

USACE Levee Screening Tool

Understanding the Classification

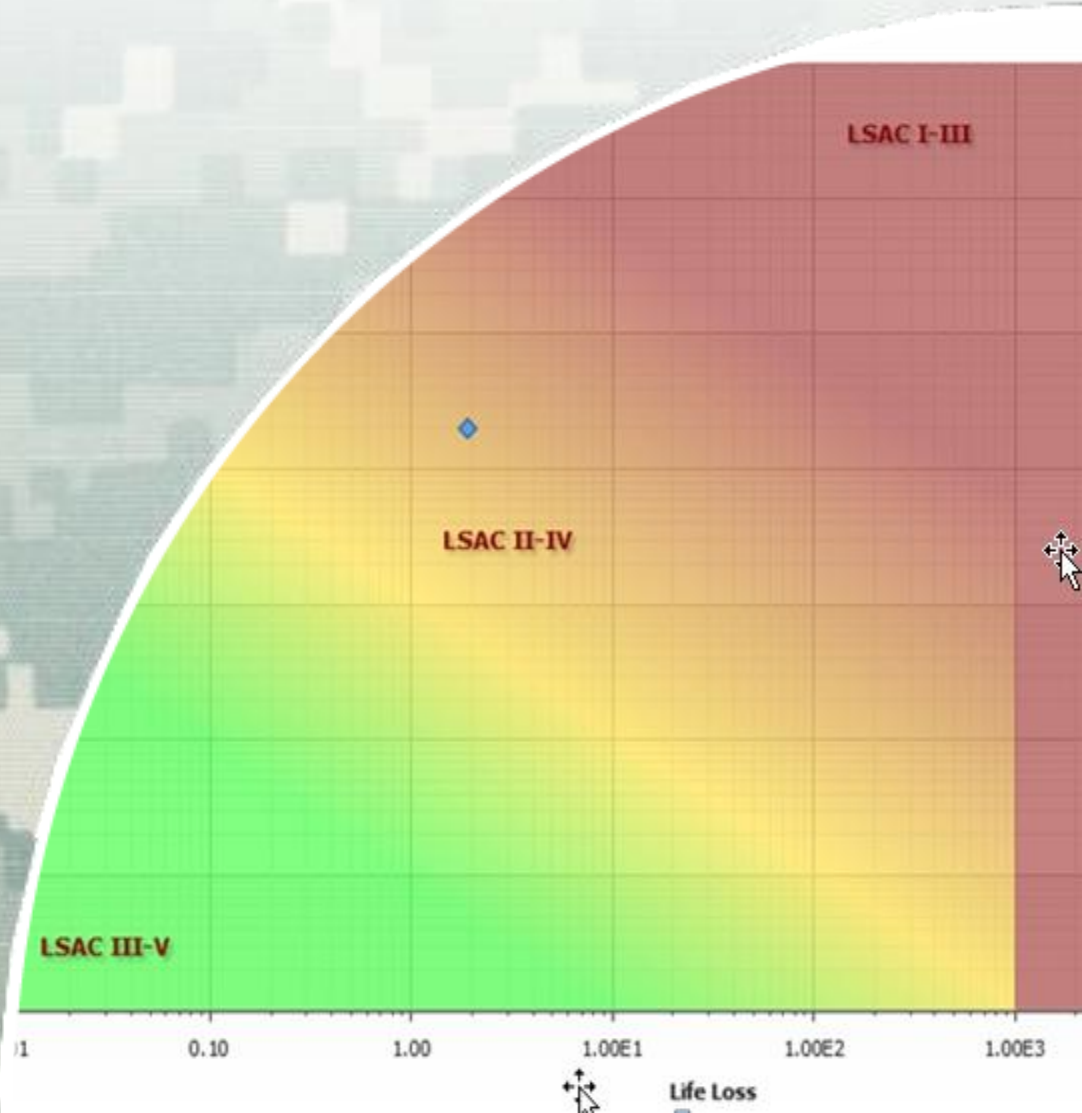
Richard J. Varuso, Ph.D., P.E.

Deputy Chief, Geotechnical Branch

Levee Safety Program Manager

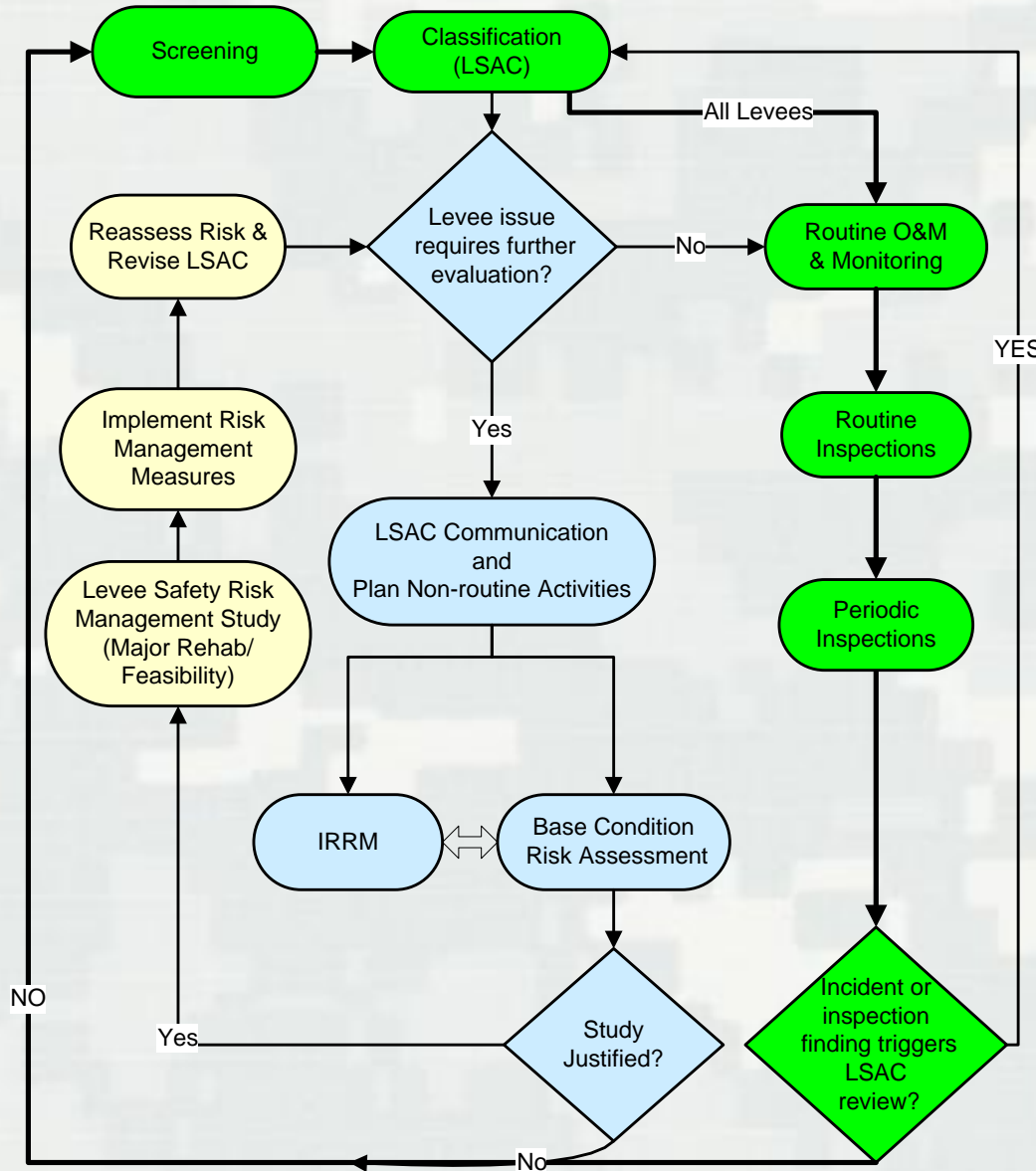
USACE - New Orleans District

17 Nov 2011

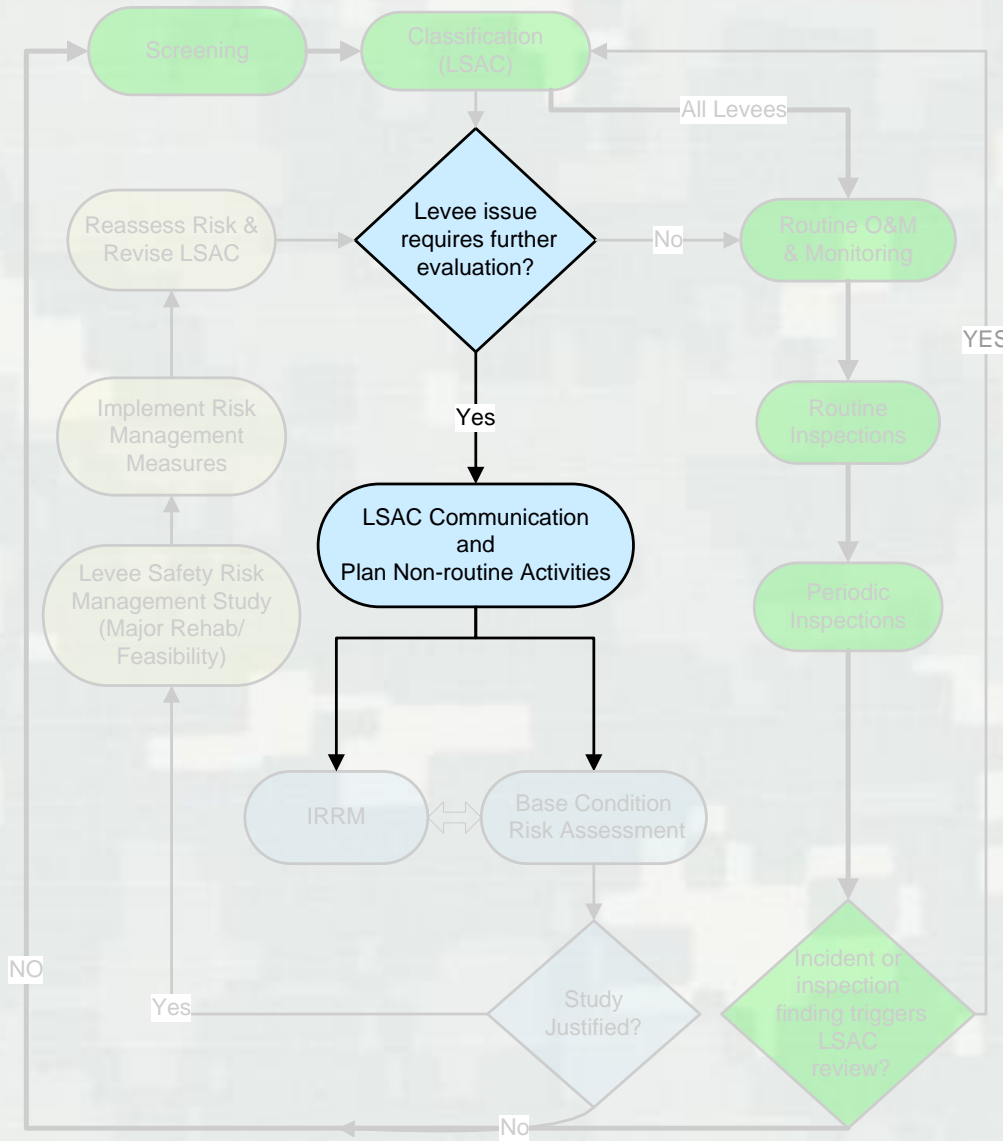


Note: Risk communication and stakeholder participation is continuous throughout the Levee Safety portfolio risk management process. See supporting tables and text for details.

Levee Safety Risk Management Portfolio Process



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Levee Safety Risk Management Portfolio Process

LSAC Communication

Plan Non-Routine Activities



Levee Safety Portfolio Management Process

- **Levee Screening Tool Outcomes (2011):**
 - ▶ Assist in the assignment of the Levee Safety Action Classification (LSAC) for each levee system.
 - ▶ Identify relative risk and initially characterize the portfolio.
 - ▶ Guide setting priorities for national levee safety activities.
 - ▶ Identify performance concerns as well as potential consequences of a levee failure.
 - ▶ Communicate levee deficiencies, qualitative conditional performance, and consequences.
 - ▶ Identify issues to assist in the development of Interim Risk Reduction Measures.
 - ▶ Future Screenings will involve Local Sponsor participation
 - ▶ All LSAC results will be communicated to the Local Sponsors



Table 1 - USACE Levee Safety Action Classification Table* 29 July 09

Levee Safety Action Class	Characteristics of this class	Actions for levees in this class <i>1) USACE Operated, and Maintained Levee Systems; 2) Other Levee Systems in USACE Program; 3) All Levee Systems.</i>
I Urgent and Compelling (Unsafe)	LIKELY FAILURE BREACH AT LESS THAN TOP OF LEVEE Combination of life, economic, or environmental consequences with probability of failure breach is extremely high. OR EXTREMELY HIGH OVERTOPPING RISK Combination of life, economic, or environmental consequences with probability of overtopping with or without subsequent breach, is extremely high.	1) Take urgent action to prevent/mitigate failure breach and implement interim risk reduction measures. Support portfolio priorities for remediation. 2) Advise owner to take urgent action to develop and implement interim risk reduction and remediation plans. Support portfolio priorities for remediation. 3) Immediately perform levee system inspection; expedite confirmation of classification; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: immediately verify that warning, evacuation, and emergency action plans are viable; purchase of flood insurance; vigilant levee monitoring program.
II Urgent (Unsafe or Potentially Unsafe)	FAILURE BREACH LIKELY AT TOP OF LEVEE Combination of life, economic, or environmental consequences with the probability of failure breach is very high. OR VERY HIGH OVERTOPPING RISK Combination of life, economic, or environmental consequences with probability of overtopping with or without subsequent breach, is very high.	1) Take immediate action to implement interim risk reduction measures; develop and implement remediation plan. Support portfolio priorities for remediation. 2) Advise owner to take immediate action to develop and implement interim risk reduction and remediation plans. Support portfolio priorities for remediation. 3) Perform levee system interim inspection; verify classification; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: verify that warning, evacuation and emergency action plan are viable; purchase of flood insurance; vigilant levee monitoring program.
III High Priority (Potentially Unsafe)	FAILURE BREACH MAY OCCUR AT TOP OF LEVEE Combination of life, economic, or environmental consequences with probability of failure breach is moderate to high. OR HIGH OVERTOPPING RISK Combination of life, economic, or environmental consequences with probability of overtopping with or without subsequent breach, is high.	1) Implement interim risk reduction measures; schedule development of remediation plan and support portfolio priorities. 2) Advise owner on development of interim risk reduction and remediation plans. Support portfolio priorities. 3) Verify inspection is current; confirm classification; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: verify that warning, evacuation, and emergency action plan are viable; purchase of flood insurance; develop and execute levee monitoring program.
IV Priority (Marginally Safe)	FAILURE BREACH AT TOP OF LEVEE NOT LIKELY Combination of life, economic, or environmental consequences with probability of failure breach is low. The levee system does not meet all essential USACE guidelines. OR MODERATE TO LOW OVERTOPPING RISK Combination of life, economic, or environmental consequences with probability of overtopping with or without subsequent breach, is low to moderate.	1) Support portfolio priorities. 2) Support portfolio priorities. 3) Continue routine levee safety activities, stress improved floodplain management to include: verify that warning, evacuation, and emergency action plan are viable; purchase of flood insurance; develop and execute levee monitoring program.
V Normal (Adequately Safe)	HIGHLY LIKELY NOT TO BREACH AT TOP OF LEVEE Levee system is considered adequately safe, meeting all essential USACE guidelines. There is a very low probability of failure breach. AND RESIDUAL RISK IS CONSIDERED TOLERABLE.	All Levee Systems Continue routine levee safety activities, normal inspections, stress improved floodplain management to include: operation and maintenance; annually ensure that warning, evacuation, and emergency action plan are functionally tested; purchase of flood insurance; maintain levee monitoring program.

General Description

Urgency & Risk Description

Actions Required Description

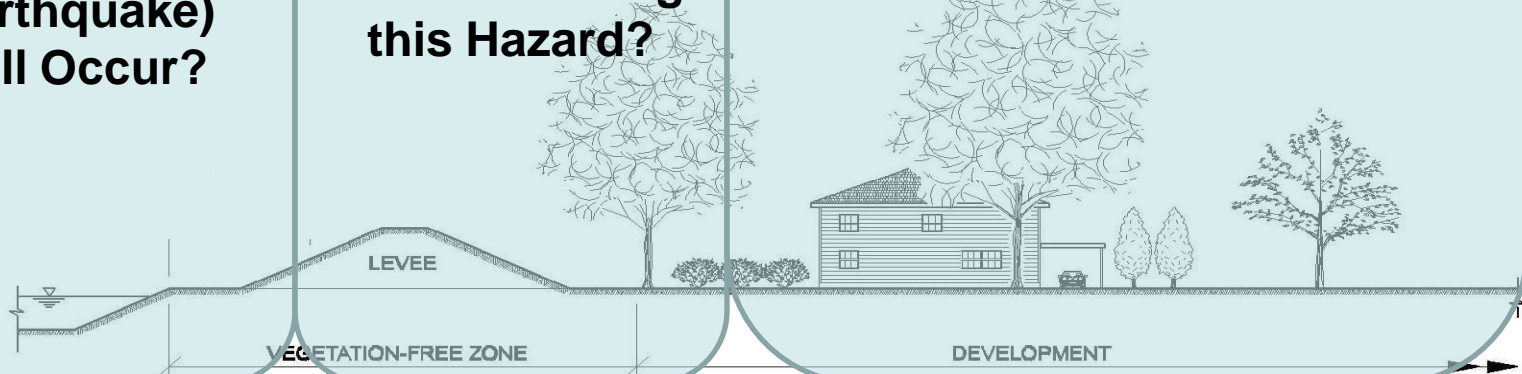
Levee System :

Loss of life is of paramount concern. Economic and environmental losses are also important.

How Likely is it that the Hazard (flood, earthquake) will Occur?

How Will the Infrastructure Perform during this Hazard?

What are the Consequences for Non-Performance?



The Corps Risk Framework



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Levee Safety Action Classification

Primary Factors

- **Existing Elevations and Hydraulic History**
 - ▶ Annual Chance Exceedance (ACE) of Levee Crown Elevation
 - ▶ ACE for design water level
 - ▶ How many times has the levee experienced these elevations

- **Performance**
 - ▶ Historic
 - ▶ Future (expected)
 - ▶ Various Performance Modes (Seepage, Stability, Foundation, etc)

- **Consequences**
 - ▶ Population
 - ▶ Infrastructure



Simplified Risk Informed Framework

Simplified risk informed model

Risk = Probability of Load x Probability of Failure x Consequences

$$\text{Risk Index} = \left[ACE_T - ACE_{OT} \right] \cdot PI \cdot C + \left[ACE_{OT} \right] \cdot C$$

The diagram illustrates the components of the Risk Index equation. Arrows point from the following text to the corresponding terms in the equation:

- Probability of flood loading points to ACE_T
- Conditional Performance prior to overtopping points to ACE_{OT}
- Consequences due to breach points to $ACE_T - ACE_{OT}$
- Probability of overtopping points to PI
- Consequences due to overtopping points to ACE_{OT}
- Consequences due to overtopping points to the final C term in the second part of the equation.



Simplified Risk Informed Framework

$$\text{Risk Index} = \left[ACE_T - ACE_{OT} \right] \cdot PI \cdot C + \left[ACE_{OT} \cdot C' \right]$$

Risk Index for
Breach Prior to
Overtopping

Risk Index for
Overtopping



Performance

Inspection Assessment Ratings

- Each performance indicator within a performance mode is rated as
 - ▶ A: Acceptable
 - ▶ M: Minimally Acceptable
 - ▶ U: Unacceptable
- Assessment ratings are made in the context of whether the observation for a specific item is an indication of distress and/or failure initiation considering actual and/or expected performance under flood loading



Performance Mode	Inspection Item Category	Inspection Item Number	Inspection Item Name
Embankment and Foundation Seepage and Piping	Levees	1	Unwanted Vegetation Growth
	Levees	3	Encroachments
	Levees	7	Settlement
	Levees	9	Cracking
	Levees	10	Animal Control
	Levees	11	Culverts / Discharge Pipes
	Levees	14	Under Seepage Relief Wells / Toe Drainage Systems
	Levees	15	Seepage
Embankment Stability	Levees	3	Encroachments
	Levees	5	Slope Stability
	Levees	7	Settlement
	Levees	8	Depressions / Rutting
	Levees	9	Cracking
	Levees	14	Underseepage Relief Wells / Toe Drainage Systems
Embankment Erosion	Levees	2	Sod Cover
	Levees	6	Erosion / Bank Caving
	Levees	12	Riprap Revetments and Bank Protection
	Levees	13	Revetments other than Riprap
Closure Systems	Levees / Floodwalls	4 / 3	Closure Systems
Floodwall Stability	Floodwalls	1	Unwanted Vegetation Growth
	Floodwalls	2	Encroachments
	Floodwalls	4	Concrete Surfaces
	Floodwalls	5	Tilting, Sliding, or Settlement of Concrete Structures
	Floodwalls	6	Foundation of Concrete Structures
	Floodwalls	8	Underseepage Relief Wells / Toe Drainage Systems
Floodwall Underseepage and Piping	Floodwalls	1	Unwanted Vegetation Growth
	Floodwalls	2	Encroachments
	Floodwalls	8	Underseepage Relief Wells / Toe Drainage Systems
	Floodwalls	9	Seepage
	n / a	n / a	Culverts / Discharge Pipes



Simplified Risk Informed Framework

Simplified risk informed model

Risk = Probability of Load x Probability of Failure x
Consequences

$$\text{Risk Index} = \left[ACE_T - ACE_{OT} \right] \cdot PI \cdot C + ACE_{OT} \cdot C$$

Consequences
due to breach

Consequences due
to overtopping

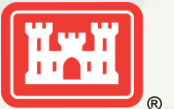
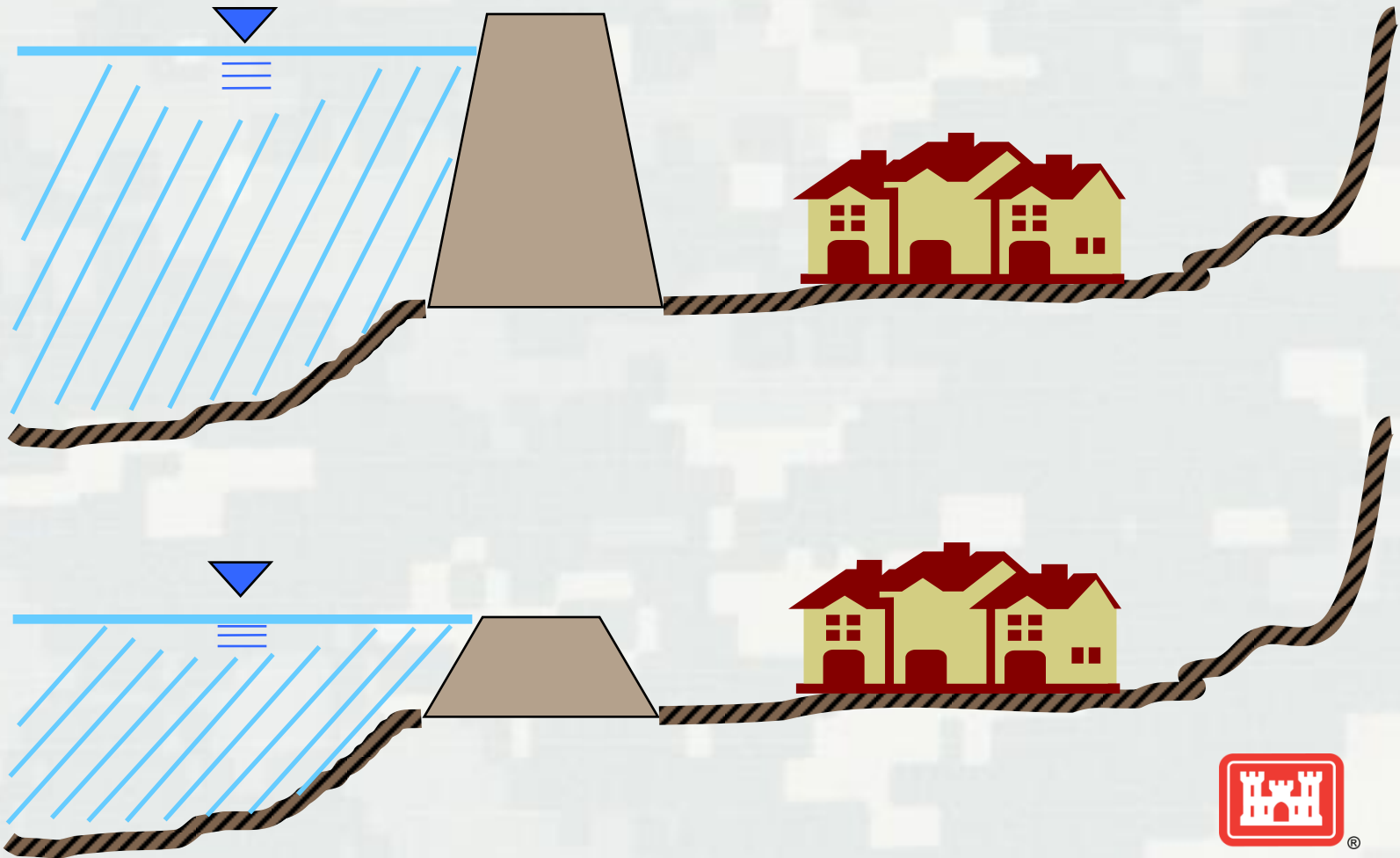


Consequences

- Economic
 - ▶ Damage to structures
- Life Safety
 - ▶ Population at risk (PAR)
 - ▶ Loss of life



Life Loss vs. PAR



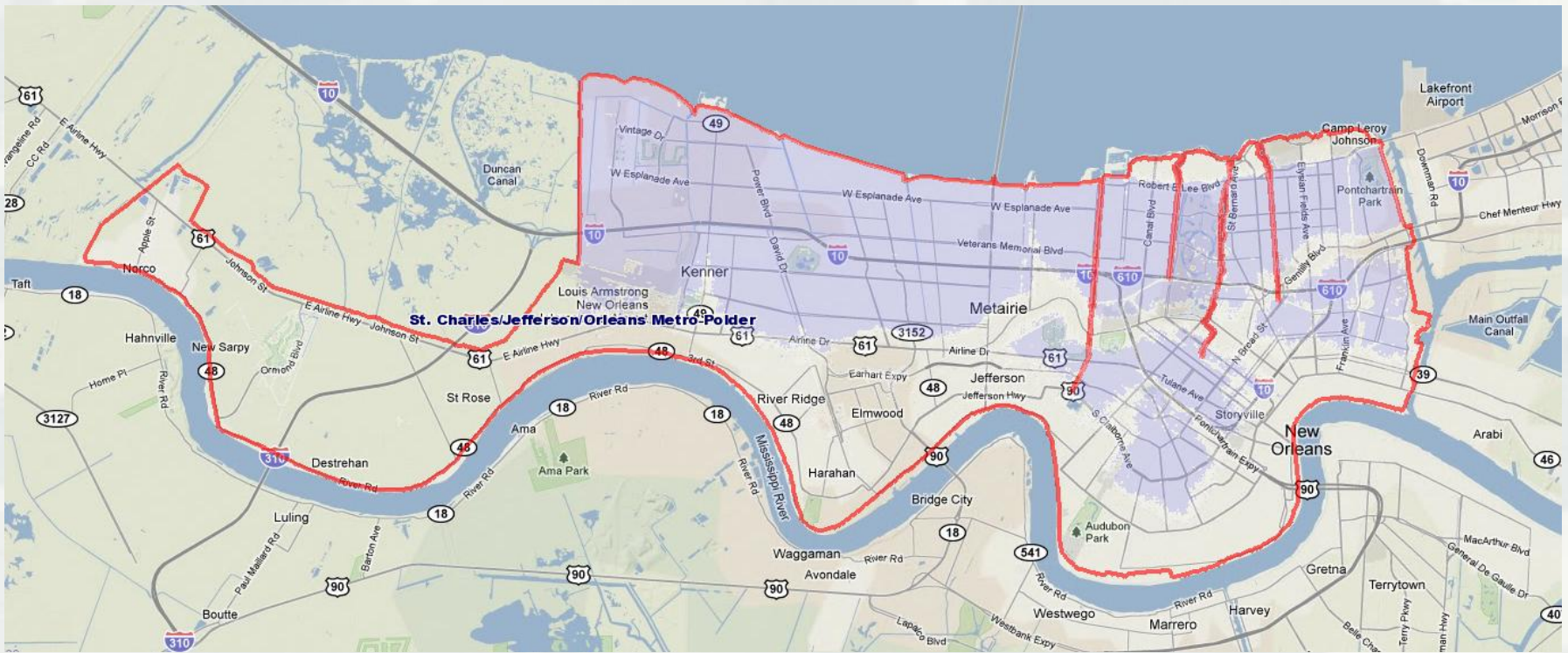
Levee Screening Approach - Consequences

- Initial distribution of people and damageable properties
 - ▶ Protected area (NLD)
 - ▶ HAZUS
 - Population at risk and economics
- Redistribution of people
 - ▶ Evacuation effectiveness = $f()$
 - Evacuation planning
 - Community awareness
 - Flood warning effectiveness
 - Population density
 - Overtopping vs. breach (warning)
- Fatality rates from Dutch (Jonkman) research



Population at Risk (PAR)

- Protected area polygon
- Census data
- Verify and update



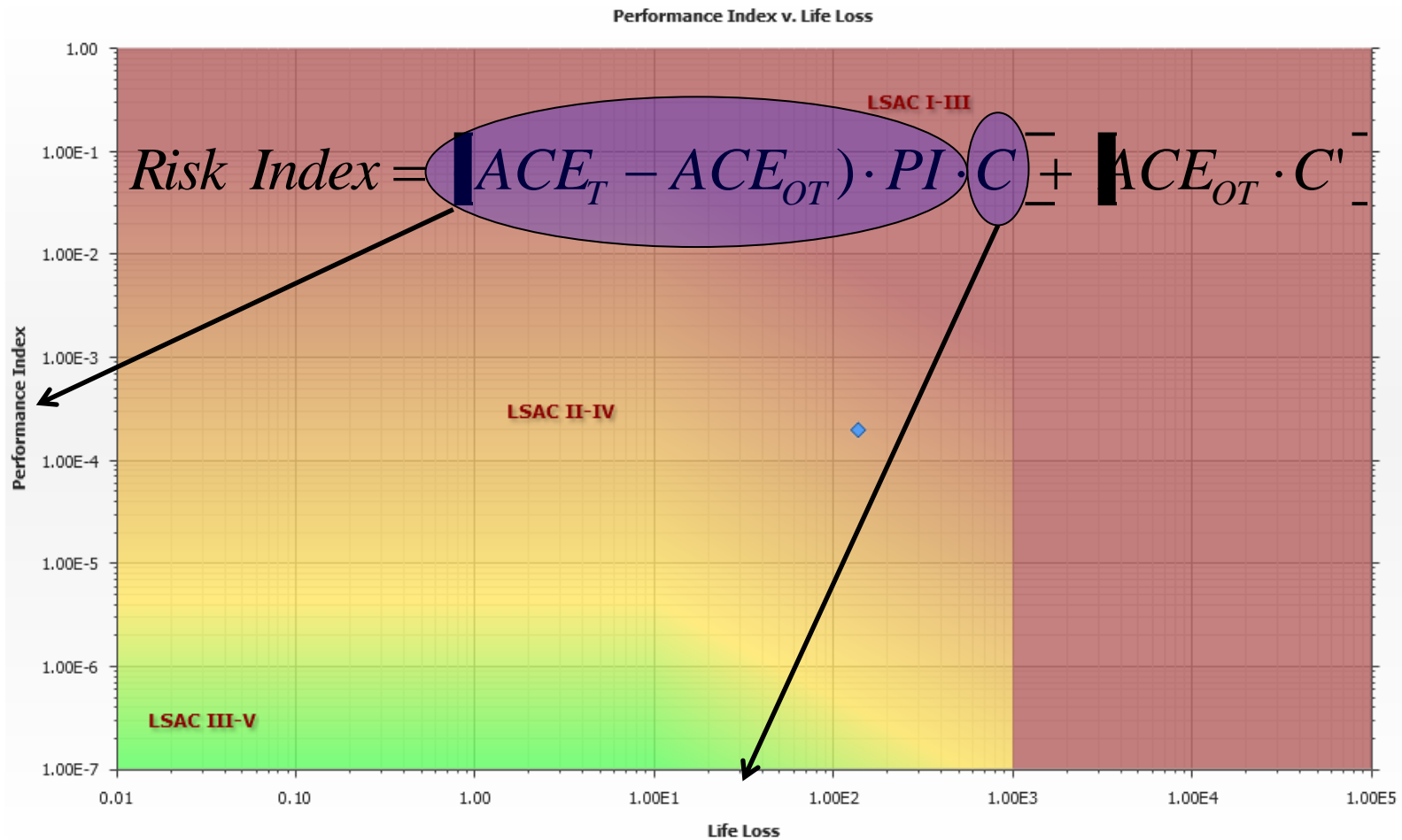
Plotting – Prior to Overtopping

Conditional Performance Index Summary

Performance Index v. Life Loss

Performance Index v. Economic Loss

Loss Category
Prior to Exceedance



Plotting – Overtopping

Conditional Performance Index Summary

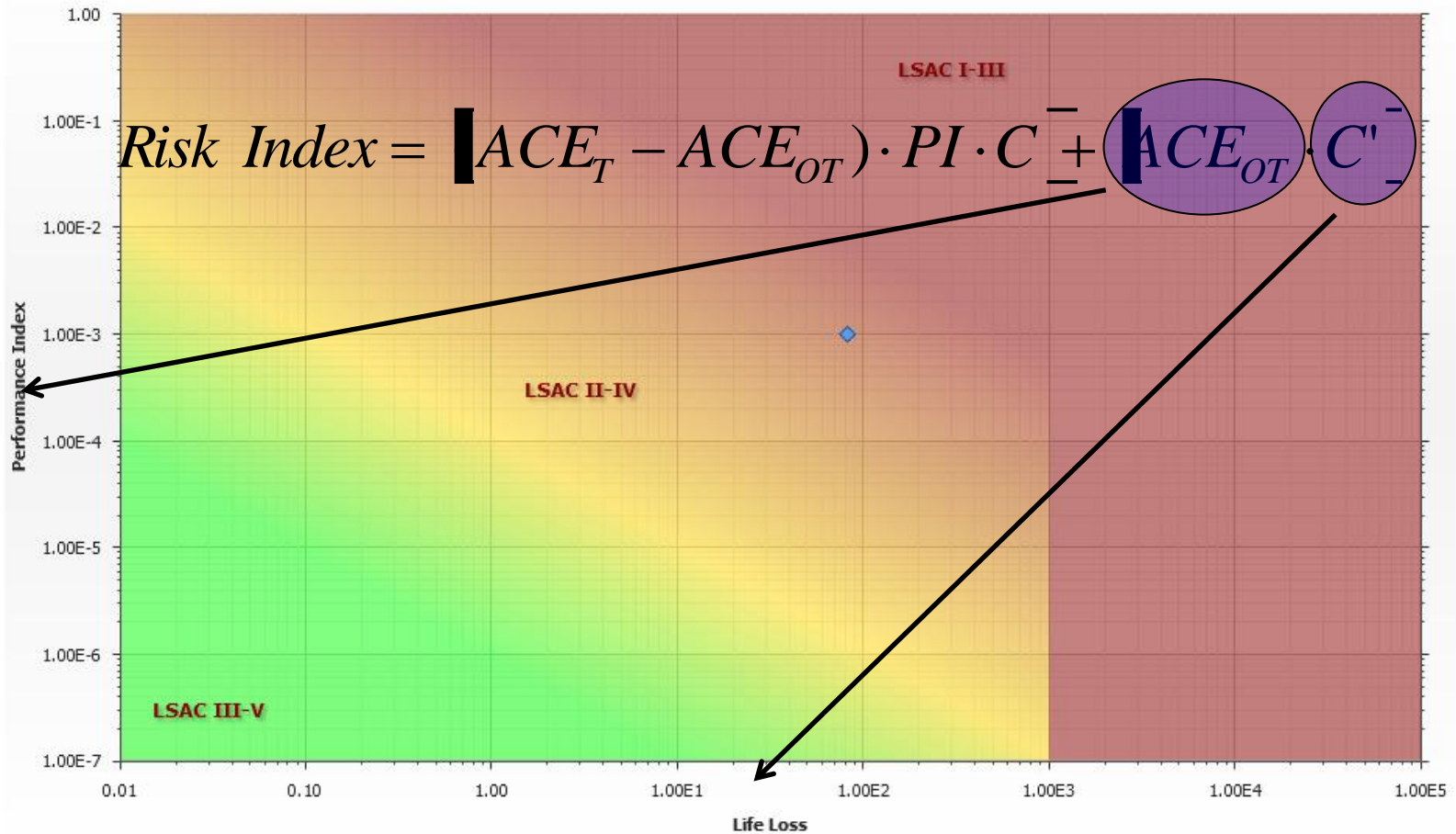
Performance Index v. Life Loss

Performance Index v. Economic Loss

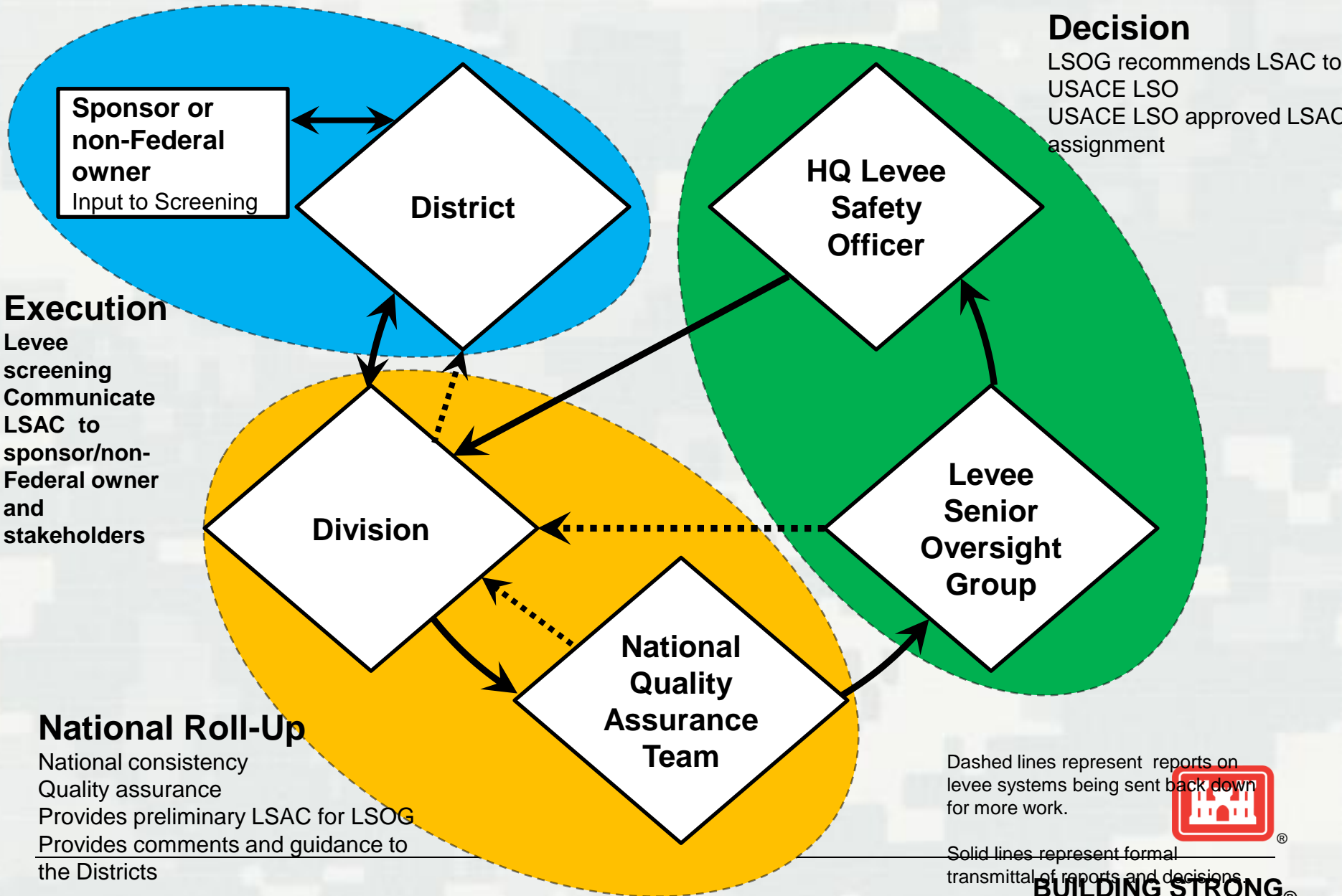
Loss Category

Capacity Exceedance

Performance Index v. Life Loss



Current Levee Screening/LSAC Assignment Process



What Does the LSAC Tell Us?

- Relative Risk for living behind a particular levee
 - ▶ Levee's Expected Performance
 - Is it in good condition **AND/OR**
 - What level of risk reduction does it provide
 - AND/OR**
 - ▶ Consequences (Is the leveed area in a flood plain)
- What priority does the levee have for available federal funding
- May not necessarily have a direct impact on:
 - ▶ O&M Inspection Rating
 - ▶ Participation in the Rehabilitation and Inspection Program (RIP)
 - ▶ FEMA Accreditation
- Interim Risk Reduction Measures (IRRM) may be needed
 - ▶ Established jointly by federal and local representatives



2011 MVN SCREENING

HSDRRS EAST JEFFERSON LEVEE DISTRICT

(Taken From The August 2011 LSOG Presentation)

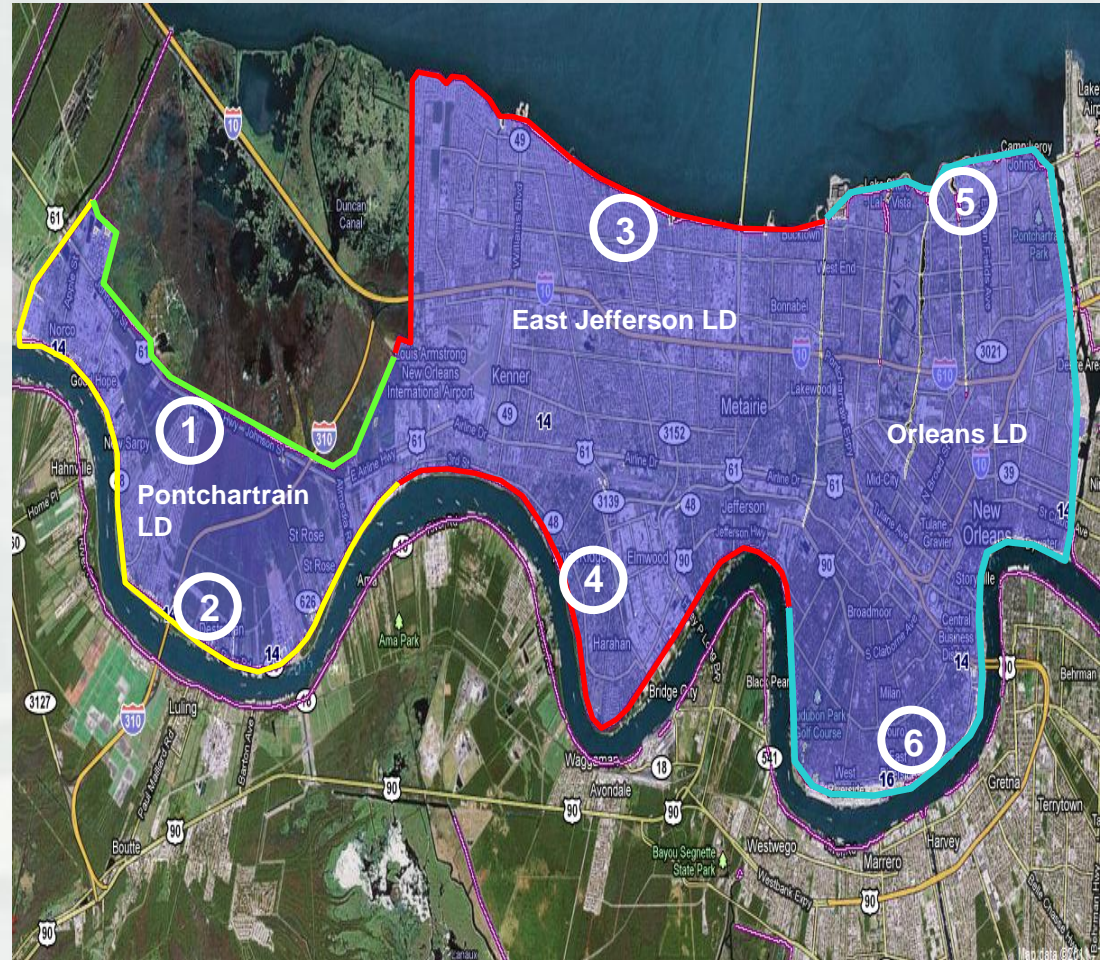


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System Screening Rationale

1. Pontchartrain HSDRRS
2. Pontchartrain MRL
3. East Jefferson HSDRRS
4. East Jefferson MRL
5. Orleans HSDRRS
6. Orleans MRL

- 2 Separate Hydraulic Events
 - ▶ Riverine (along MRL)
 - ▶ Hurricane (Lake & IHNC)
- Different Screening Factors
 - ▶ Required Design Heights
 - ▶ Hydraulic History
 - ▶ Performance Issues
 - ▶ Evacuation Preparedness

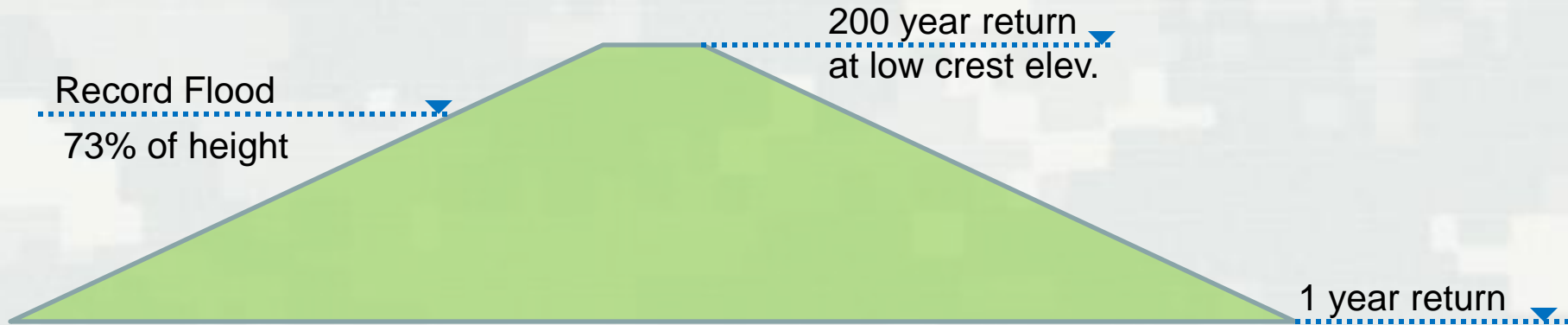


Levee Summary

- East Jefferson LD – HSDRRS
 - ▶ Protects community of East Jefferson Parish, Louisiana
 - ▶ PAR = 425,040 (day), 483,241 (night)
 - ▶ Toe annual chance exceedance (ACE) = 1.0E-00 (1 year)
 - ▶ Design capacity ACE = 1.00E-02 (100 year)
 - ▶ Overtopping ACE = 5.00E-03 (200 year)



Summary of Hydraulics



- Top Elevation at 15.5ft NAVD88
 - SWL for the 0.2% ACE hurricane event is below the hydraulic design level (OT rate = 2-4 cfs)
 - The overtopping rate with the 50% assurance for the 1% ACE is less than 0.01 cfs/ft.
 - The overtopping rate with the 90% assurance for the 1% ACE is less than 0.1 cfs/ft
 - Allowable overtopping for a levee armored with grass is 1.0 cfs/ft
- Toe Elevation at 0.0ft NAVD88
- Flood of Record at Elevation 11.4ft NAVD88
 - ▶ Hurricane Katrina (2005) – 73% of Levee Height
 - ▶ Current authorized levee height EL 14.0 NAVD88
- Authorized Capacity Frequency: 100 yr Event
- Overtopped: No Failure: No
- Times Loaded (events) 25% - 6 50% - 1 75% - 0

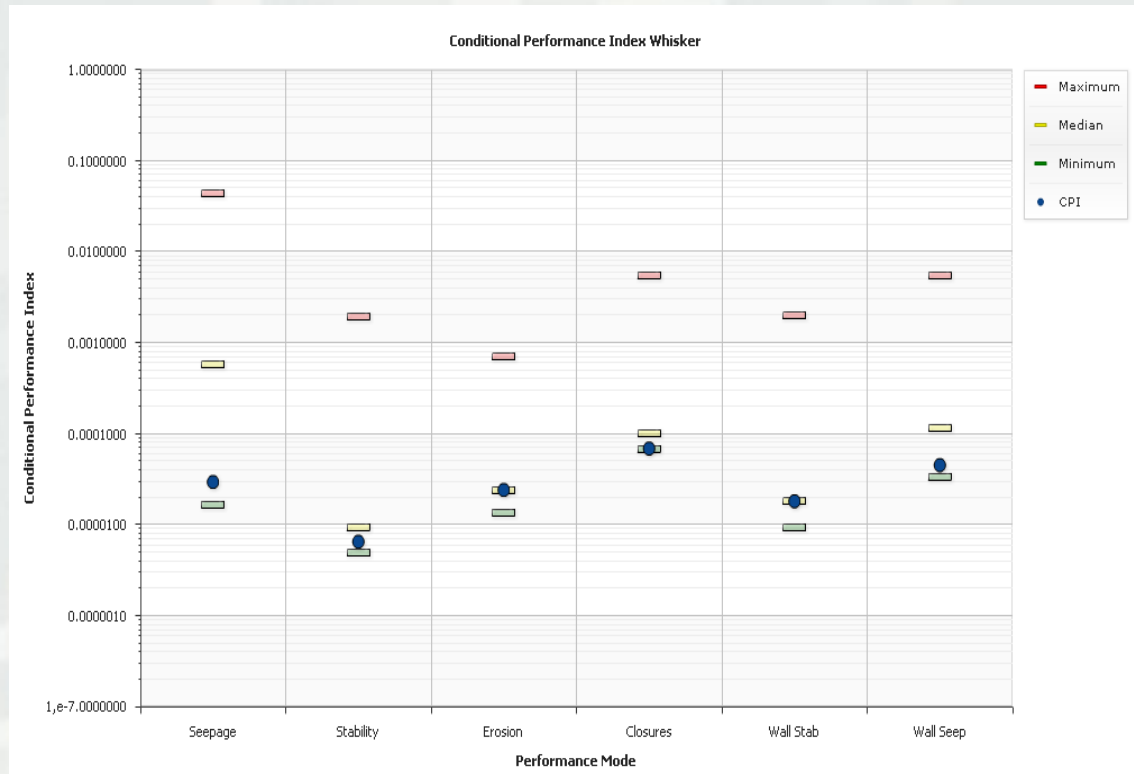


Assessment Rating Summary

Contributing Factors - Performance

Performance

- ▶ Embankment & Foundation Seepage and Piping
 - Seepage - A
- ▶ Embankment Stability
 - Slope stability - A
- ▶ Erosion
 - Erosion/Bank Caving - A
- ▶ Closures
 - Moveable Gate A
 - Culvert Gate A
- ▶ Floodwall Stability
 - Encroachment M
 - Tilting, etc. A
- ▶ Floodwall Underseepage
 - Seepage A



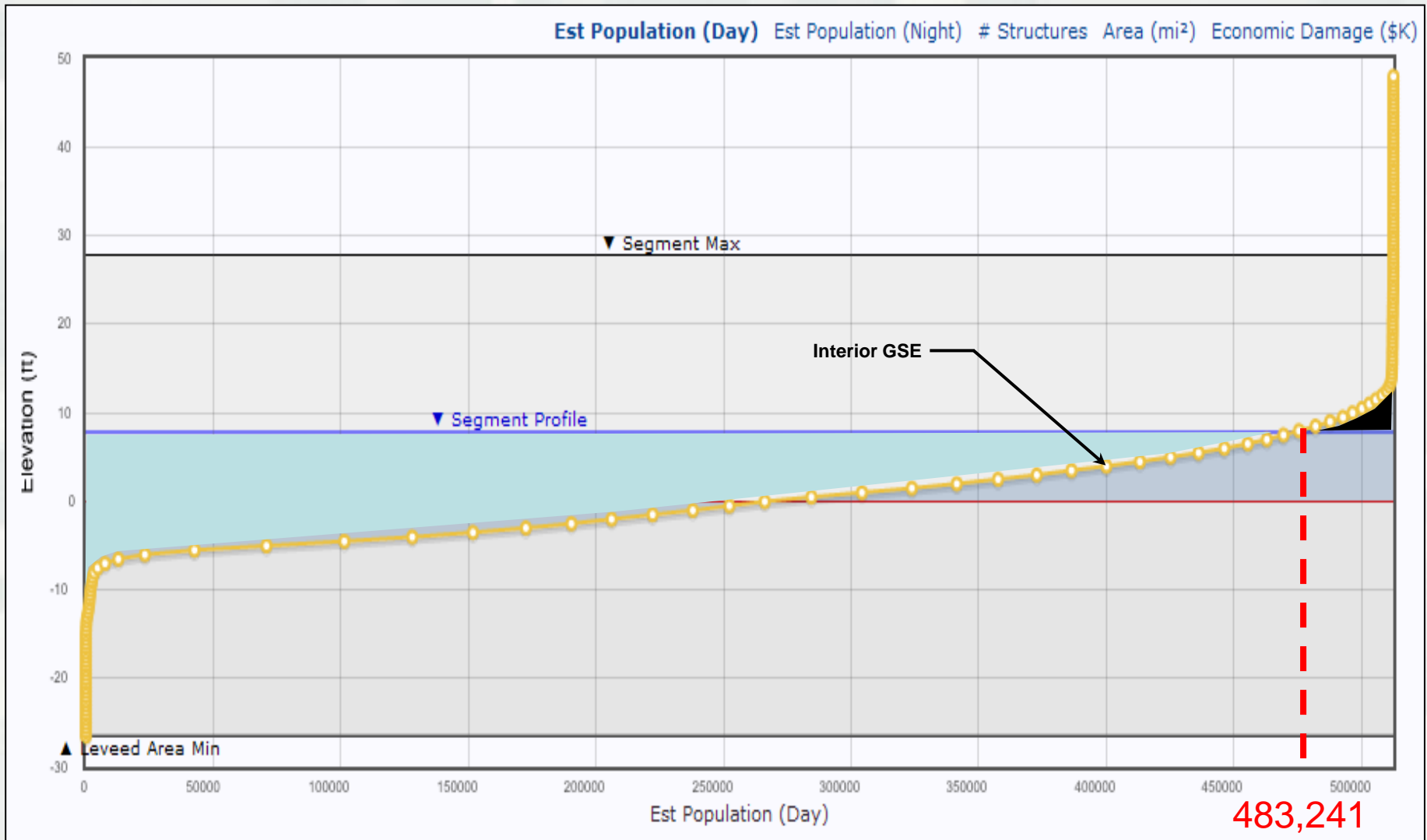
Consequences - Inundated Area



***The LST assumes the polder will fill to the elevation of the lowest levee elevation in the segment DESPITE performance evaluation**



Consequences - Inundated Area



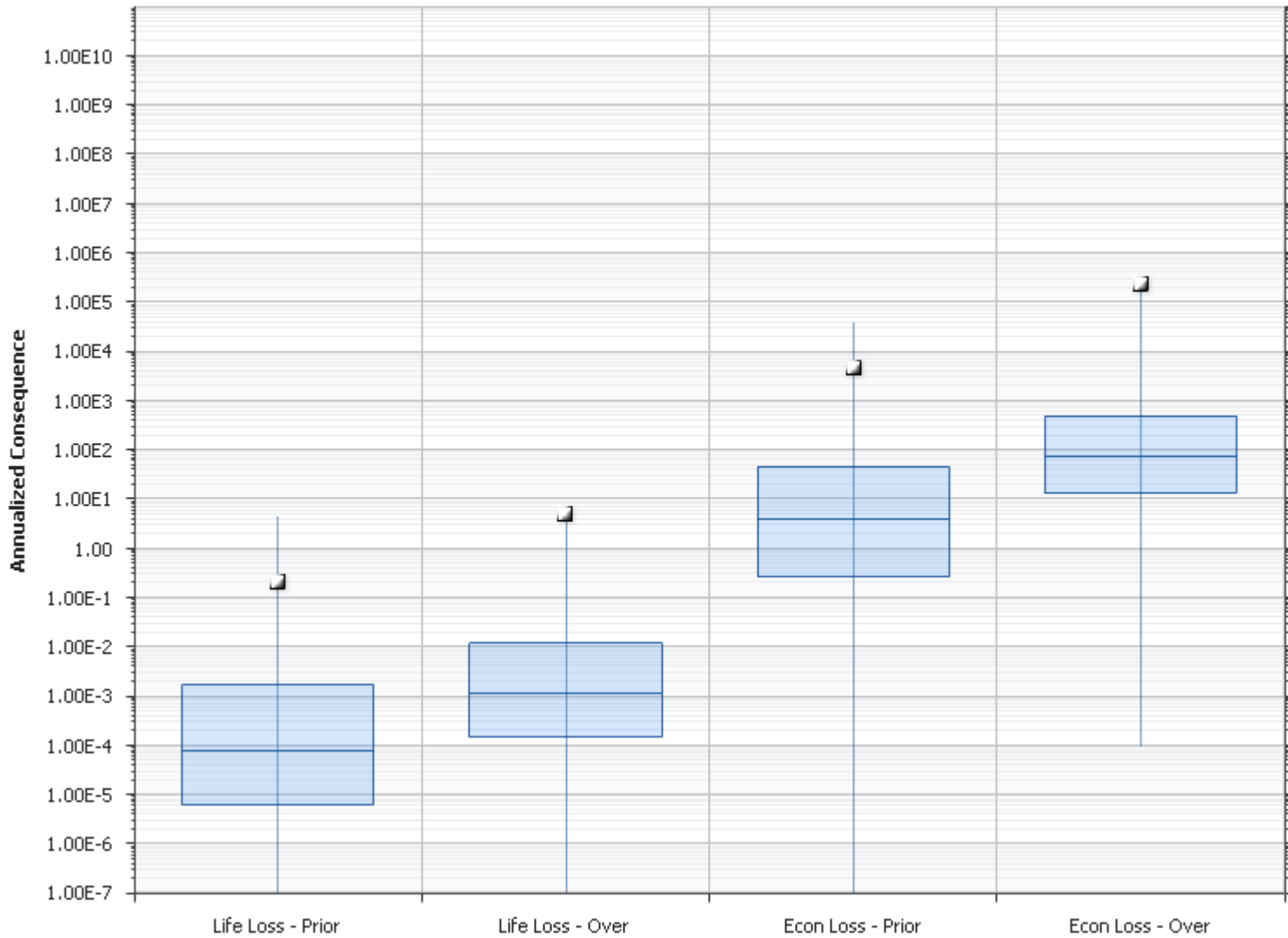
Major Contributors to Overall Risk Rating

Contribution to Risk Indices

Performance Type	Performance Index	Life Safety Index	Economic Index
Capacity Exceedance	98.14%	95.83%	98.14%
Embankment and Foundation Seepage and Piping	.29%	.84%	.29%
Embankment Stability	.06%	.19%	.06%
Embankment Erosion	.23%	.69%	.23%
Closure Systems	.67%	.65%	.67%
Floodwall Stability	.17%	.52%	.17%
Floodwall Underseepage and Piping	.44%	1.29%	.44%



East Jefferson LD - St. Charles/Jefferson/Orleans




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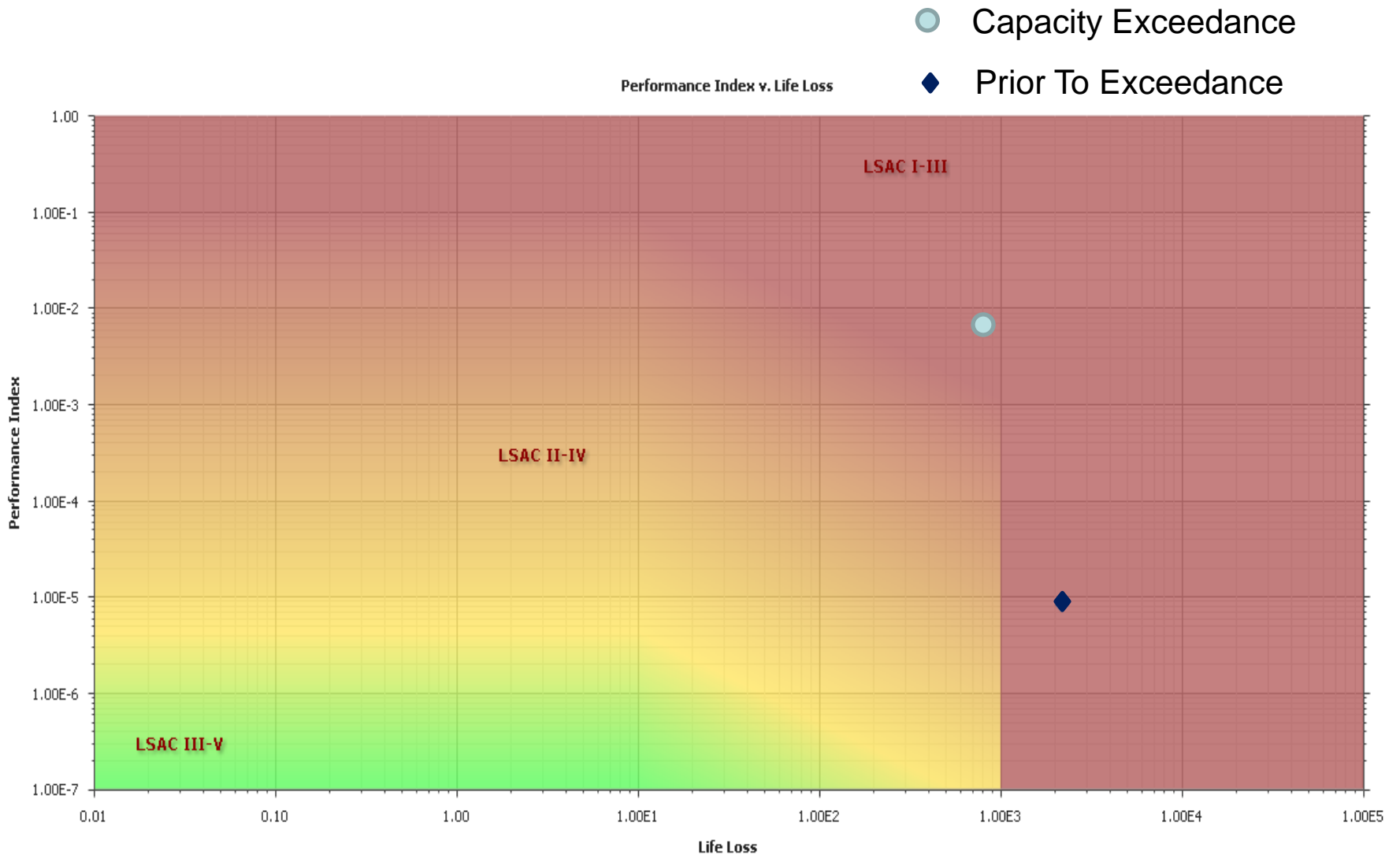
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Levee Summary

■ East Jefferson LD – HSDRRS

- ▶ Protects community of East Jefferson Parish, Louisiana
- ▶ PAR = 425,040 (day), 483,241 (night)
- ▶ Weighted fatality rate = 3.0%
- ▶ Life loss estimate
 - (Overtopping Breach) = 974
 - (Breach Prior to Overtopping) = 2945
- ▶ Economic Damages = \$47,714,179,000
- ▶ Toe annual chance exceedance (ACE) = 1.0E-00 (1 year)
- ▶ Design capacity ACE = 1.00E-02 (100 year)
- ▶ Overtopping ACE = 5.00E-03 (200 year)
- ▶ Performance index prior to overtopping = 9.48E-05 

Prior to Capacity Exceedance



LSOG Evaluation

- **Prior To Exceedance (<200 yr event)**
 - High Likelihood of performance
 - Design Criteria
 - Past Performance (Gustav & Ike)
 - High Likelihood of less population at risk (evacuations)
 - LST LSAC Range (1-3)
 - LSOG Recommendation = 3 or 4
- **Capacity Exceedance (Overtopping)**
 - Performance after Overtopping uncertain
 - Larger storm = greater surge = greater inundated area
 - LST LSAC Range (1-3)
 - LSOG Recommendation = 2

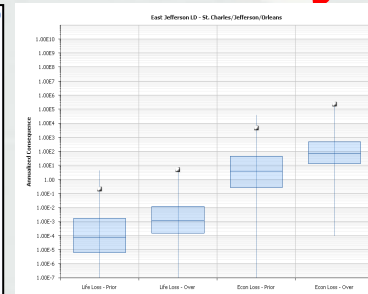
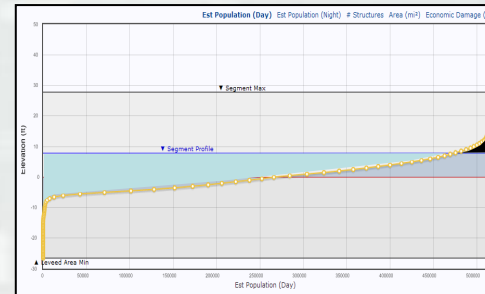


LSAC Summary

- Expected Performance
 - 100 yr Event = Superior
 - > 200 yr Event = Uncertain (armoring required?)
- Evacuation Effectiveness = Superior
- Population at Risk = **Highest of any screened levee within federal inventory**

- Final LSAC is LOWEST of:
 - Prior to Exceedance
 - Capacity Exceedance

- Draft LSAC for East Bank = 2 (overtopping)



LSAC Summary

- East Bank LSAC Ratings **NOT FINAL**
 - Tool is still being developed / improved
 - USACE has a small data set as of Aug 2011
 - As more screenings are complete over the coming months and years
 - Tool may be updated
 - Evaluation process may change
 - LSAC ratings may be adjusted
- Silver Lining
 - LSAC 2 rating does **NOT** indicate levee will not perform
 - Will keep the importance of southeast LA levees on the national radar screen
 - Does not affect FEMA accreditation or PL 84-99

