 10:15	Overview of the Levee Safety Program	Eric Halpin, P.E., HQ Assistant to Dam and Levee Safety
10:30 to 11:00	Presentation by Risk Cadre - Levee Risk Assessments	Greg Werncke, P.E., Senior Technical Advisor, Risk Management Center (RMC)
11:00 to 11:45	Understanding the Preservation of Large Diameter Gravity Pipes with Structural Epoxy - Spray-In-Place-Pipe Liner (SIPP)	Danny Warren, Warren Environmental Inc., A&W Maintenance Inc.
11:45 to 12:15	Interim Policy on Inspection	Matthew Whelan, P.E. - Levee Safety Area Representative (LSAR) Upper Wabash
1:15 to 1:45	Abandoning/Sealing/Removing Obsolete Project Components	Ross Wright, P.E. Levee Safety Area Representative (LSAR) Lower Ohio and Green Rivers
1:45 to 2:15	Controlling Water with Water - Dam-It Dams	Brian Francis, Dam-It Dams Product Specialist
2:15 to 2:45	Public Alerts and Warnings: What really matters?	Will Lehman, Economist at Hydrologic Engineering Center (HEC)
3:00 to 3:30	Installation and Inspection of Reinforced Concrete Pipes (RCP)	Trygve Hoff, American Concrete Pipe Association (ACPA) Region Engineer that serves KY, OH, & IN
3:30 to 4:30	Levee Safety Areas (LSA) - Levee sponsors will provide short discussions on lessons learned on their projects. For example - issues with gate replacements; rebuild of pumps, mowing techniques, etc.	Levee Safety Area Representatives (LSARs) - Alvey, Inspector; Bryan, PE; Lasoski, PE; Wright, PE; Whelan, PE.
7:30 to 8:00	**Presentation: Silver Jackets Overview**	Brandon Brummett, P.E., PMP - Louisville District Outreach Coordinator

"Life Safety is Paramount"

v 4.0

U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT

2016 LEVEE SAFETY MEETING

"SHARED RISKS, SHARED SOLUTIONS"

Sheraton Louisville Riverside Hotel,
Jeffersonville, IN

9-10 February 2016

AGENDA

Wednesday 10 February 2016

8:30 to 8:45	Opening Remarks - Day 2	John Bock, P.E., Chief, Engineering Division and Levee Safety Officer (LSO)
8:45 to 9:15	Painting and Repainting Waterfront Steel Structures	Mark Jelinek, Sherwin Williams
9:15 to 9:45	Programs and Project Management Studies	Amy Babey, PMP, Chief of Plan Formulation Section
9:45 to 10:15	Discuss Silver Jackets Study for Metro Louisville Emergency Preparedness Plan (EPP)	Nathan Bryan, P.E., Levee Safety, Geotechnical Engineer
10:30 to 11:00	Cannelton Relief Well Project	Rick Hockett, PG, Risk Cadre, Geologist
11:00 to 11:30	Overtopping Leading to Levee Breaches	Terry Sullivan, P.E., Geotechnical/Geology Branch Chief, Eastern Division, Risk Management Center, Institute of Water Resources
11:30 to 12:30	USACE Assistance During Emergency Operations	Don Walker, Emergency Operations Manager, Emergency Operations Center (EOC) Louisville District
1:30 to 2:00	Western Excelsior - Current Work on New Orleans Levee Systems	Lee Pierce, Western Excelsior
2:00 to 2:30	Mechanical Solutions to Pump Station & Levee Components	Mark Robertson, P.E., Regional Technical Specialist (RTS) Mechanical Engineer LRL
2:30 to 3:00	H&H Presentation on Revised Wabash River Discharges and Potential Impacts to Levee Sponsors Maintaining Levees Along the Wabash River; & Potential Update Study to Ohio River Discharges - Study.	Richard Pruitt, P.E., Chief of Hydrology & Hydraulics Section

"Life Safety is Paramount"

v 4.0

USACE Levee Safety Program

Shared Risks, Shared Solutions

Eric Halpin, P.E.

Special Assistant for Dam and Levee Safety

HQUSACE

9 Feb 2016

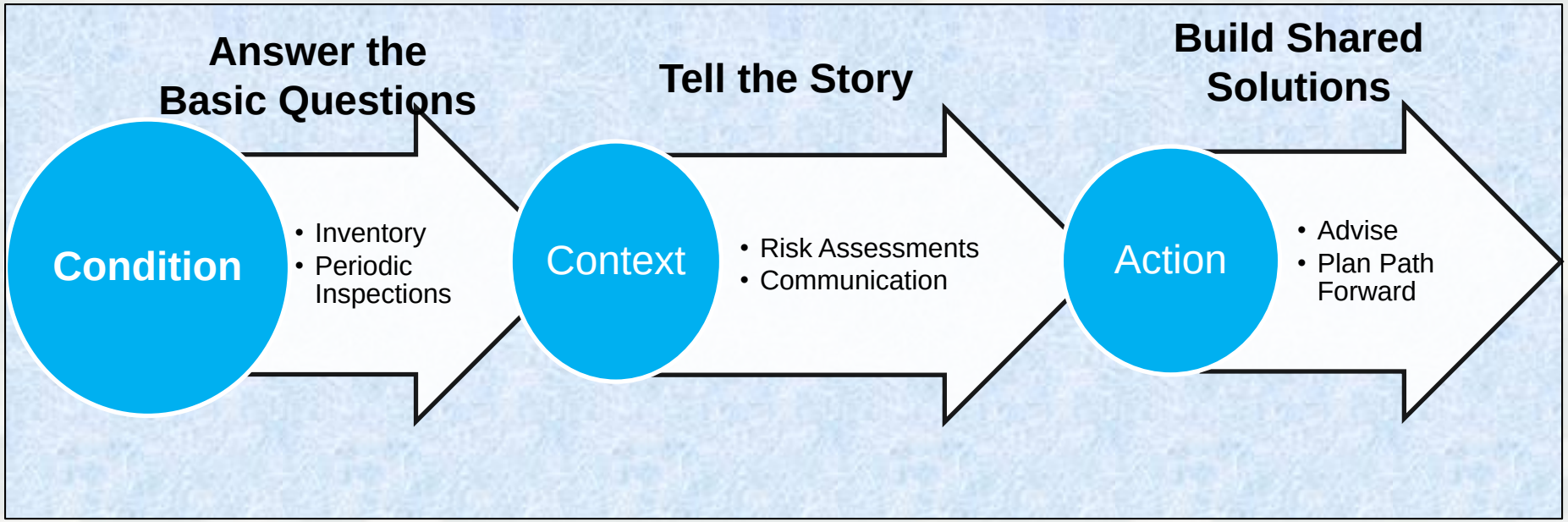
US Army Corps of Engineers

BUILDING STRONG®

Agenda

- What We've Learned
- Risk Communication
- Non-Project Segments
- I-Walls
- Levee Safety EC
- National Levee Initiative
- Other Additional Topics?

USACE Levee Safety Program
Implementing the Risk Framework



- Why the risk framework? Better decisions.
  - ▶ Conditions of uncertainty
  - ▶ Focuses on evidence
  - ▶ Improves objectivity

BUILDING STRONG®

Why Have a Safety Program?

Residual Risk is Real

Important to Understand the Tradeoffs

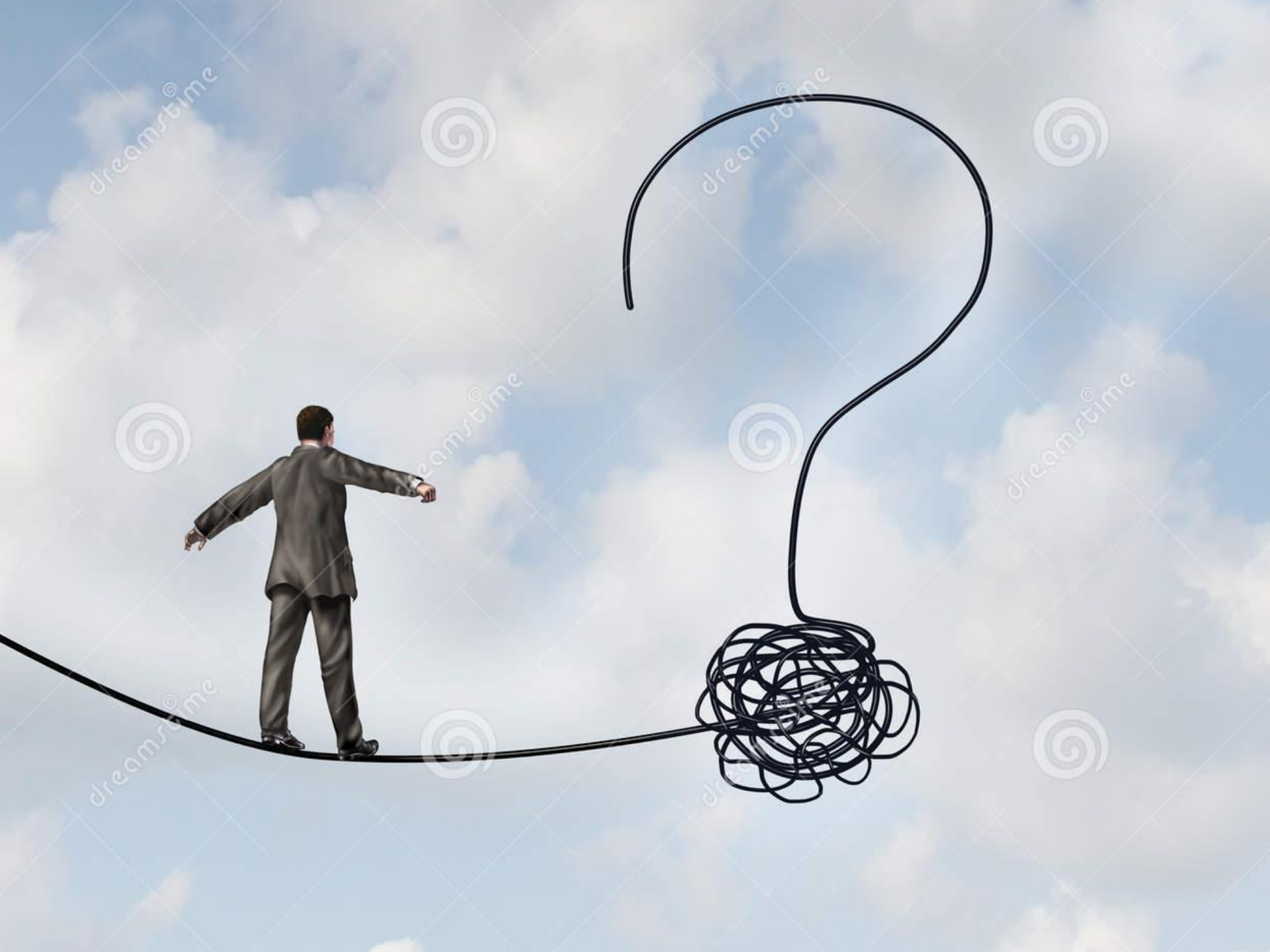
We have an important Continuing Role

Manage Risks

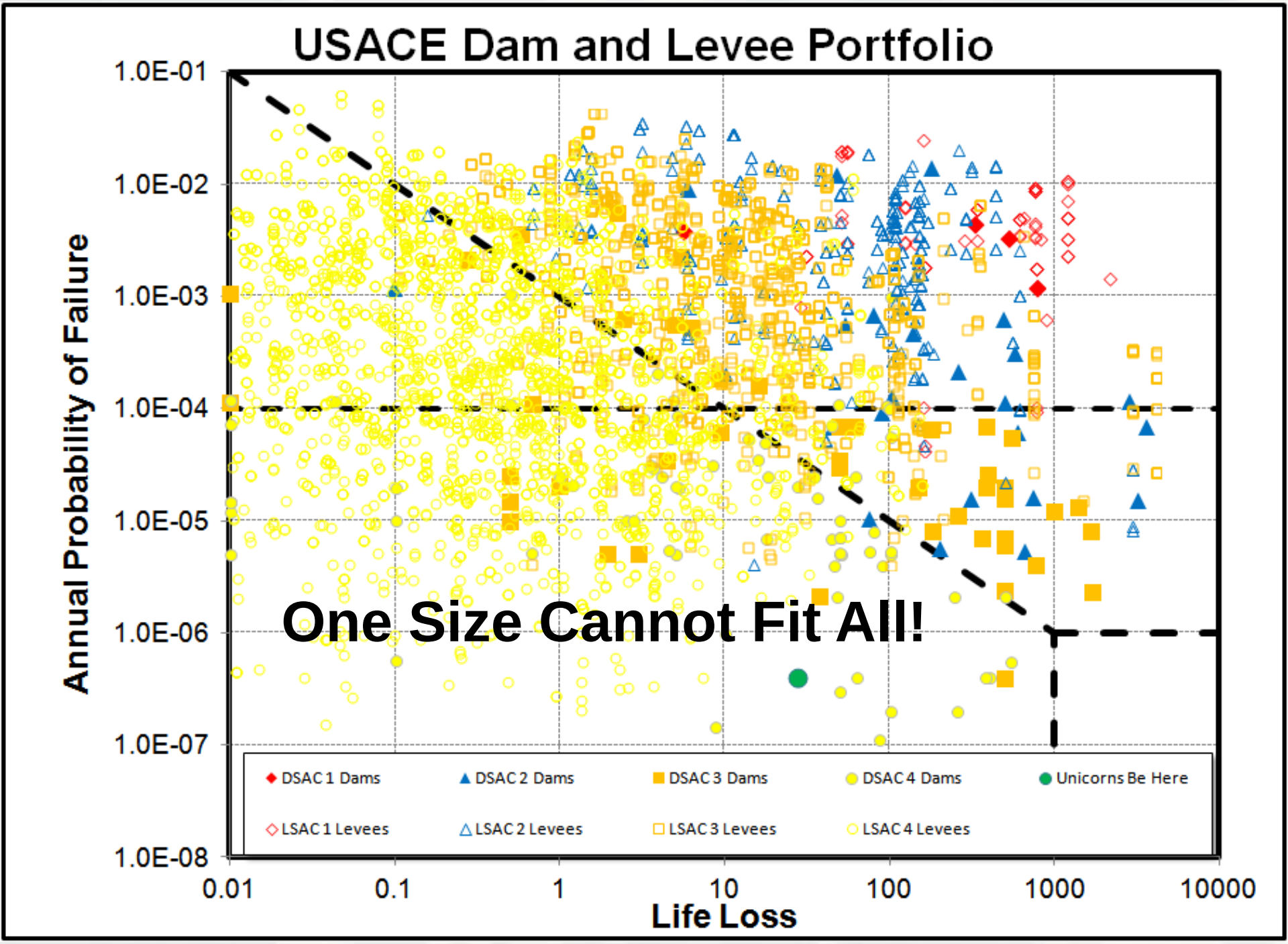
Understand the Problems

Improve Communications

Make Better Decisions

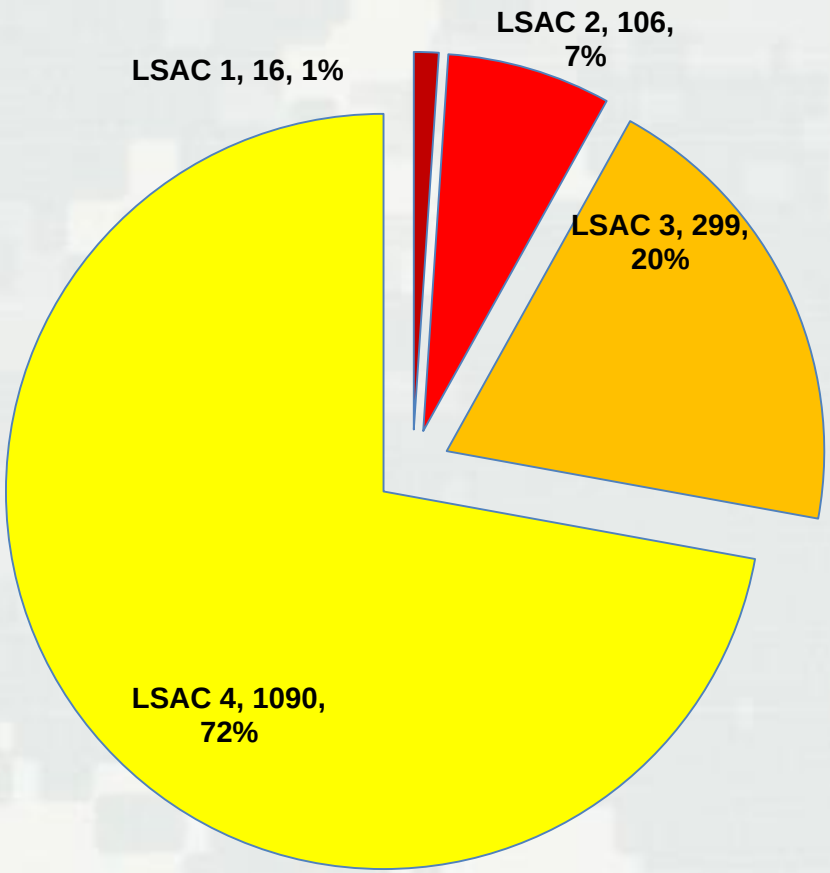


How well do engineering standards address risks?


USACE Dam and Levee Portfolio
Annual Probability of Failure
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
0.01
0.1
1
10
100
1000
10000
Life Loss
One Size Cannot Fit All!
DSAC 1 Dams
DSAC 2 Dams
DSAC 3 Dams
DSAC 4 Dams
Unicorns Be Here
LSAC 1 Levees
LSAC 2 Levees
LSAC 3 Levees
LSAC 4 Levees

Risk Assessment Status

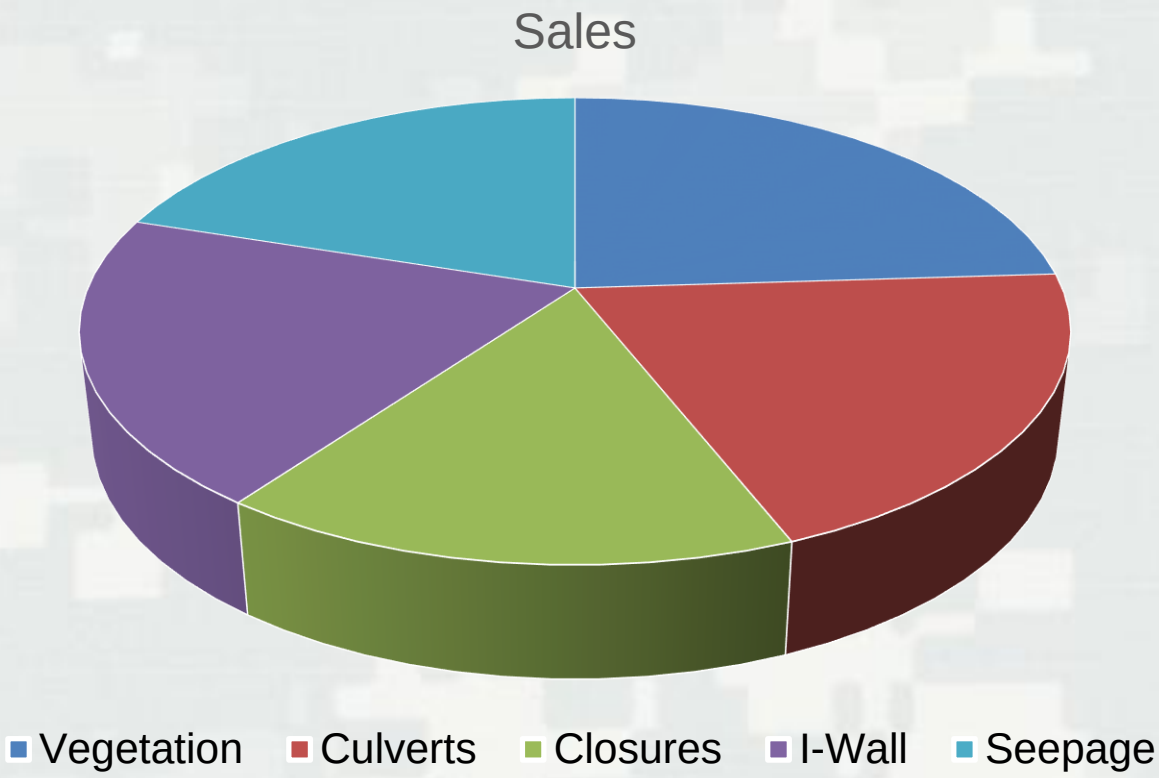
Levee Safety Action Classification
Very High (LSAC 1)
High (LSAC 2)
Moderate (LSAC 3)
Low (LSAC 4)
Normal/Routine (LSAC 5)



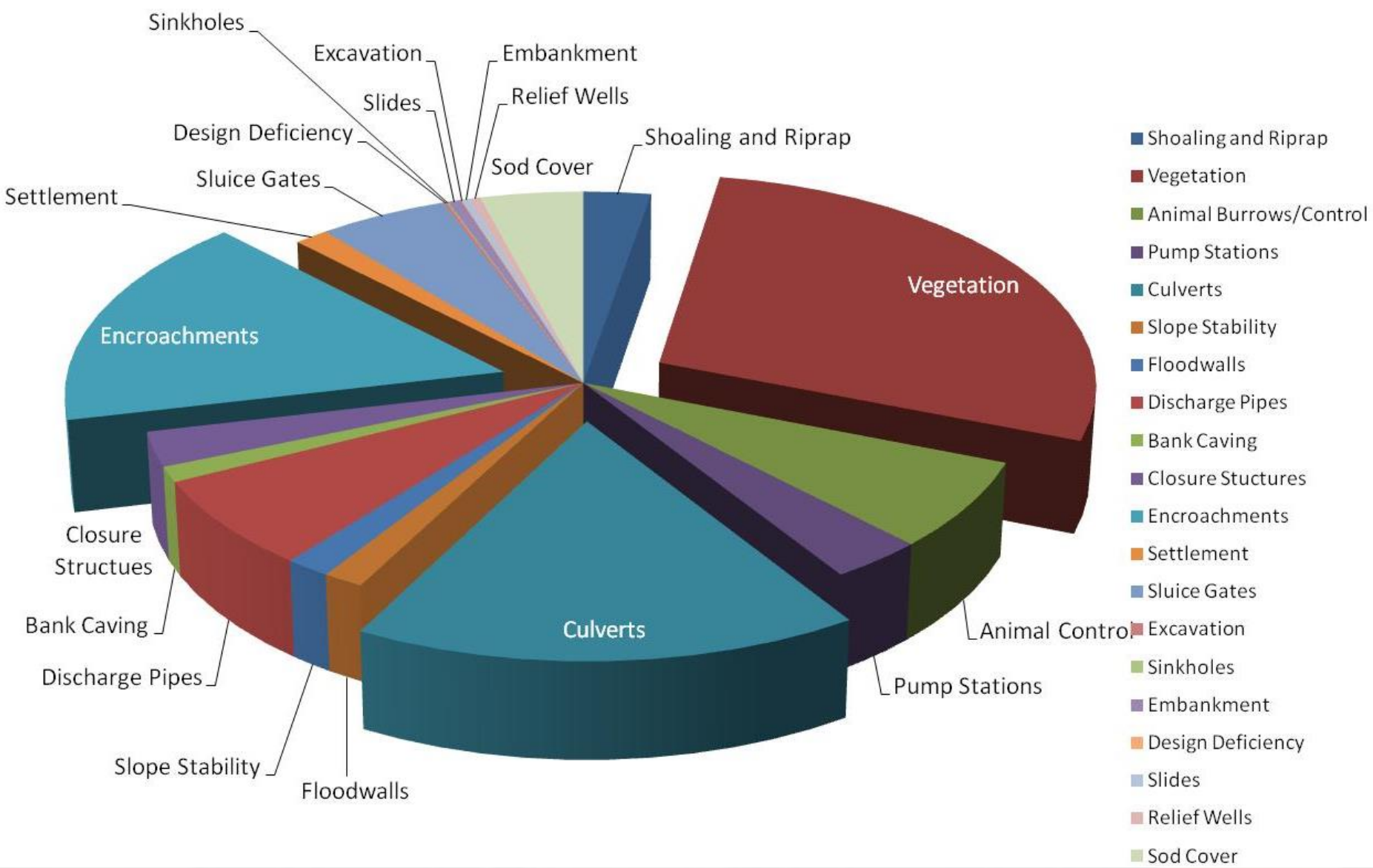
Total ready for approval = 1,511
Total remaining = 1,376

In Louisville
LSAC 2's = 8%
LSAC 3's = 23%
LSAC 4's = 69%

Risk Drivers in Portfolio of Louisville District

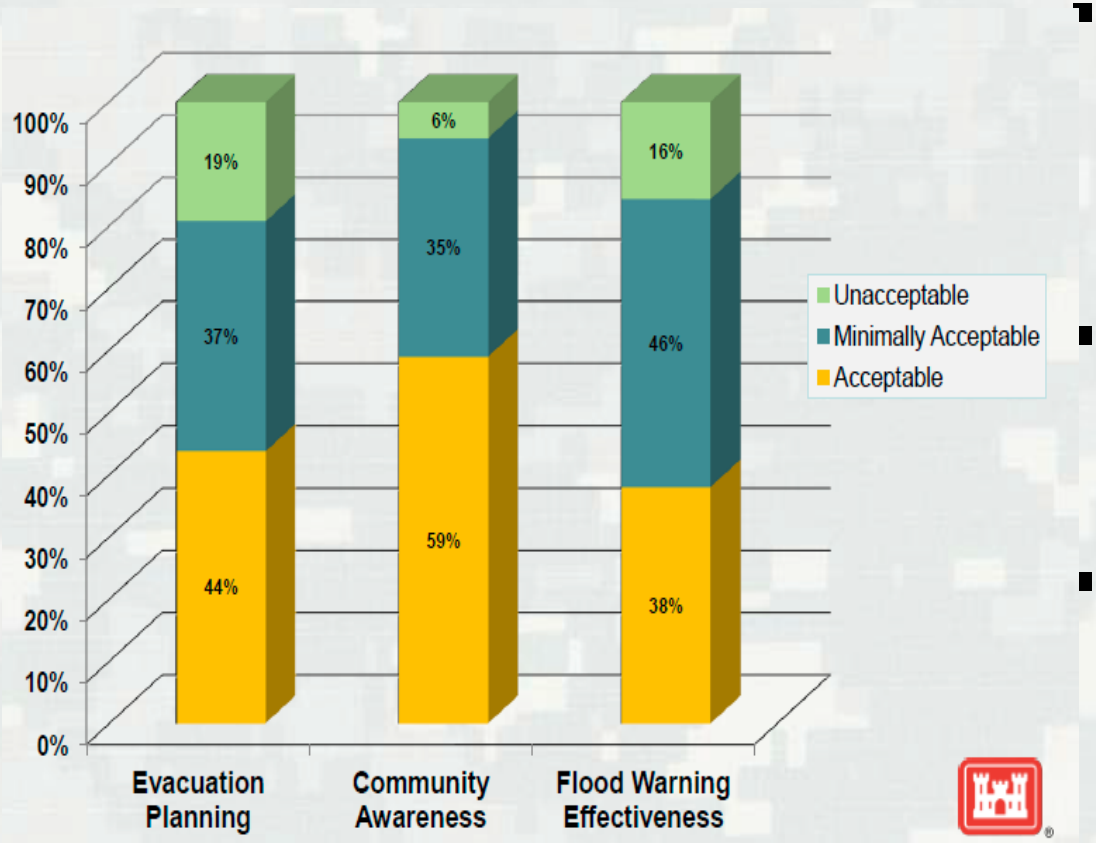


USACE Major Inspection Deficiencies



Communities are Not All the Same

(Making Shared Responsibility Work)



- Our Sponsors are not always the Communicators in Communities
- Good Relationships = good Communication
- Communities Get their Information From Multiple Sources

Sponsors
FEMA
USACE Levee Safety
USACE FRM
Communities

Risk Communication

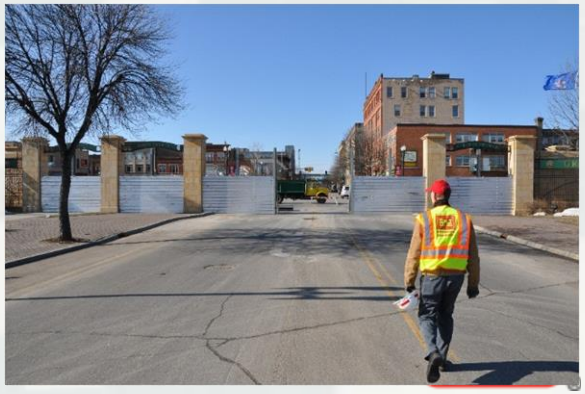
Why Communicate Now?

(Authorities and Timing)

- WRDA 2007 Title IX, 9004, re-*emphasized by WRRDA 2014, Section 3016:*
  - ► "Let people know what we know…"
- Inspection of Completed Works, (33 CFR 208.10)
  - ► "Ensure projects can safely deliver benefits"
- Policy Guidance Letter on Placing Levees in a Risk Context, Emphasis on Communication and Sponsor Engagement – signed 6 November 2016
- *It's the right thing to do and We are Ready!*

Lessons from Dam Safety, Levee Pilots, and Rollout Feedback

- Local issues and impacts are unique, process needs to be scalable
- Extensive involvement with sponsors and stakeholders is necessary
- Use of numbers (LSAC) is not effective in talking about risk
  - Tell why risk is high and what can be done about it



Overall Process

- USACE characterizes the levee risk, based on risk assessments
- Districts coordinate a risk communication strategy with sponsors and FEMA
- Strategies and timelines are flexible, based on risk and audiences
- After communication a publicly available Levee System Summary is posted to the National Levee Database

Programmatic Expectations for Engaging Sponsors

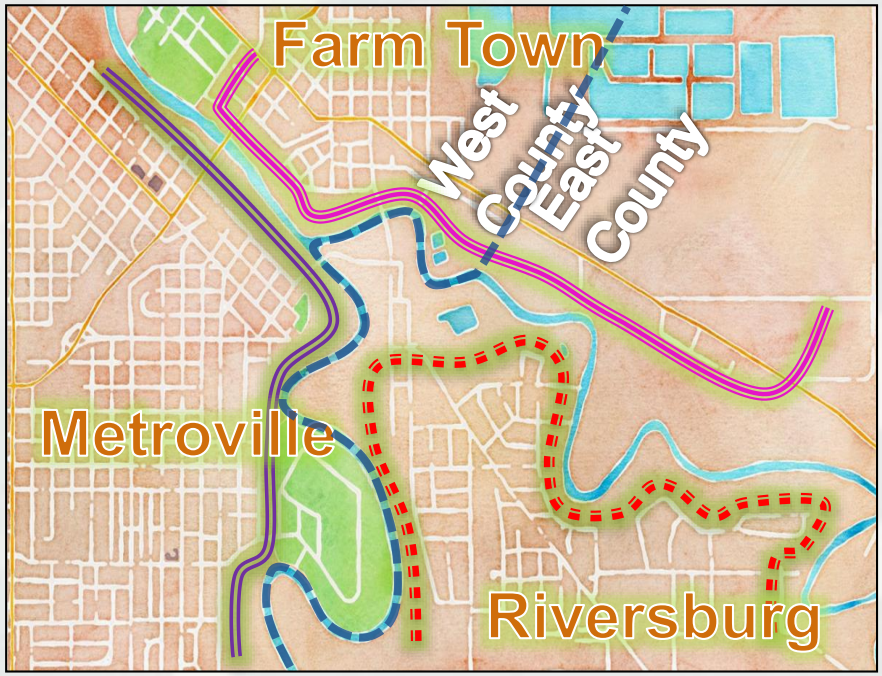
- Responsible for O&M
- Most credible communicators to community
- Engaged as participants in all Levee Safety Program activities – inspections, risk assessments and risk management activities
- Regular dialogues are encouraged

Challenges to Anticipate

- Numerous levee systems: timely and current risk communication
- Coordination with multiple entities
- Community impacts: economic development, flood insurance, PL84-99 status….
- Comfort level for risk communication?
- Translating technical information for general public consumption

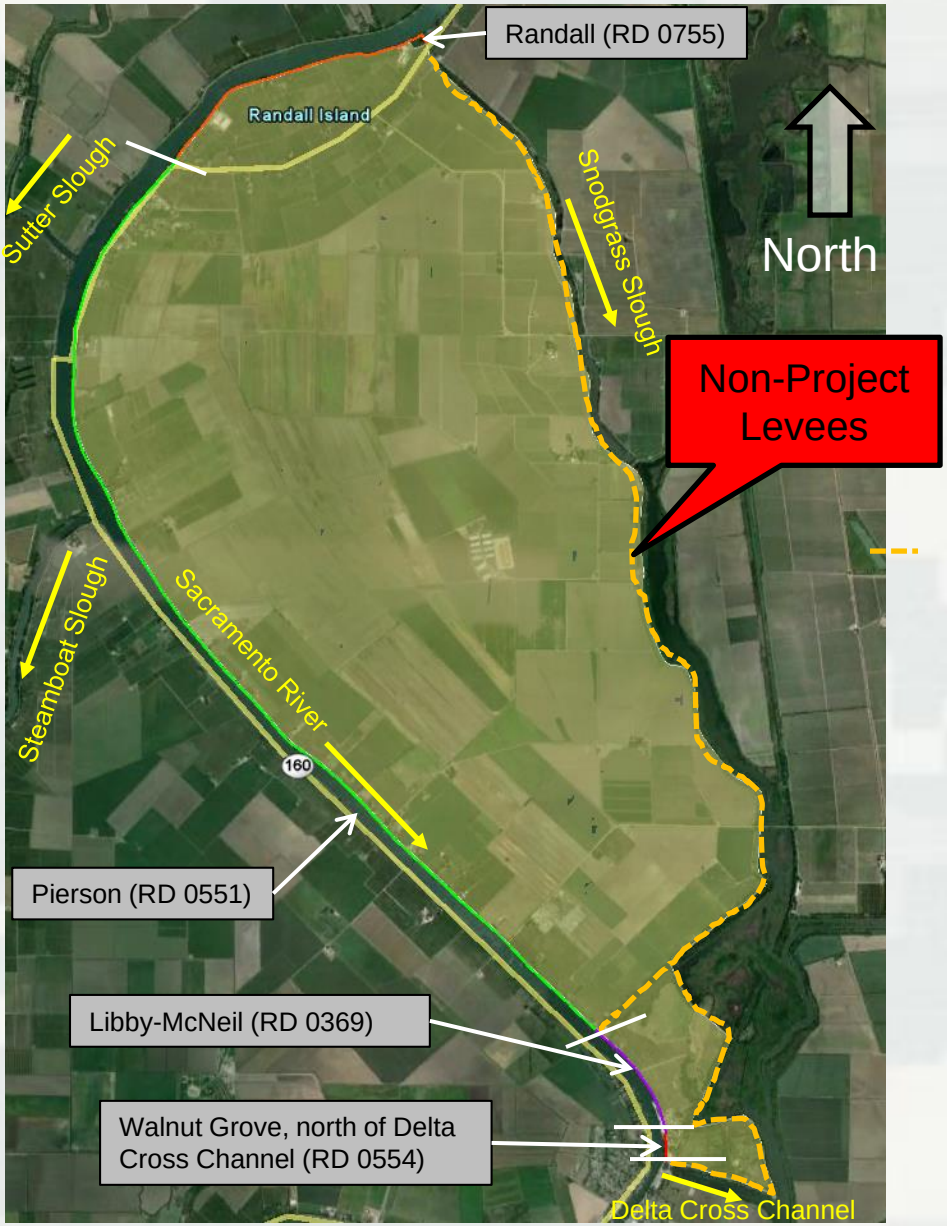
Non-Project Segments

- Levee System: one or more levee segments and other features integral to excluding flood waters from the leveed area.
- Some levee segments tie into <u>manmade</u> Non-Project Segments
  - Roadways, railroads, canals, and other levee embankments
- Non-Project Segments are part of the levee system.



Examples

11/18/2013 10:59


Randall (RD 0755)
Randall Island
Sutter Slough
Snodgrass Slough
North
Non-Project Levees
Steamboat Slough
Sacramento River
160
Pierson (RD 0551)
Libby-McNeil (RD 0369)
Walnut Grove, north of Delta Cross Channel (RD 0554)
Delta Cross Channel

New Concept – “No Verdict”

- May (and) will have inspection and risk information (screening) for part of the levee system
- If we cannot obtain inspection and screening information for the non-project segments, this may result in an overall “No Verdict” LSAC and inspection rating for the system
- Still will have a segment LSAC and inspection rating

BUILDING STRONG®

I-Walls

I-Walls

- HQ USACE initiated a directive to implement the lessons learned from the Interagency Performance Evaluation Task Force (IEPT) on the performance of I-walls.
- The directive entails a three-phased approach to evaluate existing I-walls
  - Phase 1 (Visual Inspection)
  - Phase 2 (Visual Inspection and Analysis)
  - Phase 3 (ETL 1110-2-575 in 2011)
- Purpose of each phase was to help indentify projects at risk of poor performance

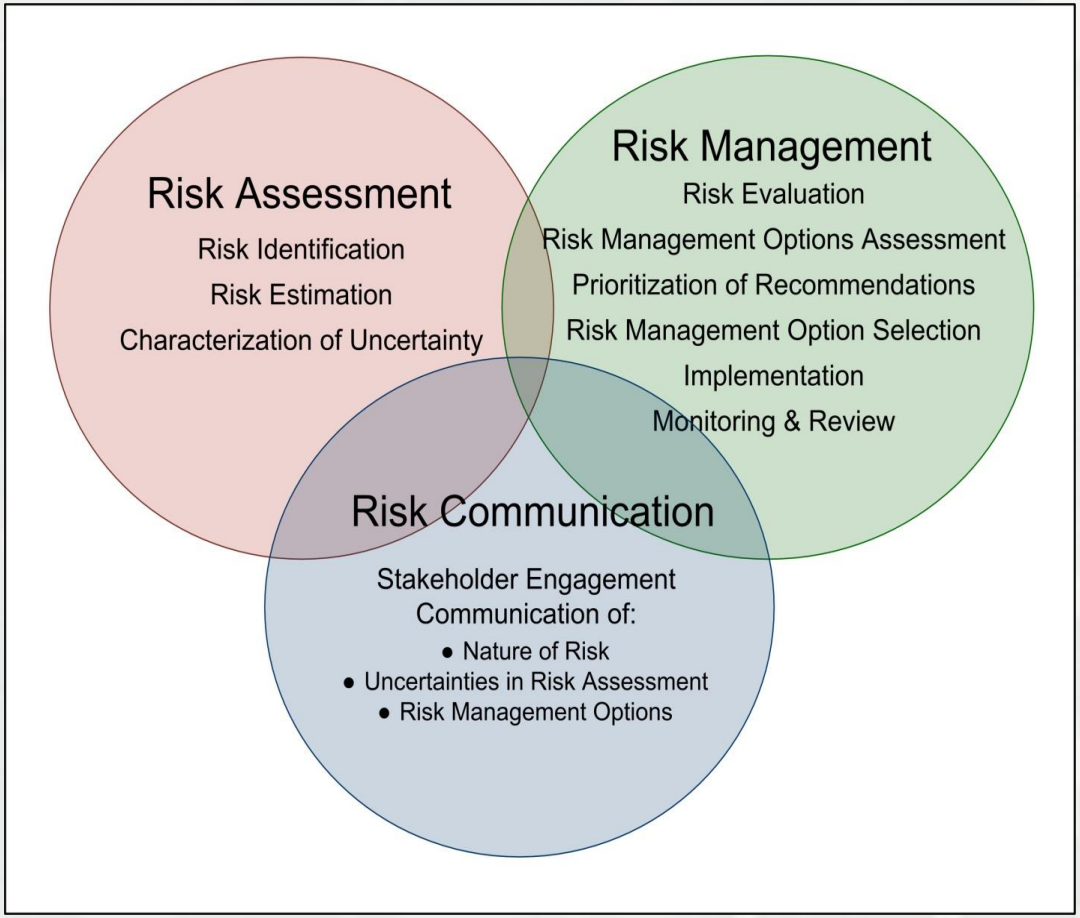
Phase Comparison

Factor	Phase 1	Phase 2	Phase 3
Height (i.e. >6ft)	√		
Encroachments and Vegetation (Factor in PFMs)		√	√
Sheet Pile Embedment (Factor in Rotational PFM)		√	√
Deflection (Factor in Rotational PFM)		√	√
Global Stability (PFM)		√	√
Seepage Analysis (PFM)		√	√
Rotational Analysis (PFM)			√
Overtopping leading to			√

USACE I-wall Review

- (1) I-walls Stats: 322 I-wall Total reaches
  - Phase I fail: 239 (74%): Phase II fail: 133 (41%)
  - Phase 3 completed: 0: Undetermined: 14 (4%)
- Prioritize the Phase 3 I-wall reaches
  - ▶ Based on LSAC
  - ▶ Risk driver for the levee segment/system.
  - ▶ For those with No LSAC
    - Use a combination of likelihood of poor performance and estimate of life loss

Levee Safety Program EC



Principles

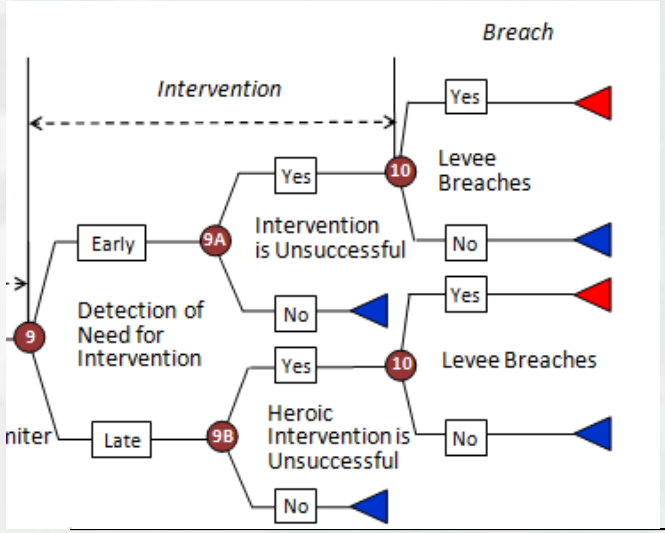
Objectives

Activities

Metrics

Design and Construction of Levees

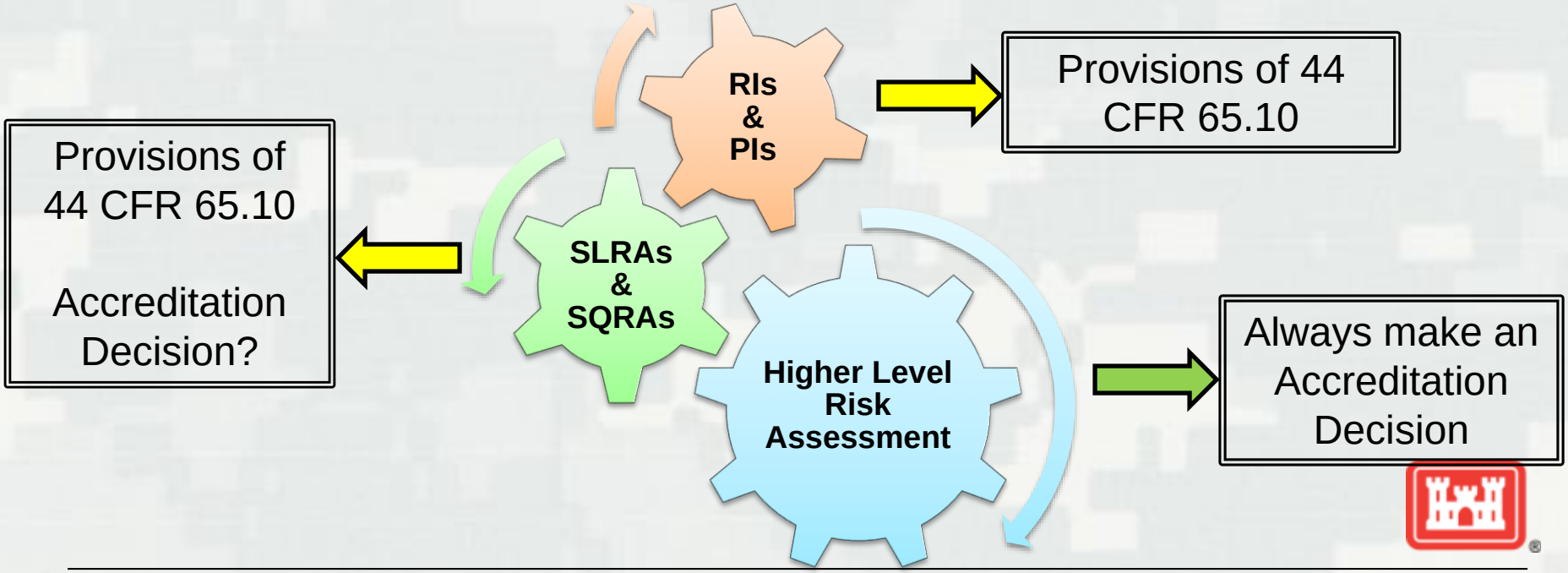
EM 1110-2-1913



- ▶Regional design approaches
- ▶Risk-based potential failure modes to establish design objectives and approaches
- ▶Performance expectations including operations, maintenance, flood-fighting efforts and associated documentation

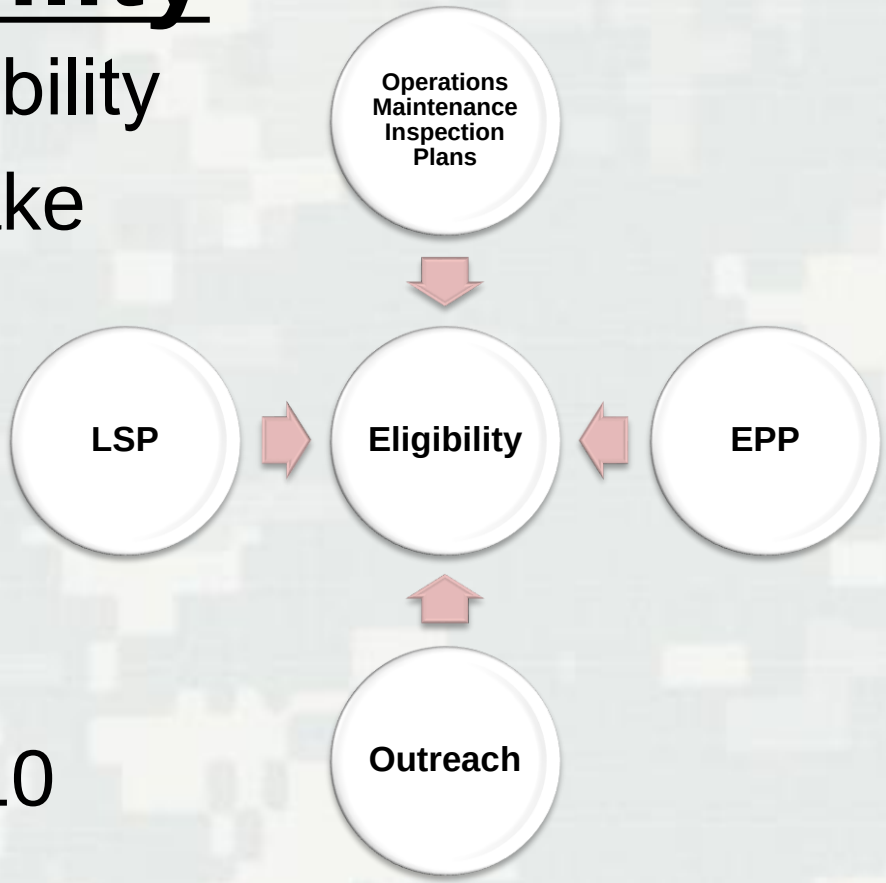
Levee Evaluations for NFIP

- Guidance will address how Levee Safety Activities will be used to evaluate levees for the NFIP – scalable decision making



Rehabilitation Program Eligibility

- Inspection Rating ≠ Eligibility
- EP will be a guide to make eligibility determinations
- Requirements synchronized with Levee Safety EC
- Update to 33 CFR 203.10



National Levee Safety Program

Build Levee Safety Capacity in States/Tribes

- Levee Rehab, Grants, & Technical Assistance
- Levee Review, Guidelines, & Liability Report

Align the Federal Family

- Reports on Federal Alignment and Joint National Programs
- Designing Incentives

Build Risk Awareness and Education

- Education & Awareness Guidance
- Reports to Congress, National Committee on Levee Safety, & Stakeholder Plan

Life Safety is Paramount

Protecting People, Not Infrastructure

Levee Risk Assessments

Greg Werncke, P.E.

Senior Technical Advisor

Risk Management Center - Louisville

February 2016

US Army Corps of Engineers

BUILDING STRONG®

Purpose of Levee Risk Assessments

- GOAL: Reduce life safety and economic risks for those living and working in leveed areas
- Provides a means for comparison and prioritization of levee systems in the national portfolio (LSAC)
- Determine baseline risks associated with a levee system
- Prioritize modifications and repairs to make levees safer
- Certification for the NFIP (future FEMA Task Force requirement)
- Verify and compare with LST (Screening) results
- Used in making risk-informed decisions for planning studies
- Provides an in-depth look at levee system performance and vulnerabilities over a full range of loadings
- Gives Corps' Districts and Sponsors a better understanding of their levee system

Levee Safety Evaluations

- **Periodic Inspections**
  - 1534 of 1618 completed
- **Levee Screening Tool**
  - Nearly 1500 completed – remainder in FY 16
  - Results used to prioritize national portfolio based on screening level risks
- **Levee Risk Assessments**
  - 12 in-progress or completed
  - High risk levees currently in queue based on LST results
  - Metro Louisville and Evansville Levee systems currently in queue

Risk Assessment Process

BUILDING STRONG®

Overview of Process

- Collect and review all available background information.
- Conduct a brief site visit focused on vulnerabilities.
- Review loading conditions and baseline consequences.
- Brainstorm potential failure modes.
- Categorize risk-drivers and non-risk-drivers.
- Discuss, evaluate, and classify risk for risk-drivers.
- Document justification for non-risk-drivers.
- Document major findings and key background information (i.e., “build the case”).

Guiding Principles

- Apply a higher level of rigor than LST to further identify and refine project risks, assess the LSAC, and recommend prioritization of activities.
- Perform the majority of work on-site or at district office.
- Team is mostly comprised of a multi-disciplined risk cadre and district staff supplemented by a RMC Senior Advisor and Technical Advisor.
- Cadre works with Corps Districts and Local Sponsors to conduct the risk assessment.
- Assess risks in a semi-quantitative manner using a risk matrix to portray severity of risks

Basis for LST

Performance Mode	Base Failure Rate
Embankment and Foundation Seepage and Piping	0.001
Embankment Stability	0.0001
Embankment Erosion	0.0001
Closure Systems	0.0005
Flood Wall Stability	0.0001
Floodwall Underseepage and Piping	0.0005

ICW Number	ICW Description	Inspection Rating	Assessment Rating	Adjust	Likelihood Ratio
1	Unwanted Vegetation Growth	U	M	↑	1.10
3	Encroachments	A	A	↓	0.76
7	Settlement	M	U	↑	1.32
9	Cracking	A	A	↓	0.76
10	Animal Control	M	A	↓	0.76
11	Culverts / Discharge Pipes	A	A	↓	0.76
14	Underseepage Relief Wells / Toe Drainage Systems	N/A	N/A		1.00
15	Seepage	A	U	↑	14.80
Conditional Performance Index for Embankment and Foundation Seepage and Piping					6.96E-03

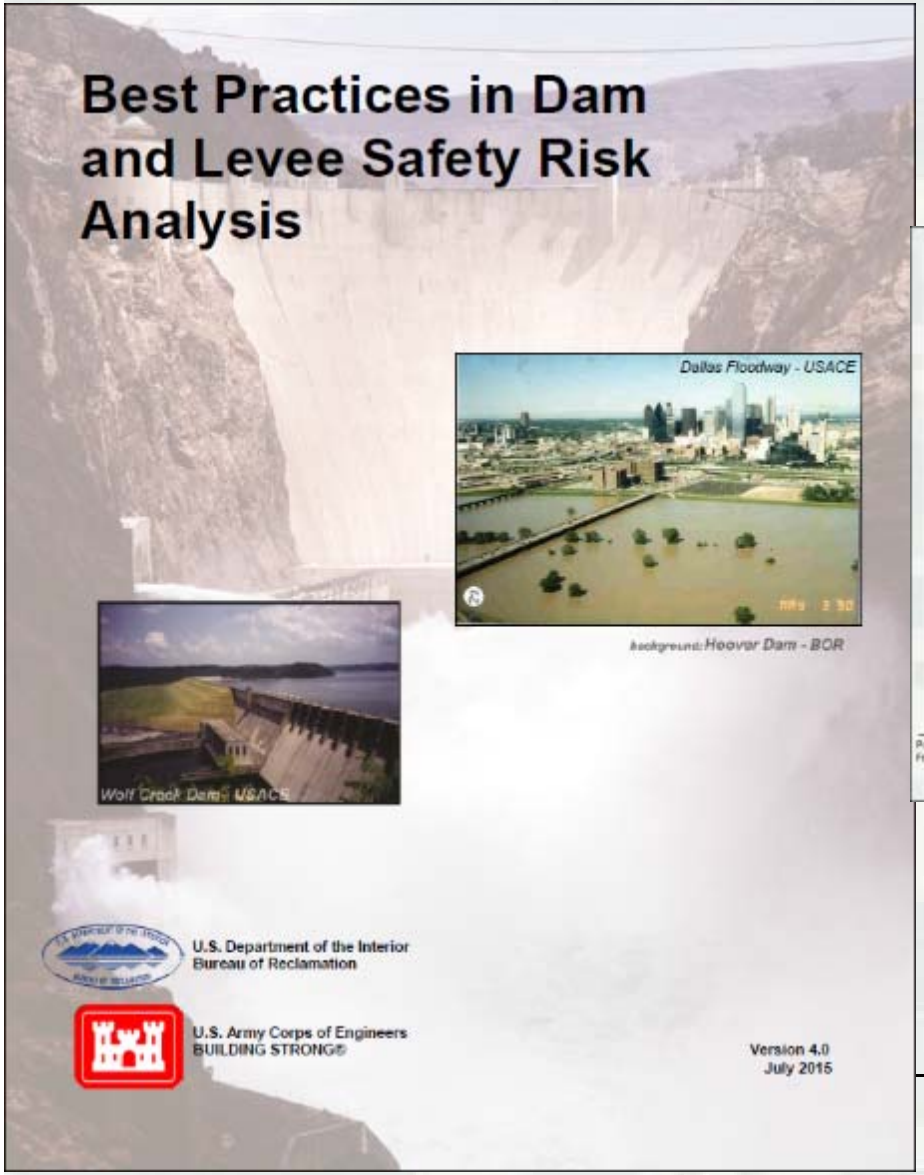
Base Failure Rates
Prior estimate of the probability of breach

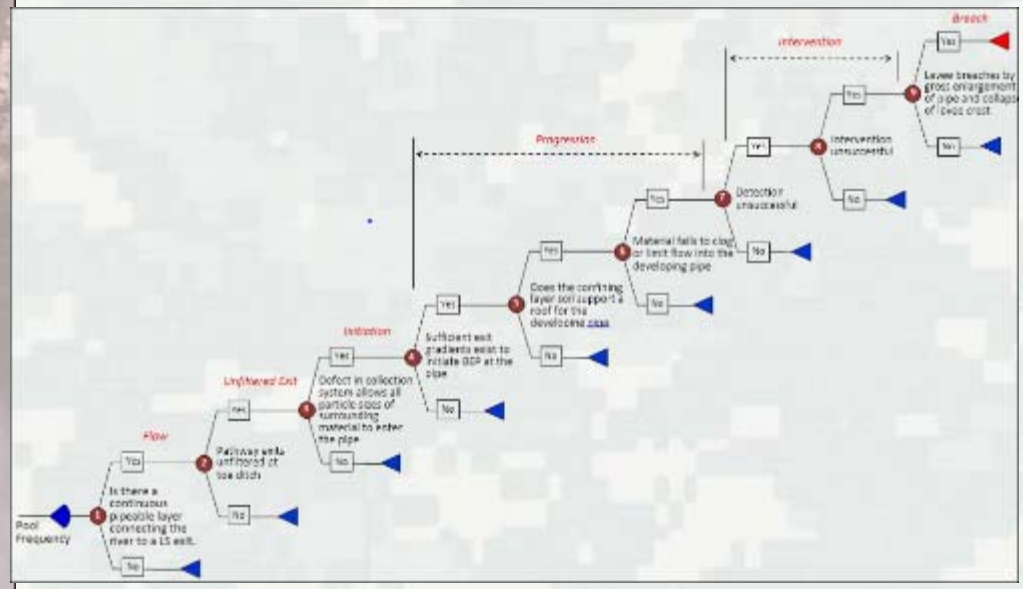
Likelihood Ratios
Adjust base failure rates based on available information
"Bayesian Updating"

Conditional Performance Index, CPI
Combine information to obtain posterior estimate of the probability of breach

BUILDING STRONG®

Basis for Risk Assessment





BUILDING STRONG®

Failure Likelihood

Quantitative Risk Assessment

Average Annual Life Loss (AALL)

Annual Probability of Failure (APF)

ACE

SRP

Incremental Consequences

$$\text{Incremental Risk} = \sum \left[\begin{array}{c}\text{Probability}\\ \text{of the Loading}\end{array}\right]\left[\begin{array}{c}\text{Probability of Failure}\\ \text{Given the Loading}\end{array}\right]\left[\begin{array}{c}\text{Consequences}\\ \text{Given Failure}\end{array}\right]$$

Semi-Quantitative Risk Assessment

Failure Likelihood
f(Loading <u>and</u> System Response)

Consequence Level

BUILDING STRONG®

Levee Risk Assessment Process – What are the steps?

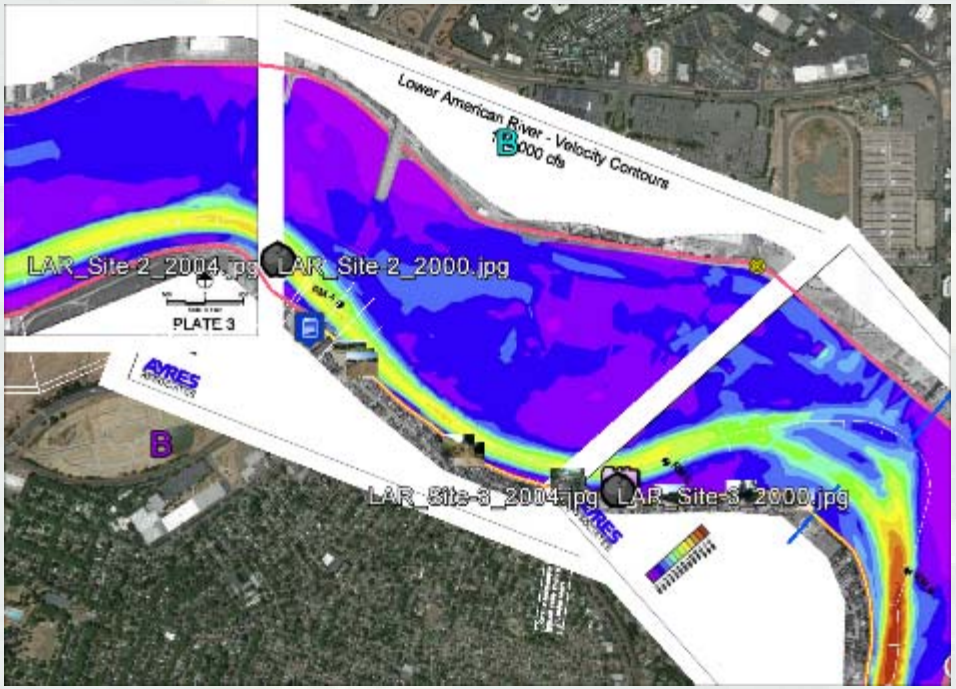
1. Site Recon/Data Collection
2. Reach Breakdown
3. Modeling and Mapping of Inundation Consequence Estimates
4. Potential Failure Modes Analysis
5. Estimate of Warning Times, Breach Formation, Life Safety and Economic Consequences
6. Develop Risk Estimates (Performance and Consequences)
7. Report Writing/Building the Case
8. Reviews

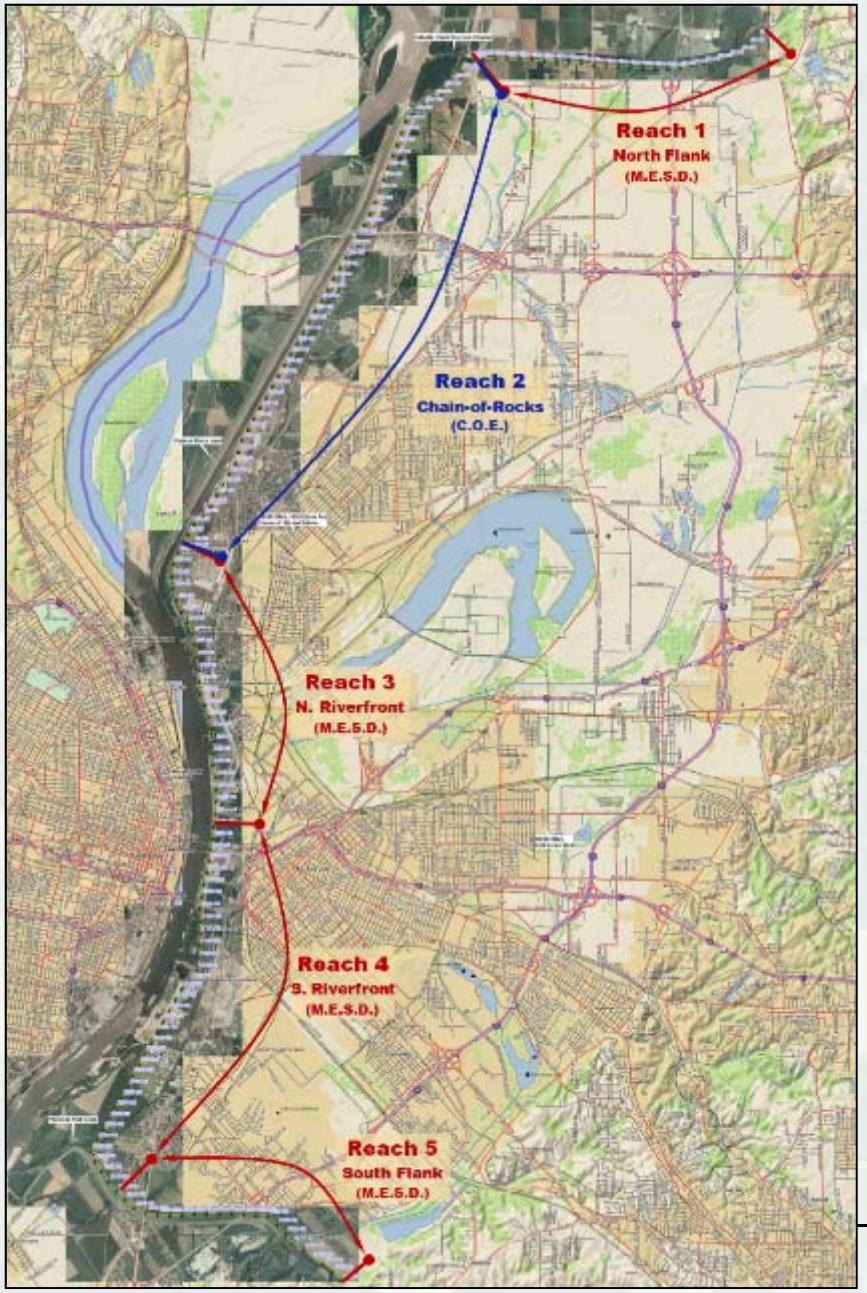
Data and Information

- Work with District and Levee Sponsors to obtain past performance information, construction history, previous studies, design calcs, drawings, inspections, etc.
- Data must become Knowledge (studied)
- Knowledge must be documented and communicated (summarized)
- Judgment for risk assessment relies on <u>expertise</u> and knowledge
- The Levee Safety case relies on well-documented knowledge and carefully evaluated uncertainty (communication)

Data: GIS/Google Earth

- Excellent way to organize and retrieve data spatially
- Use layered approach to access information





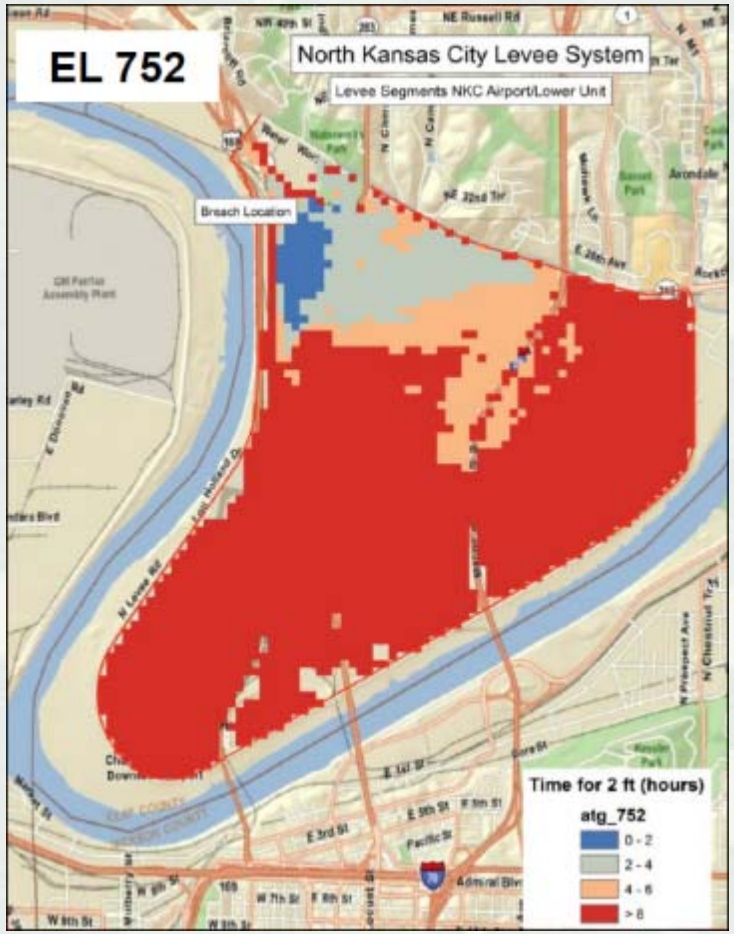
Levee Reaches

The system are broken into reaches for risk assessment based on several factors:

1. **Sponsorship**
2. **Loading**
3. **Levee Foundation Characteristics**
4. **Levee Embankment Characteristics**
5. **Structural Features**
6. **Population at Risk**
7. **Proposed Construction Alternatives**

Inundation Mapping

Breach Models developed for risk cadre to get a preliminary estimate of risks.



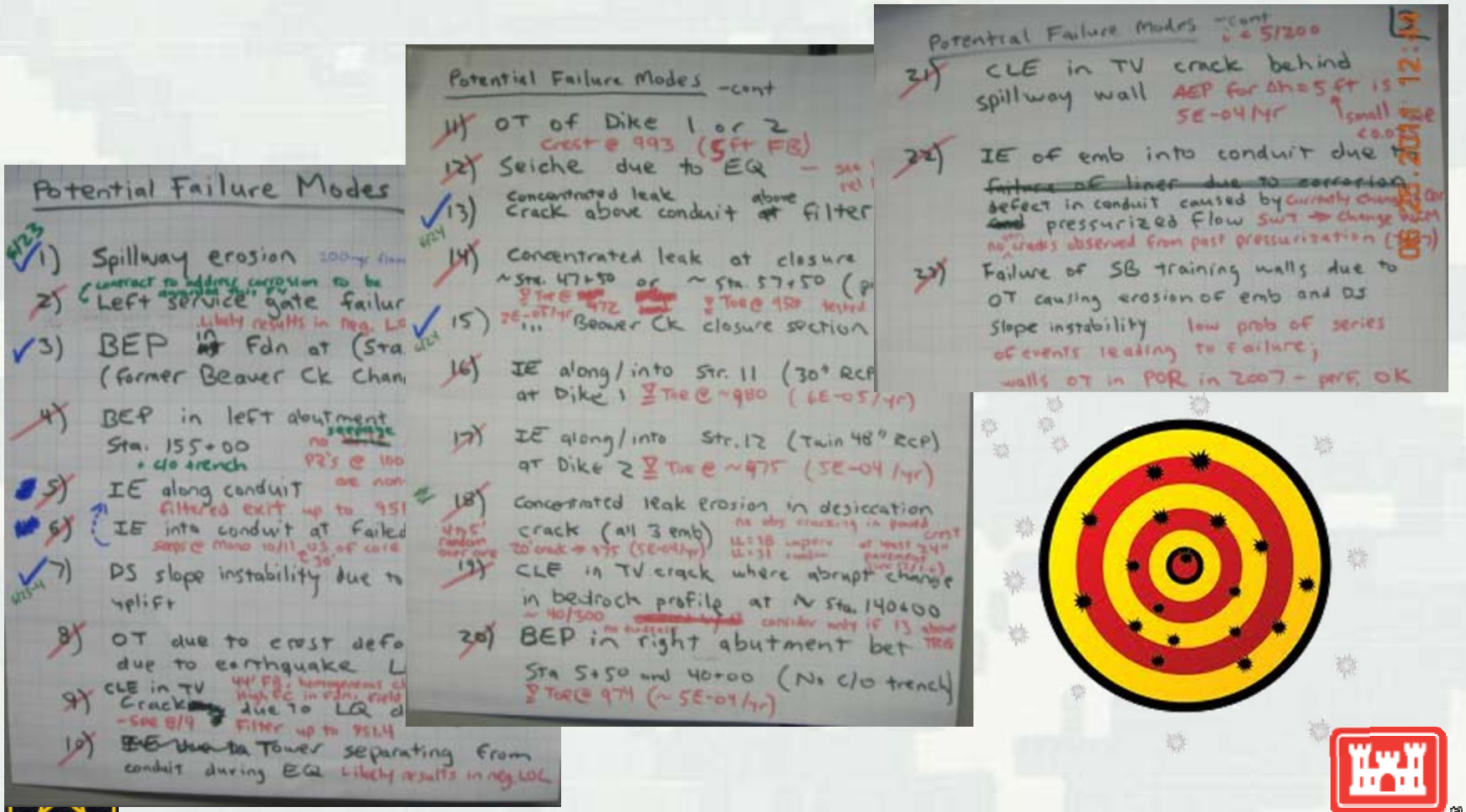
Arrival Times

Depth Grid

Potential Failure Mode Analysis

- Potential Failure Mode (PFM): A unique set of conditions and/or sequence of events that could result in failure.
- Levee failure: “Failure characterized by the sudden, rapid, uncontrolled, and potentially life-threatening release of water.”
- Facilitated process of identifying and fully describing potential failure modes based on a team’s understanding of the project’s vulnerabilities from a review of existing data and conditions.
- Cadre should thoroughly review information beforehand.
- PFMA is the key step in the RA process.

Brainstorming



U.S.ARMY
BUILDING STRONG®

Example PFMA Findings

PFM 1: Overtopping leading to breach

PFM 2: Erosion of Levee Embankment due to overbank erosion (where channel velocity is high) – erosion occurs at the river side bank

PFM 3: Waterside instability of levee caused by erosion – erosion of the channel undermining the levee embankment causing instability of the waterside slope – break out for E, F, G

PFM 4: Through embankment seepage at cutoff wall location due to vegetation, animal burrows, or encroachments

PFM 5: Seepage into pipe or penetration leads to breach (concentrated leak erosion)

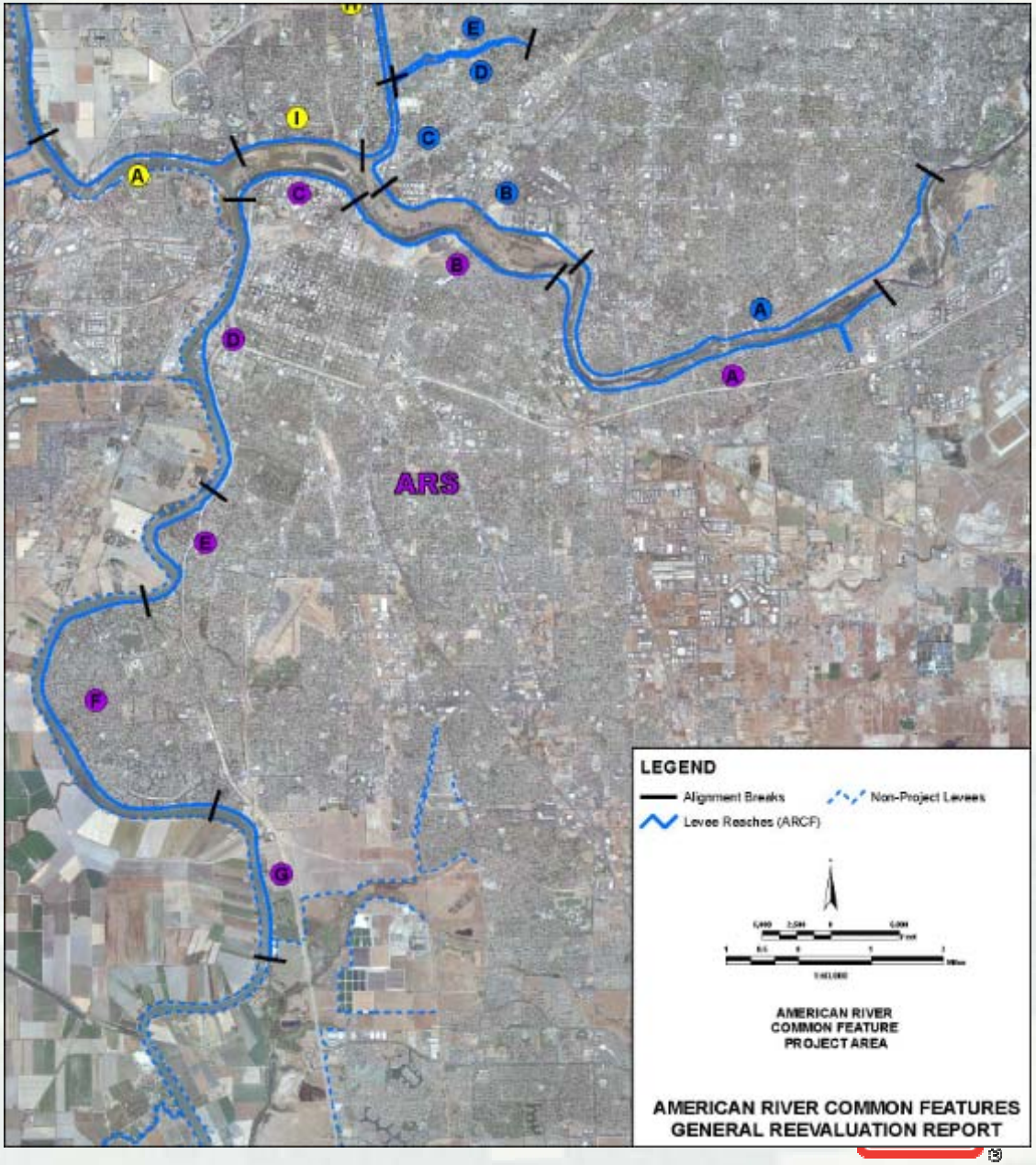
PFMA 6: Seepage along a pipe or penetration leads to breach

PFMA Example

American Rivers Levee System

- American North System consists or 4 levee reaches

- American River South System (Downtown Sacramento) consists of 8 levee reaches



BUILDING STRONG®

American Rivers Levee PFM Classification

- 12 Levee Reaches
- 38 Failure Modes

- 81 Risk Drivers
- 257 Non- Risk Drivers

….which means a lot of data to digest and a lot of PFMs to evaluate.

Data retrieval and correlation at points along the levee is key to accessing the information necessary to evaluate the failure mode.

PFM Risk Drivers

		ARN				ARS							
PFM #	PFM Description	Seg A	Seg B	Seg C	Seg D	Seg A	Seg B	Seg C	Seg D	Seg E	Seg F	Seg G	Seg H
PFM 1	Overtopping Leading to Breach	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PFM 2	Erosion of Levee Due to Overbank Erosion	Y	NRD	NRD	NRD	Y	Y	Y	NA	NA	NA	NA	NA
PFM 3	Waterside Instability of Levee Caused by	Y	NRD	NRD	NRD	Y	Y	Y	Y	Y	Y	Y	Y
PFM 4a	Through Embankment Seepage with Cut-Off Wall Leads to Breach by Sloughing	NRD	NRD	NRD	NA	Y	Y	Y	Y	NRD	NRD	NRD	NA
PFM 4b	Through Embankment Seepage without Cut-Off Wall Leads to Breach by Sloughing	NRD	NA	NRD	NRD	NRD	NRD	NRD	NRD	NA	NA	NA	NA
PFM 5	Seepage Into Pipe or Penetration Leads to Breach (Stoping Mechanism)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PFM 6a	Concentrated Leak Erosion Along Pipe or Penetration with Cut-Off Wall	NRD	NRD	NRD	NA	NRD	NRD	NRD	Y	Y	Y	Y	NA
PFM 6b	Concentrated Leak Erosion Along Pipe or Penetration without Cut-Off Wall	Y	NA	Y	Y	NRD	NRD	NRD	Y	NA	NA	NA	Y
PFM 7	Cut-Off Wall Doesn't Completely Penetrate the Pervious Zones in Foundation Leading to B.E.P.	NRD	NRD	NRD	NA	NRD	NRD	NRD	Y	Y	Y	Y	NA
PFM 8a	Instability of the Landside Slope	NRD	NRD	NRD	Y	Y	Y	Y	NRD	Y	Y	Y	Y
PFM 8b	Instability of the Riverside Slope	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 9	Sand Lenses or Voids in Cut-Off Wall During Construction Leads to B.E.P.	Y	Y	NRD	NA	Y	Y	Y	NRD	NRD	NRD	NRD	NA
PFM 10	Seismic Event Damages Slurry Cut-Off Wall Leading to Through Embankment Seepage	NRD	NRD	NRD	NA	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NA
PFM 11	Seismic Event Damages Slurry Cut-Off Wall Leading to Foundation Seepage	NRD	NRD	NRD	NA	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NA
PFM 12	Liquefaction of the Levee Foundation Causes Crest to Settle and Overtop During Follow-On Flood	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 13	B.E.P. in Foundation Where There is No Cut-Off Wall	Y	NA	Y	Y	NRD	NRD	NRD	NRD	NRD	NRD	NRD	Y
PFM 14	Through Embankment Seepage Where there is No Cut-Off Wall	Y	NA	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 15	Mechanical Failure of Pumps Leading to Interior Flooding	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 16	Electrical Failure of Pumps Leads to Interior Flooding	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 17	Flap Gates/Valves in Pipes Fail to Close During Flood Leading to Interior Flooding	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 18	Surface Erosion Causes Rutting In Slope and Crest Leading to Overtopping	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 19	Cracks in Embankment Leads to Instability of Slope	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 20	Wave Overwash During Flood Event Erodes Crest and Leads to Overtopping	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 21	Separation (Cracking) Between Embankment and Slurry Wall Leads to Slope Instability	NRD	NRD	NRD	NA	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NA
PFM 22	Inability to Open Gates at the Sacramento By-Pass Leads to Overtopping	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 23	Gate Failure or Mis-Operation of Secondary Spillway at Folsom Dam Leads to Overtopping of the Levee	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 24	Earthquake Causes Instability of Levee Slope Leading to Crest Deformation and	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 25	Rapid Drawdown Leads to Slope Instability of Embankment	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD	NRD
PFM 26	"Window" Closures Along Cut-Off Wall Leads to Sloughing of Embankment or B.E.P. through Foundation	Y	Y	Y	NA	Y	Y	Y	NA	NA	NA	NA	NA
PFM 27	Erosion of the Riverside Clay Cap, Which Ties the Cutoff Wall Into the Levee Crest (at Pump Station and Gravity drain STA 3180) and Leads to Sloughing of the Embankment	NA	NRD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PFM 28	Inability to Set Closure Structures Leads to Uncontrolled Release into Leveed Area (Unloaded)	NA	NA	NRD	NA	NA	NA	NA	NA	NA	NA	NRD	NRD
PFM 29	Failure of Stop Logs/Miter Gate Leads to Uncontrolled Release into Leveed Area	NA	NA	NRD	NA	NA	NA	NA	NA	NA	NA	NRD	NRD
PFM 30	Seepage Around Closure Structures Leads to Concentrated Leak Erosion	NA	NA	NRD	NA	NA	NA	NA	NA	NA	NA	NRD	NRD
PFM 31	Seepage Under Closure Structure Sill Leads to B.E.P.	NA	NA	NRD	NA	NA	NA	NA	NA	NA	NA	NRD	NRD
PFM 32	Seepage Under Floodwall Leads to B.E.P	NA	NA	NRD	NRD	NA	NRD	NA	NRD	NA	NA	NRD	NRD
PFM 33	Structural Failure (Internal Stability) of the Floodwall	NA	NA	NRD	NRD	NA	NRD	NA	NRD	NA	NA	NRD	NRD
PFM 34	Overturning/Sliding Failure (External Stability) of Floodwall	NA	NA	NRD	NRD	NA	NRD	NA	NRD	NA	NA	NRD	NRD
PFM 35	Dewatering Well Failure at the I-5 "Boat" Section are Insufficient to Prevent Heave Leading to B.E.P	NA	NA	NA	NA	NA	NA	NA	NRD	NA	NA	NA	NA
PFM 36	BEP at Cutoff Wall Window (No Closure)	NA	NA	NA	NA	NA	NA	NA	NRD	NRD	NRD	Y	NA
PFM 37	Concentrated Leak Erosion Through Fine Grained Embankment Material	NA	NA	NA	NA	NRD	NA	NA	NA	NA	NA	NA	NRD
PFM 38	Internal Erosion Failure, Due to Improper Filter Pack, into the I-5 "Boat" Section Dewatering Wells Leads to Subsidence of the Levee Crest at Overtopping	NA	NA	NA	NA	NA	NA	NA	NRD	NA	NA	NA	NA

BUILDING STRONG®

Failure Mode Categories

- "**Non-Risk Driver**" failure modes: either physically impossible or judged to be a negligible contributor to the project's total risk; excluded from the risk assessment.

- "**Risk Driver**" failure modes: consensus opinion of the PFMA Team to focus on PFMs that are the main risk drivers to the dam.

BUILDING STRONG®

Discussion of Risk-Driver PFMs

- Document pertinent background information.
- Fully describe from initiation to uncontrolled release.
- Document “more likely” and “less likely” factors.
- Assign classification for likelihood of failure and provide rationale and confidence.
- Assign classification for consequences and provide rationale and confidence.
- Discuss possible recommendations for additional monitoring, risk-reduction, data, or analysis.

BUILDING STRONG®

Failure Mode Description

Elements of a potential failure mode description:

- Initiator (e.g., reservoir load, earthquake, deterioration/aging, misoperation/malfunction)
- Failure mechanism, including location and/or path (step-by-step progression)
- Is intervention possible???
- Resulting impact on the structure (e.g., rapidity of failure and breach characteristics)

BUILDING STRONG®

Failure Mode Description Example

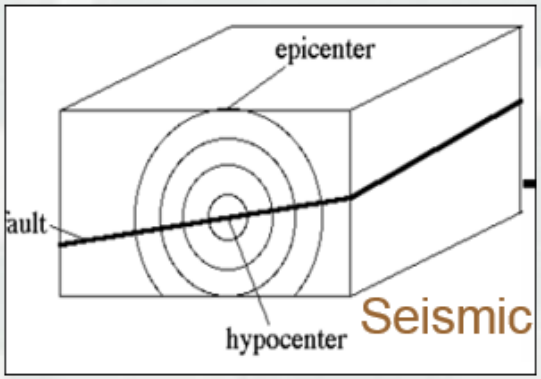
7.5 PFM 11 – Foundation Backward Erosion Piping

As the water surface elevation rises, a continuous (riverside to landside) zone of fine to medium uniform sand beneath the levee embankment is charged. An unfiltered exit exists at the landside toe either due to an exposed sand foundation or through a defect in the clay/silt blanket. Sufficient seepage forces exist to detach soil particles in the fine to medium sand layer at the seepage exit, initiating backward erosion piping. Sufficient global gradients exist to allow progression towards the river. The overlying materials support a continuous and stable roof above the developing pipe. Riverside materials fail to clog or choke off the progressing pipe. Detection and intervention are unsuccessful. Backward erosion piping continues undetected until the pipe reaches the riverside face and connects with the river. Gross enlargement of the pipe occurs leading to instability and collapse of the embankment, lowering the available freeboard below the water surface elevation. Erosion continues to full breach development and uncontrolled release with associated consequences.

More and Less Likely Factors

- Provide pertinent background information on the loadings, conditions, and events that make this potential failure mode “more likely” or “less likely” to occur.

More Likely Factors	Less Likely Factors
• Freeboard deficiency • Wind and wave setup is significant for this project. • There are some low spots on the levee that have settled by about 1 foot. • Design wind/wave height is in the range of 6 to 8 feet. • Highly erodible embankment material with fairly steep side slopes • DS slope does not have sufficient grass protection for erosion control. • Difficult to flood fight for length of embankment • Crest may be softened due to surface water infiltration; previous road repairs indicated material was soft.	• Short duration of loading • This failure mode would require an extreme flood event.

P (Loading)	P (Failure)	P (Consequences)
		

Failure Likelihood Categories

Failure Likelihood Categories

- Remote: APF is more remote than 1/1,000,000. Several events must occur concurrently or in series to cause failure, and most, if not all, have negligible likelihood such that the failure likelihood is negligible.
- Low: APF is between 1/1,000,000 and 1/100,000. The possibility cannot be ruled out, but there is no compelling evidence to suggest it has occurred or that a condition or flaw exists that could lead to initiation.
- Moderate: APF is between 1/100,000 and 1/10,000. Fundamental condition or flaw is known to exist; indirect evidence suggests it is plausible; and key evidence is weighted more heavily toward "less likely" than "more likely."
- High: APF is between 1/10,000 and 1/1,000. Fundamental condition or flaw is known to exist; indirect evidence suggests it is plausible; and key evidence is weighted more heavily toward "more likely" than "less likely."
- Very High: APF is between 1/1,000 and 1/100. There is direct evidence or substantial indirect evidence to suggest it has initiated or is likely to occur in near future.
- Failure Progression Likely: APF is between 1/100 and 1/10. Performance suggests failure is initiating and likely to progress in near future.
- Failure Progression Observed: APF is more frequent (greater) than 1/10. Performance confirms progression towards failure is occurring.

Failure Likelihood Assignment

- Discuss critical load level for potential failure mode.
- If the ACE of the flood for the critical load level is virtually certain to cause failure (SRP ≈ 1), then APF ≈ ACE.
- Start the discussions with the ACE of the loading, and then reduce that probability based on the likelihood of the step-by-step progression leading to failure (i.e., subsequent nodes have probabilities less than one).

BUILDING STRONG®

Confidence

- High: The team is confident in the order of magnitude for the assigned category and, it is unlikely that additional information would change the estimate.
- Low: The team is not confident in the order of magnitude for the assigned category, and it is entirely possible that additional information would change the estimate.
- Moderate: The team is relatively confident in the order of magnitude for the assigned category, but key additional information might possibly change the estimate.

Consequence Estimation

- Discuss breach location, warning time, flood arrival time, inundation depth, and evacuation rates for each risk-driving potential failure mode.
- Discuss life loss and economic loss estimates from inundation data

Consequence Categories

Consequence Level	Incremental Consequences	
	Life Loss	Economic Loss [3]
Very Low	(See Note 1)	N/A
Low	(See Note 2)	Less than $10M
Moderate	1 to 10	$10M to $100M
High	10 to 100	$100M to $1B
Very High	100 to 1,000	$1B to $10B
Extremely High	More than 1,000	More than $10B

Life Loss Estimation

- Breach Parameters
- Population at Risk
- Warning Time
- Mobilization and Evacuation Effectiveness

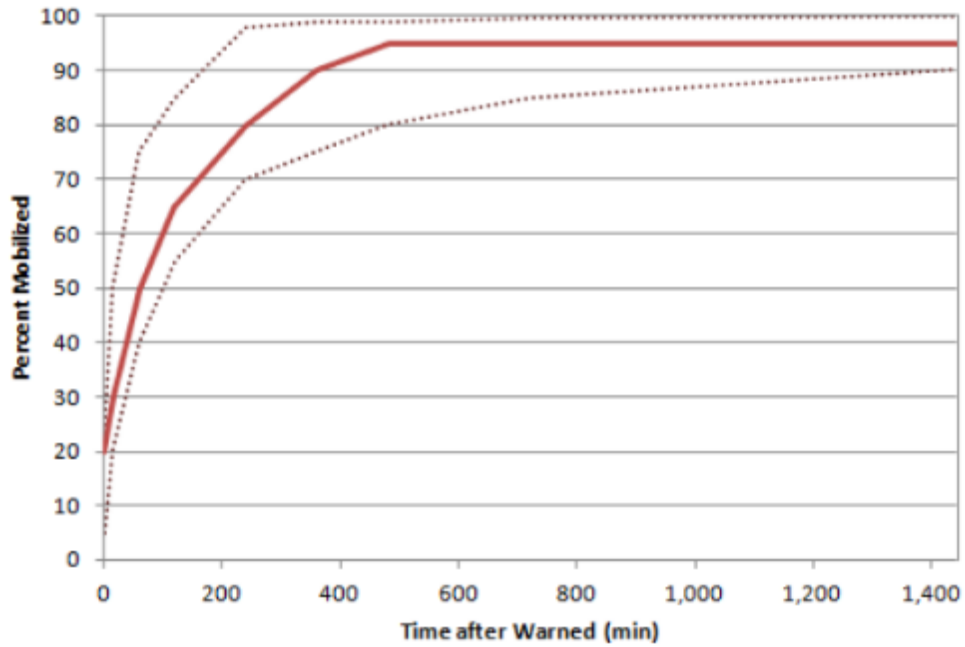
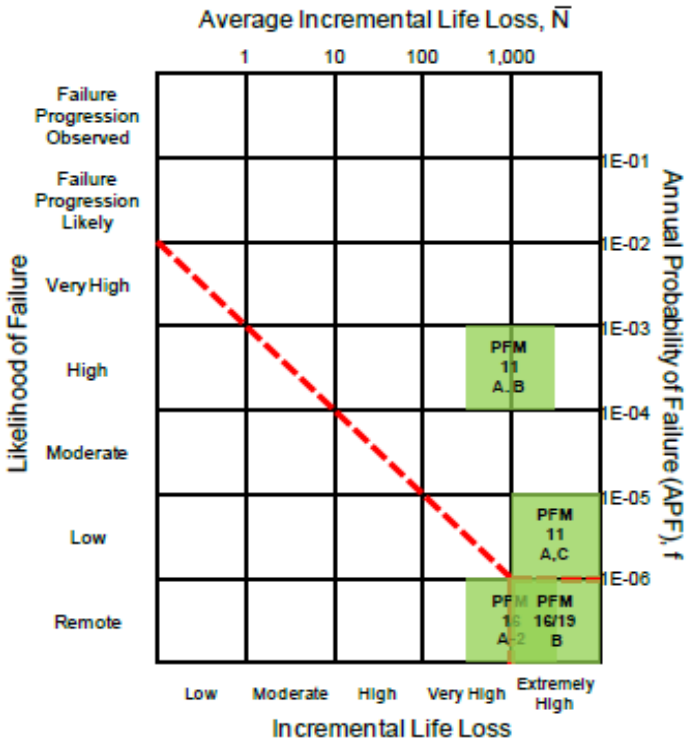
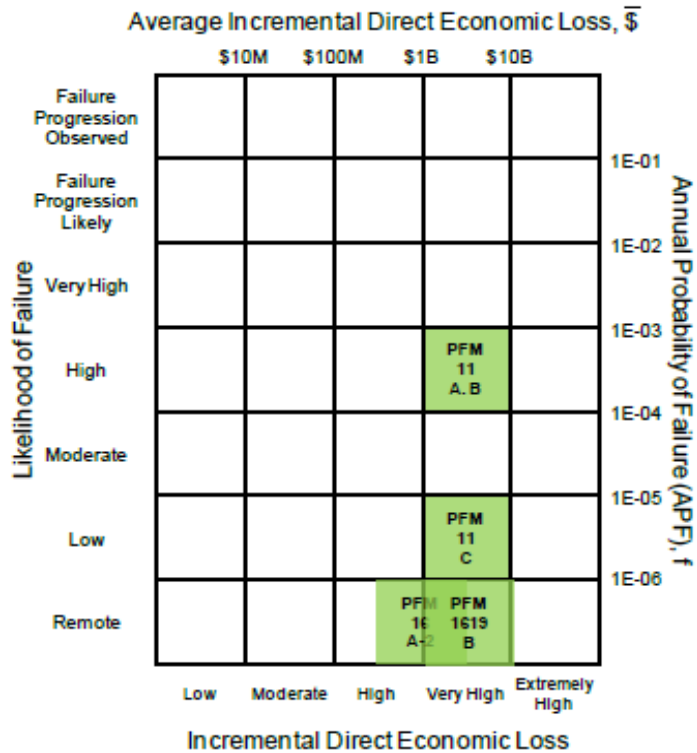


Figure 6-9 Flood Stage/Overtopping Mobilization Rates

Table 6-5 Medium-Level Emergency Evacuation Triggers

Sacramento County Evacuation Plan *Evacuation Triggers* *Medium-Level Emergency*		
Threat / Hazard	Trigger Details	Reference/ Source
Natural Hazards		
Flood - Levee overtopping; extensive sheet flooding	• Sacramento River "I" Street monitor – up to 27 feet. • American River "H" Street monitor – up to 41 feet. • Morrison Creek at Mack Rd – 13 feet and rising. • Natomas East Main Drain at Arcade Creek – 33 feet and rising. • Arcade Creek at East Main Drain Canal – 33 feet and rising. • Cosumnes River climbing and reaching top of levees. • National Weather Service flood and flash flood warnings.	Sacramento County DWR's River Warning Stage





Unit/ Reach	PFM	Failure Likelihood	Confidence	Incremental Loss of Life	Confidence	Economic Loss	Confidence
Unit 1 A, B	PFM 11 – Backwards erosion piping in foundation	High	Low	Very High to Extremely High	Moderate	Very High	Moderate to High
Unit 1 C	PFM 11 – Backwards erosion piping in foundation Sta. 1231+00 to 1349+50	Low	Low to Moderate	Extremely High	Moderate to High	Very High	Moderate to High
Unit 1 B	PFM 16 – Concentrated leak erosion along pipe penetrations (Riverside Pump Plant)	Remote	Moderate	Extremely High	Moderate to High	Very High	Moderate to High
Unit 1 A-2	PFM 16 – Concentrated leak erosion along pipe penetrations (Pump Plant 1A)	Remote	Moderate	Very High to Extremely High	Low to Moderate	Very High	Low to Moderate
Unit 1 B	PFM 19 –Riverside Erosion due to Scour near Structures	Remote	Moderate to High	Extremely High	Moderate to High	Very High	Moderate to High

Unit 1 – Incremental Life Safety and Direct Economic Loss Matrix

Risk Results

- Use Incremental Risk Matrices to inform LSAC
- Use results to make recommendations and prioritize Levee Safety, O&M, additional studies, emergency response/planning needs, etc.
- Evaluate Interim Risk Reduction Measures (IRRM)
- Results can inform NFIP certification
- Verify and compare with LST (Screening) results
- Used in making risk-informed decisions for planning studies
- Provides an in-depth look at levee system performance and vulnerabilities over a full range of loadings
- Gives Corps' Districts and Sponsors a better understanding of their levee system

Levee RA Conclusions

- Levee Risk Assessments help reduce life safety and economic risks for those living and working in leveed areas
- Provides a means for comparison and prioritization of levee systems in the national portfolio (LSAC)
- Identifies and prioritizes modifications and repairs to make levees safer
- Can be used to inform certification for the NFIP (future FEMA Task Force)
- Helps verify / validate LST (Screening) results
- RA provide information that can be used to make risk-informed decisions for planning studies
- Provides an in-depth look at levee system performance and vulnerabilities over a full range of loadings
- Gives Corps' Districts and Sponsors a better understanding of their levee system

Questions???

Understanding the Preservation of Large Diameter Pipe

With

Dan Warren

Confined Space Coating Success
Over 40 Years Experience
Boston State House, 1971
40 Years of Doing Things Right The First Time

Safety First!

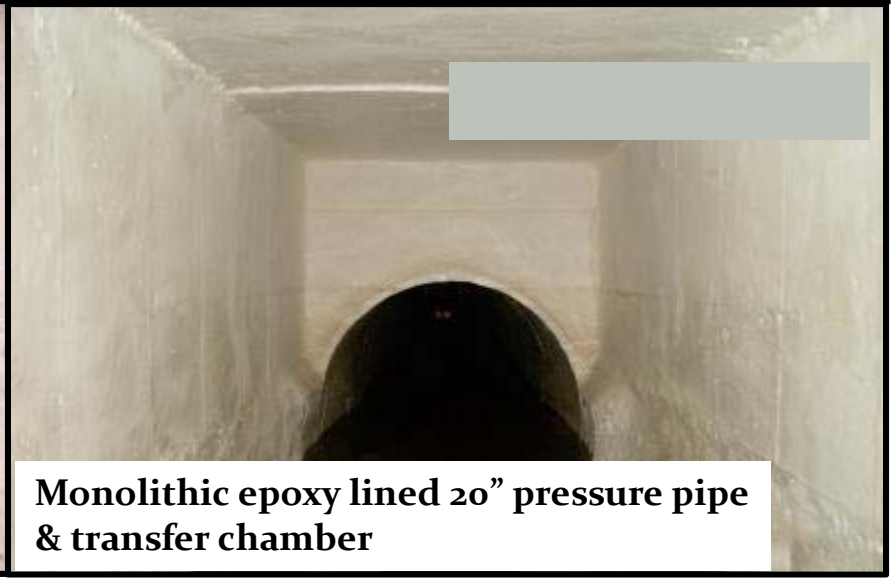
- Confined Space Hazards
- Work together as a team
- Communication
- Assess, Analyze, Act
- Job Safety Analysis
- Personal Protective Equipment
- Anyone can stop the job at anytime

Force Mains Come in Many Shapes and Sizes

Exposed Force Main ~Philadelphia

Above Ground Force Main ~ Puerto Rico

Aeration Pipe 40 psi (In Progress) ~Clear Water, Florida



Monolithic epoxy lined 20" pressure pipe & transfer chamber

Large Gravity Pipe Vs Large Pressure Pipe

- Gravity Pipe
  - More forgiving
  - Variety of products will prove to be effective
- Pressure Pipe
  - Difficult to fix
  - Few products are effective
  - Only CIPP bonded to host pipe surface will perform
  - Spray or spincast cast Epoxy method has best track record due to damp surface adhesion advantage
  - Tenacious bond:
    - Steel (1,500 psi)
    - Concrete (1,000 psi)

Surface Preparation Methods

*__Priority one__ when dealing with large diameter pressure pipe

Testing and Inspection of Large Diameter Pipe

- Adhesion:
  - Verify using portable adhesion tester ASTM D4541
  - Tested at specified intervals along the pipe
  - Metal pipe should be at least 1,000 psi
- Pinholes & Voids:
  - Detect using a holiday spark testing device
  - Voltage provided by liner manufacturer
  - Defects need to be marked and repaired before returning the pipe to service
- Pre and Post Video Inspection:
  - Verify existing conditions and post liner installation conditions

Victor Valley Adhesion

Superior Bond Guarantees Success

- Prevents *migration of* material traveling between the host pipe and repair liner

- Handles water hammering, cavitation, and abrasion better

- Superior bond products have a 20+ year track record of success in high flow environments

Poor Product Selection

OSHA NEWS RELEASE ON TUNNEL FIRE

Chemical Fire Kills Five Workers Spraying Flammable Materials Inside Water Tunnel

Within an hour crews were still at the site late Wednesday afternoon, after the bodies of the five workers had been removed. After the fire started about 2 P.M. Tuesday, Clear Creek Fire Authority Chief Kelly Babeon learned that the men were using MEK. He read warnings that indicated the chemical solvent was flammable.

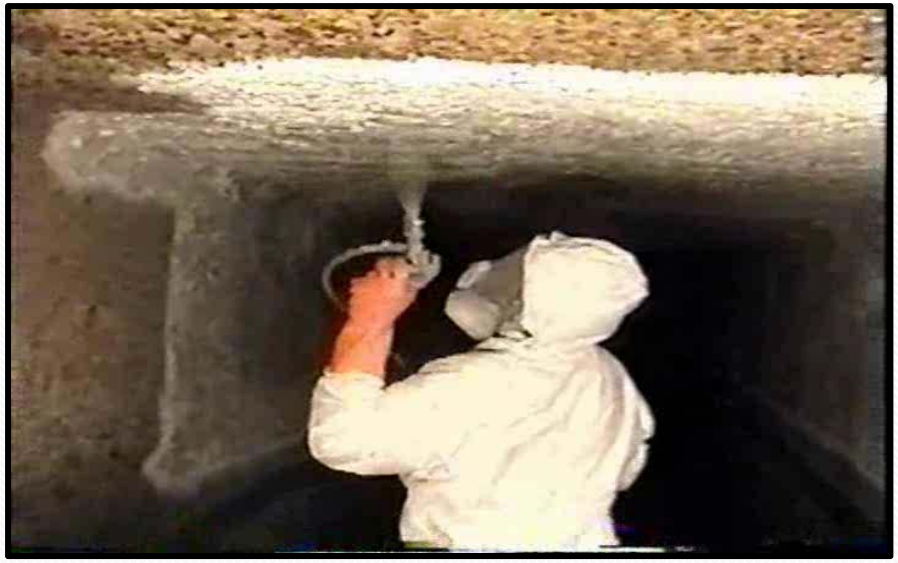
Babeon had only five men, and none had experience fighting fires in a confined space, which requires special training, he said.

“It shouldn’t have happened. There were things that could have been done to prevent it,” Carolynn Dejaynes said. “He was my whole life. I’m only 31, and I’m a widow.”

Product Characteristics

Spray or Spincast

- 100% solids = safe for workers & environment
- Great bond to damp surfaces
- Deep penetration into host pipe
  - Improves structural integrity and tensile strength
- Conforms to all shapes and configurations with no joints or breaks
- Wet out bag liner materials such as:
  - S Glass, E Glass, carbon fiber, needled felt, etc.
- Cures at ambient temperature
- Can be engineered to ASTM 1261
- NSF 61 approved

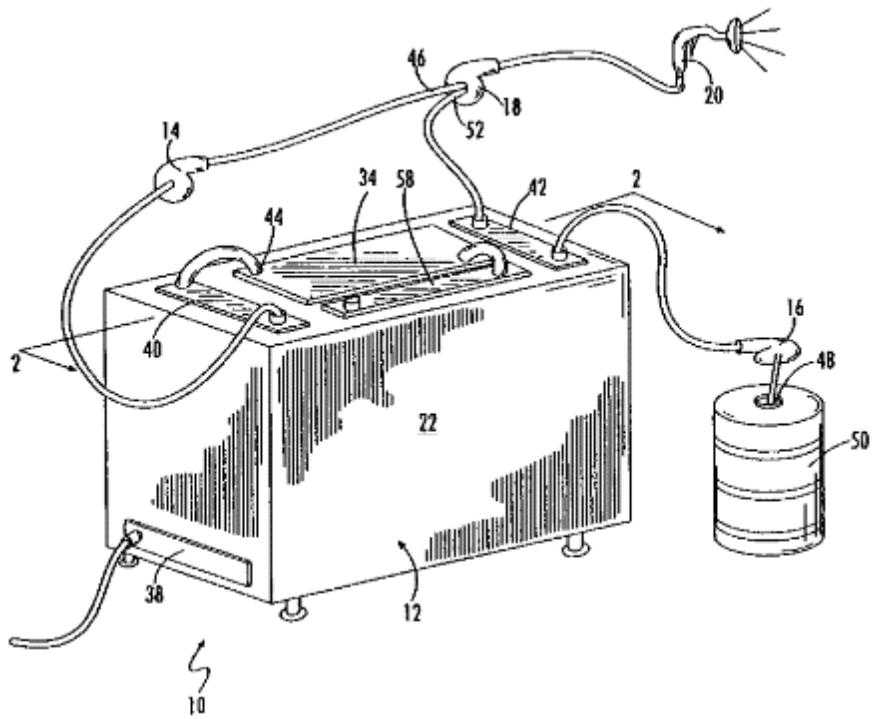


Warren Environmental

100% Solids Epoxy

WARREN ENVIRONMENTAL

- 100% Solids In Wet and Dry Form
- ZERO VOC Product
- Little / No odor
- No chance of spontaneous combustion of airborne solvents during application or cure
- Flame/Smoke &Toxic Gas Tested
  - ASTM E-84-97a BSS7239-88
- Single Coat-High Build Application (500 mills)
- Tenacious Bond to Almost Every Substrate
- Superior Adhesion on Damp Surfaces
- Smooth finish Increases process flow
- No Shrinkage (Reduces risk of delamination)
- Non-Conductive
- >75 Year Design Life
- Seamless Lining
- Excellent Thermal Expansion with Steel and Concrete
- Time savings = Less Down Time 4 hour return to submerged service
- NSF Approved Products Available
- Over 250,000 World Wide Applications
- 30 Year Track Record



Warren Environmental Heat Exchange System for Conditioning Epoxy for Spray

Method and System for Preheating Epoxy Coatings for Spray Application

Patent No.: US 7,926,739 B2

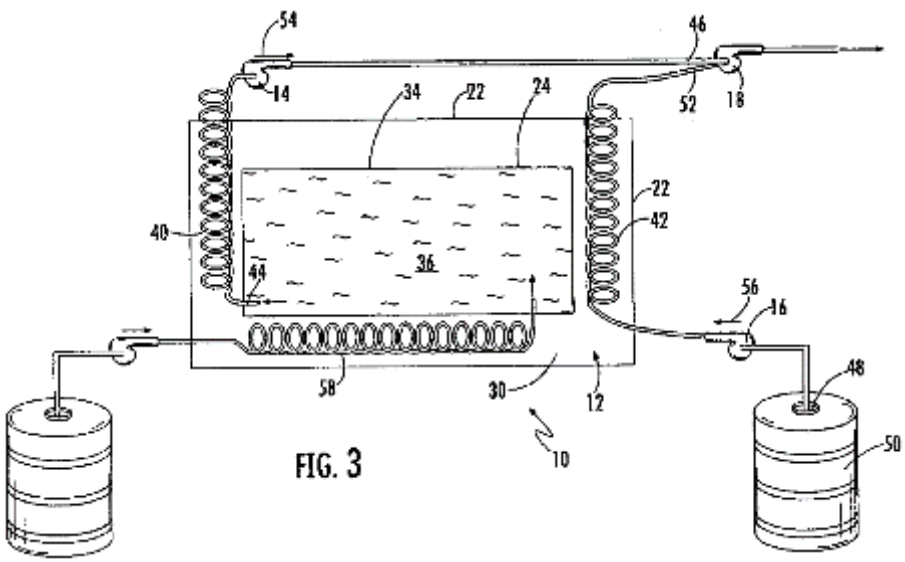


FIG. 3

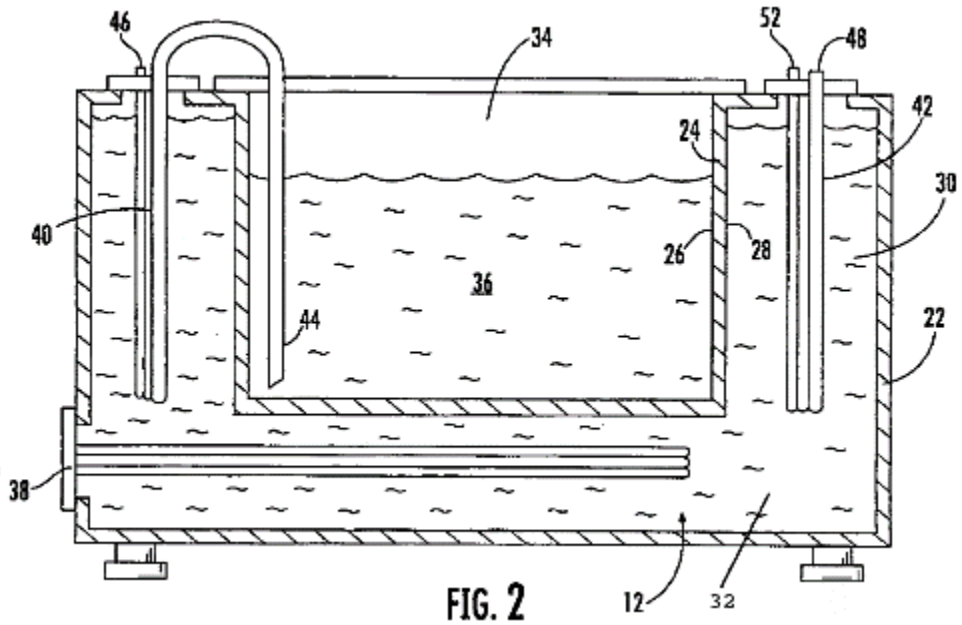


FIG. 2

- ***ENR.com***, "Robinson reservoir receives cutting edge upgrade" ~2013

- ***Construction Equipment Guide***, "Husband, Wife team find solutions to unusual problems in tough spaces" ~ 2012

- ***NACE International***, "Zero *(VOC)* Structural Epoxy Rehabilitation of Steel and Concrete Tanks, Pipes and Structures" ~ 2003

- ***American Water Works Association (AWWA),*** "Creating a feasible five-year inspection and capital improvement plan for a 26-mile aqueduct in Northern Utah" ~2012

- ***NASSCO Times***, "Meet a member" ~ 2013

- ***Journal of Protective Coatings and Linings*** *(JPCL)*, "Corrosion-Laden Clarifier Restored" ~2002

- ***JPCL***, "Innovative Practice, New Equipment Development to spray 100% solids epoxy coating" ~ 1993

Average Test Results On Peak Load In FT/LBS

6" Test Beam Conditions	Number Tested	Repair Condition	Initial Damage Level	Average Peak Load/Length (lb/linear foot)	Average deflection (in.) at Peak Load
Control	6	Dry	None	5095	0.0175
DHD	4	Dry	Heavy	6401	0.0223
DMD	4	Dry	Moderate	6493	0.0157
WHD	4	Wet	Heavy	5908	0.0222
WMD	4	Wet	Moderate	6286	0.0164

Dr. Kent Harries

Large Diameter Pipe 1 of 2

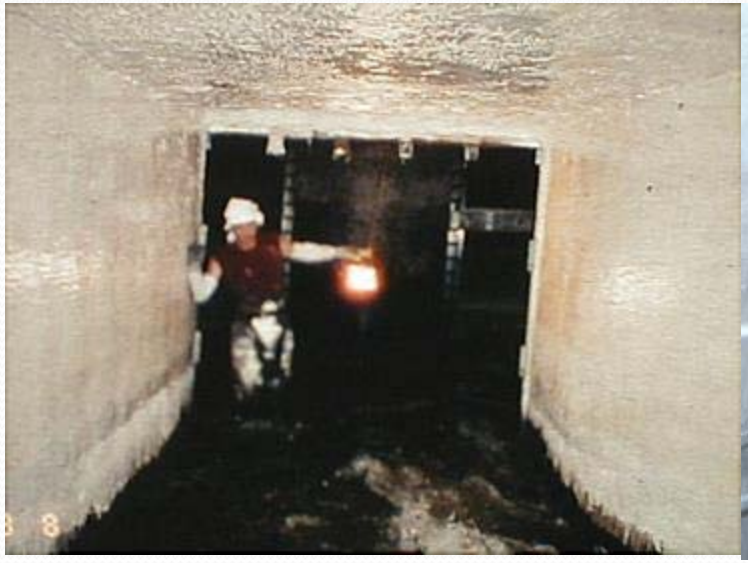
Before

After

New York Aqueduct

16 year Inspection New York Aqueduct, May 12th 2010 on Warren Epoxy. Inspection performed by Parsons Brinckerhoff, New York Office. The Single Coat, 40 mil application was in PERFECT CONDITION after 16 years of constant flow.

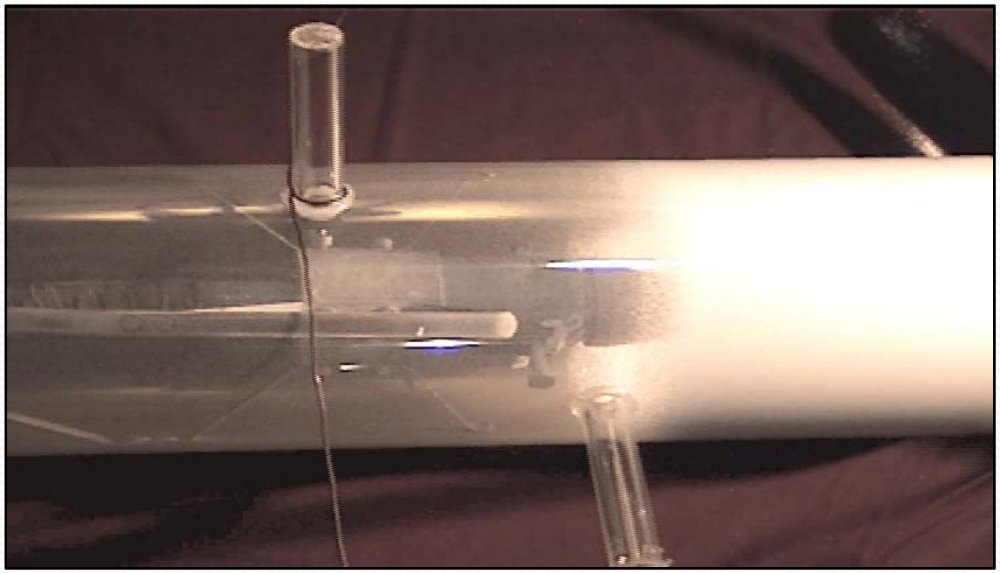
Miami Dade Pump Station and Large Diameter Pipe Rehab



Application Techniques: Spin Cast

ADVANTAGES

- Seamless Lining
- 4" – 54" pipe
- Does not block laterals
- Quick and easy
- Up to 500' runs



Infusion Lining Process

- Prepare the surface of the pipe
- Spincast or hand spray area to be rehabbed with thin layer of epoxy
- Roll out and Inflate internal airbladder with structural sleeve around it
- Hold under air pressure until epoxy has adhered to the substrate as well as impregnated the liner
- Pull out reusable internal bladder
- Spincast or hand spray final layer of epoxy to desired millage

QA/QC Check

Infusion

Post Infusion

Finished Product

Warren Environmental, Inc.
solvent free, corrosion resistant 100% solids structural epoxy systems
NASTT's 2014 No-Dig Show
The Magic of Trenchless
NASTT's
Innovative
Product
Award
Winner

Tasmania Flume

Sonora Pass

<u>NEVER</u> use materials in confined space work with any hidden flammable solvents or dilatant

<u>ONLY</u> use products that are 100% solid in their wet form

Specified products for safety must be tested to Wind tunnel burn ASTM E-84-97a Toxic smoke test BSS7239-88

Questions?

Interim Policy for Determining Eligibility Status under PL 84-99

Matthew Whelan, P.E.

Geotechnical Engineer

Louisville District

9 February 2016

Purpose

- Overview of the Interim Policy
- Individual Rated Items that affect eligibility
- What to do if you lose eligibility
- Interim? Re-write of ER 500-1-1
- Conclusion

Overview of Interim Policy

- USACE in process of revising policy
- Outlines specific requirements for eligibility
- Overall System Rating does NOT determine eligibility in the Rehabilitation Program

Individual Rated Items that affect Eligibility

- <u>Levee Embankments</u>
  - ▶ Encroachments
  - ▶ Closure Structures
  - ▶ Slope Stability
  - ▶ Erosion/Bank Caving
  - ▶ Animal Control
  - ▶ Culverts/Discharge Pipes
  - ▶ Relief Wells/Toe Drains

Individual Rated Items that affect Eligibility

- <u>Floodwalls</u>
  - Encroachments
  - Closure Structures
  - Tilting, Sliding, or Settlement
  - Foundations of Concrete Structures
  - Relief Wells/Toe Drains

Individual Rated Items that affect Eligibility

- <u>Pump Stations</u>
  - Intake and Discharge Pipelines
  - Sluice/Slide Gates
  - Flap Gates/Flap Valves/Pinch Valves
- <u>Interior Drainage System</u>
  - Culverts/Discharge Pipes
  - Sluice/Slide Gates
  - Flap Gates/Flap Valves/Pinch Valves

What Individually Rated Items did you not see?

What to do if you loose Eligibility in the Rehabilitation Program

- Fix it as soon as possible and notify District for follow up inspection.
- System Wide Improvement Framework (SWIF). Process consists of a Letter of Intent that leads to development of a long term SWIF.

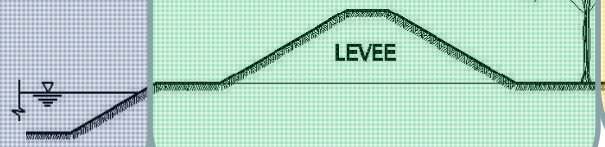
Interim?

- Currently a re-write occurring for ER 500-1-1 which outlines eligibility requirements.
- USACE placing more emphasis on risk and fixing worst issues first.
  - Emergency preparedness
  - Risk communication to community
  - Prioritizing maintenance activities; O&M Plan

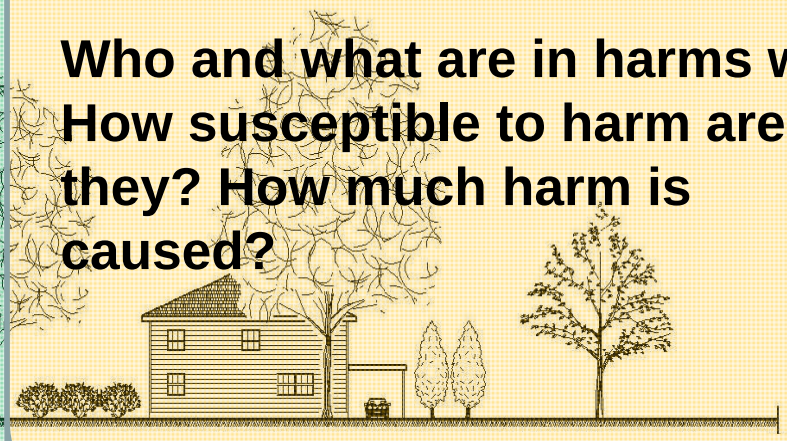
Future Eligibility Focus

What are the hazards and how likely are they to occur?

How will the infrastructure perform in the face of these hazards?



Who and what are in harms way? How susceptible to harm are they? How much harm is caused?



- Focuses on full range of flood risk factors
- Encourages taking appropriate "actions" to manage flood risk
- Shifts efforts and attention from the structure to risk management

BUILDING STRONG®

Conclusion

- Be aware of individual items that can lead to ineligibility (interim).
- Revised policy will be coming on board in future.