

DAM SAFETY & EARTHQUAKES

Earthquake Summit 2024

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US Army Corps
of Engineers®

- What is a Dam?
- What is Dam Safety and why do we need it?
- USACE Dam Safety Program
- Inspections and Assessments
- Earthquake impact zone

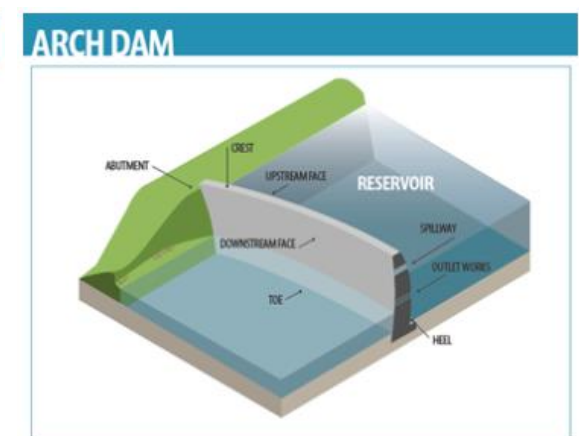
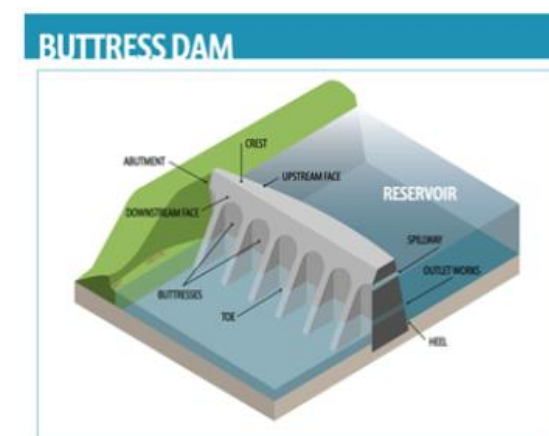
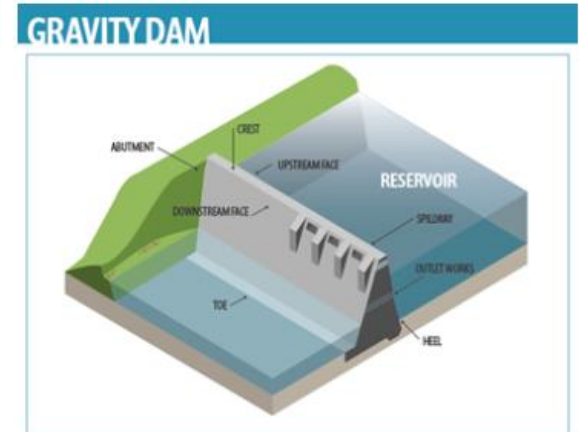
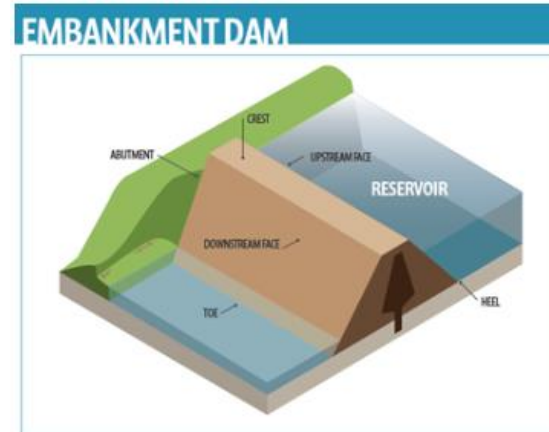
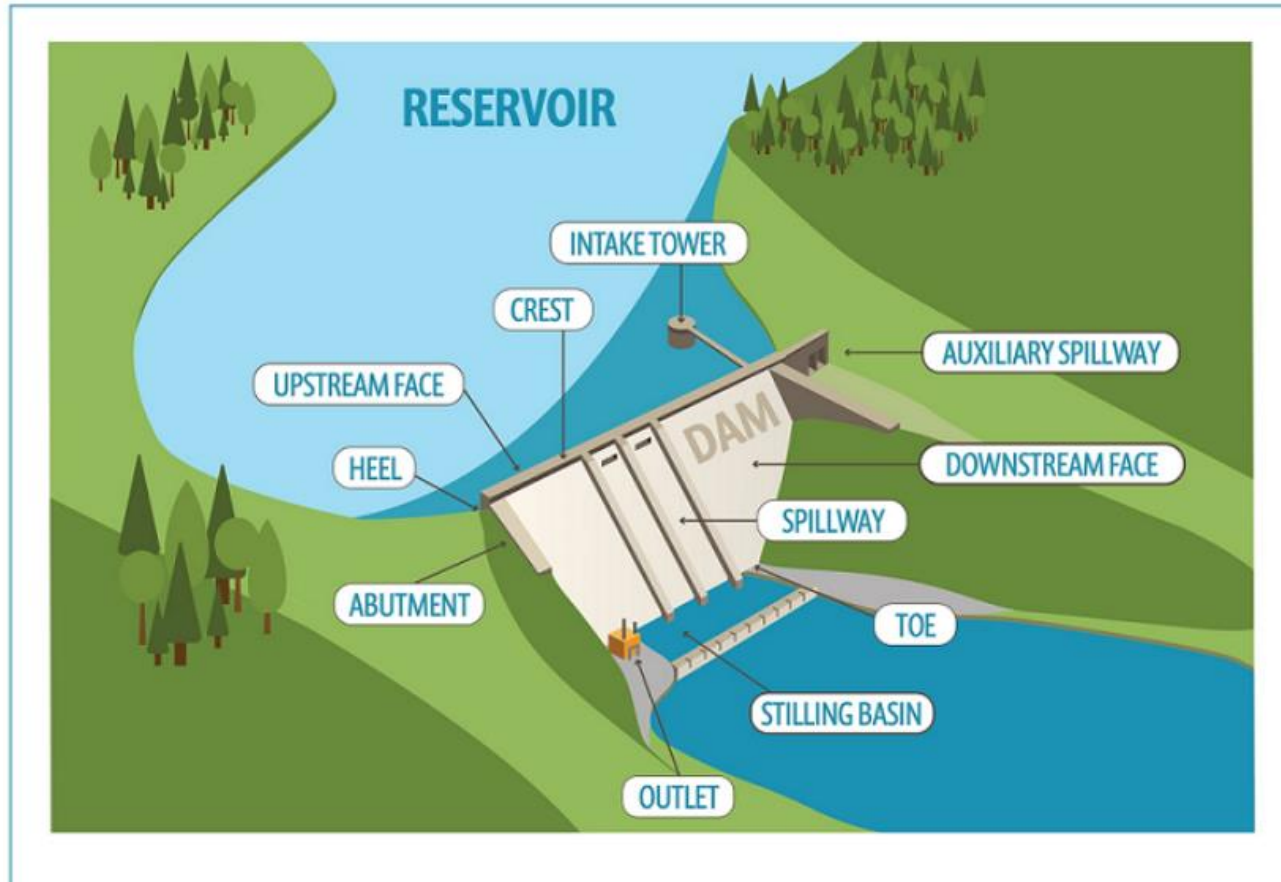


WHAT IS A DAM?

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- A dam is a structure that is built across a river or body of water to hold, divert, or regulate water. Often the body of water stored behind a dam is referred to as the reservoir or lake.





ER 1110-2-1156

SAFETY OF DAMS – POLICY AND PROCEDURES

31 Mar 14

1.7 Dam Safety Definition. Dam Safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to routinely monitor, evaluate, identify or predict dam safety issues and consequences related to failure including ensuring all reservoir regulation activities are performed in accordance with established water control plans. These actions are to be performed in concert with activities to document, publicize, and reduce, eliminate, or remediate, to the extent reasonably practicable, any unacceptable risks.



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WHY DO WE NEED DAM SAFETY?

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BECAUSE DAMS CAN FAIL!



1976 Teton Dam

- Internal erosion
- Killed 11 people and 16,000 livestock
- Total damages and claims up to \$2B

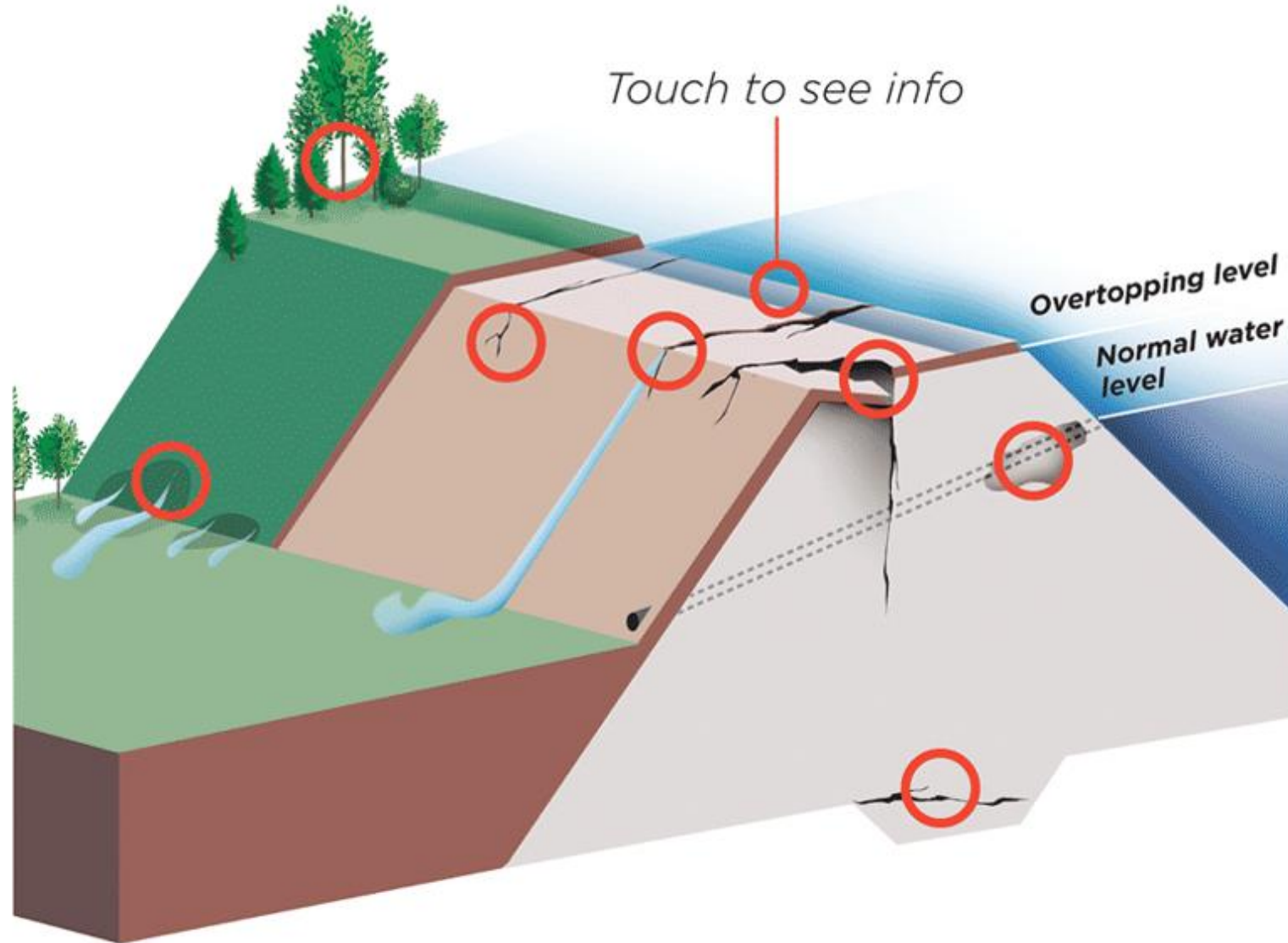


2005 Taum Sauk Reservoir

- Overtopping
- Zero fatalities
- \$650M+ in reconstruction and fines

Typical defects and potential failure modes

Dam failures are most likely to happen for these reasons:



SOURCES: Association of State Dam Safety Officials, Federal Emergency Management Agency; Based on graphic by Jeff Colson, USACE Dam Safety Program

Michael Hogue/DMN



Question:

What kinds of potential failures do you see?

- Inadequate maintenance
- Cracking
- Overtopping
- Structural failure
- Seepage and piping
- Stability failure



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RECENT DAM CRISIS IN THE U.S.

7



2017 Oroville Dam

- Spillway chute erosion





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RECENT DAM FAILURE IN THE U.S.



2020 Edenville Dam

- Static Liquefaction



8 seconds later



36 seconds later



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DAM SAFETY IMPROVEMENTS SPURRED BY FAILURE

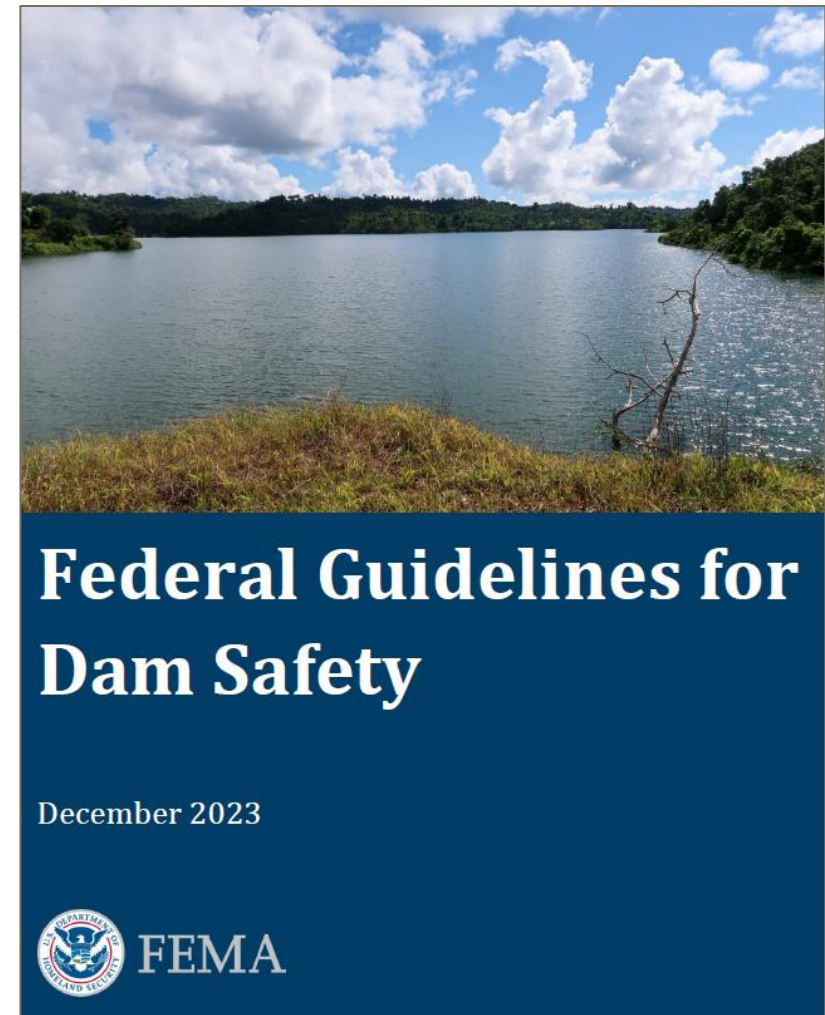


1889 South Fork Dam, PA
1928 St. Frances Dam, CA
1972 Buffalo Ck Dam, WV
1972 Canyon Lake Dam, SD
1976 Teton Dam, ID
1977 Laurel Run Dam, PA
1977 Kelly Barnes Dam, GA

⇒ No Legislation, 2000 Dead
⇒ CA Initiates the Dam Safety Program
⇒ Congress passes National Dam
Inspection Act of 1972
⇒ Reclamation Safety of Dams
⇒ **1979 Federal Guidelines for Dam
Safety passed, FEMA officially
created**



- Initiated in April 1977 by an Ad Hoc Interagency Committee (FCCSET)
- Published in June 1979
 - Most recently updated in December 2023
- Provide the Standard for Federal Agency Programs:
 - Establish a dam safety officer and staff
 - Update inventory of dams
 - Document design criteria and construction activities
 - Prepare initial reservoir filling plans and reservoir regulation criteria
 - Maintain training and awareness
 - Prepare and maintain EAP for each dam
 - Establish a program of periodic inspections
 - Monitor and evaluate performance of each dam





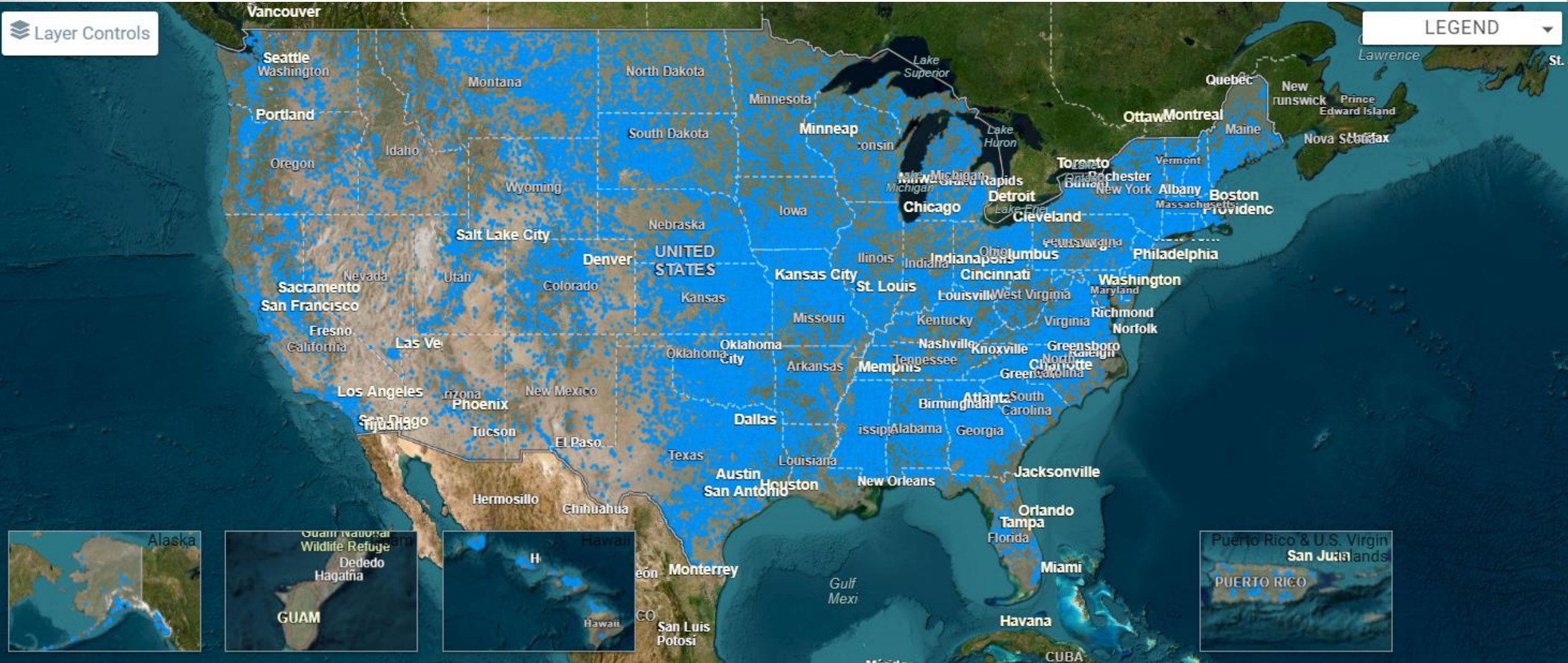
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HOW MANY DAMS ARE THERE IN THE US?



Layer Controls

LEGEND





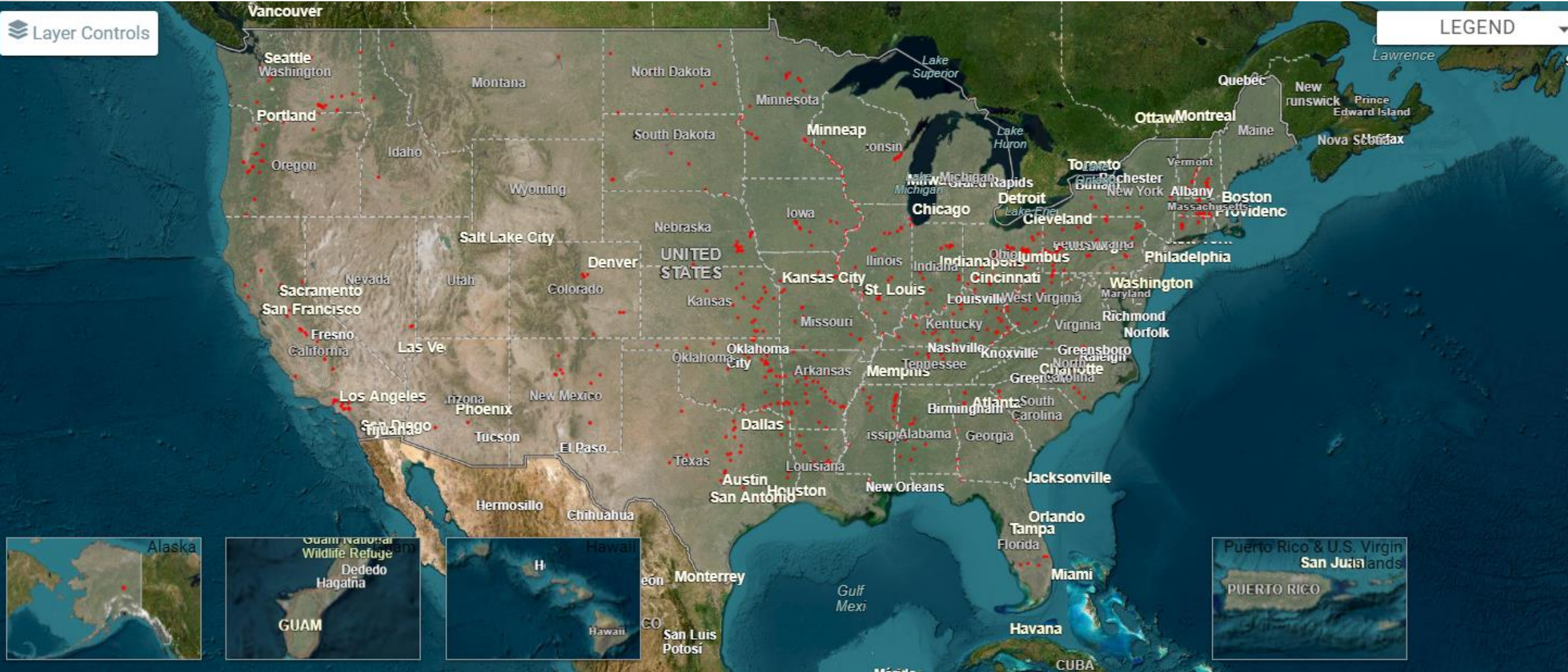
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HOW MANY DAMS DOES USACE OWN?



Layer Controls

LEGEND





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USACE DAM SAFETY PROGRAM

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- USACE is a self-regulated dam owner
- Policy: ER 1110-2-1156, Safety of Dams, Policies and Procedures
- Dam Benefits:
 - Flood Risk Management
 - Navigation
 - Water Supply
 - Hydropower
 - Environmental Stewardship
 - Fish and Wildlife Conservation
 - Recreation





Hydraulic Steel Structures

Dam Safety Training

Risk Assessments

Instrumentation Monitoring

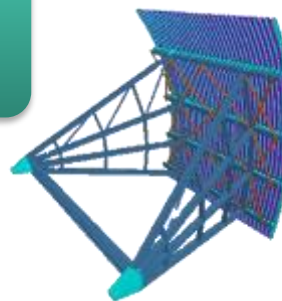
Periodic Inspections

Annual Inspections

EAP Updates & Exercises

Studies and Analysis

Emergency Action Plan
XYZ Dam



USACE DAM SAFETY PROGRAM



INSPECTIONS AND ASSESSMENTS



- Dam Safety Inspections
- Risk Assessments (assignment of DSAC rating)
 - Screening level
 - Periodic Assessments
 - Issue Evaluation Studies
 - Dam Safety Modification Studies

URGENCY OF ACTION (DSAC)	ACTIONS FOR DAMS IN THIS CLASS***	CHARACTERISTICS OF THIS CLASS
VERY HIGH (1)	Take immediate action to avoid failure. Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support remediation using all resources and funding necessary. Initiate intensive management and situation reports.	CRITICALLY NEAR FAILURE: Progression toward failure is confirmed to be taking place under normal operations. Dam is almost certain to fail under normal operations to within a few years without intervention. OR EXTREMELY HIGH INCREMENTAL RISK**: Combination of life or economic consequences with likelihood of failure is very high. USACE considers this level of life-risk to be unacceptable except in extraordinary circumstances.
HIGH (2)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as warranted. Ensure the 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 the need for remediation.	FAILURE INITIATION FORESEEN: For confirmed and unconfirmed 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 INCREMENTAL RISK**: The combination of life or economic consequences with likelihood of failure is high. USACE considers this level of life-risk to be unacceptable except in extraordinary circumstances.
MODERATE (3)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as warranted. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize investigations to support the need for remediation informed by consequences and other factors.	MODERATE TO HIGH INCREMENTAL RISK**: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is moderate. USACE considers this level of life-risk to be unacceptable except in unusual circumstances.
LOW (4)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.	LOW INCREMENTAL RISK**: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is low to very low and the dam may not meet all essential USACE guidelines. USACE considers this level of life-risk to be in the range of tolerability but the dam does not meet all essential USACE guidelines.
NORMAL (5)	Continue routine dam safety activities and normal operations, maintenance, monitoring, and evaluation.	VERY LOW INCREMENTAL RISK**: The combination of life, economic, or environmental consequences with likelihood of failure is low to very low and the dam meets all essential USACE guidelines. USACE considers this level of life-safety risk to be tolerable.

*At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan.
 ** INCREMENTAL RISK is used to inform the decision on the DSAC assignment; NON-BREACH RISK is not reflected in this table.
 ***DSAC 1 and 2 dams with no life loss will be referred to the appropriate business line program and are given lower priority in the dam safety program.



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DAM SAFETY INSPECTIONS

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- Initial Inspection (after construction)
- Continuing Evaluation Inspections
 - Intermediate, Annual, and Routine
- Periodic Inspections
- Special/Emergency Inspections

- Inspection team members
 - Engineers
 - Civil, Mechanical, Geotechnical, Structural, Hydraulic, Electrical
 - Geologist
 - Project Staff (very important!)
 - Others





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ENOUGH DAM TALK



We are here for earthquakes!





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USACE PUBLICATIONS



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Engineer Regulations



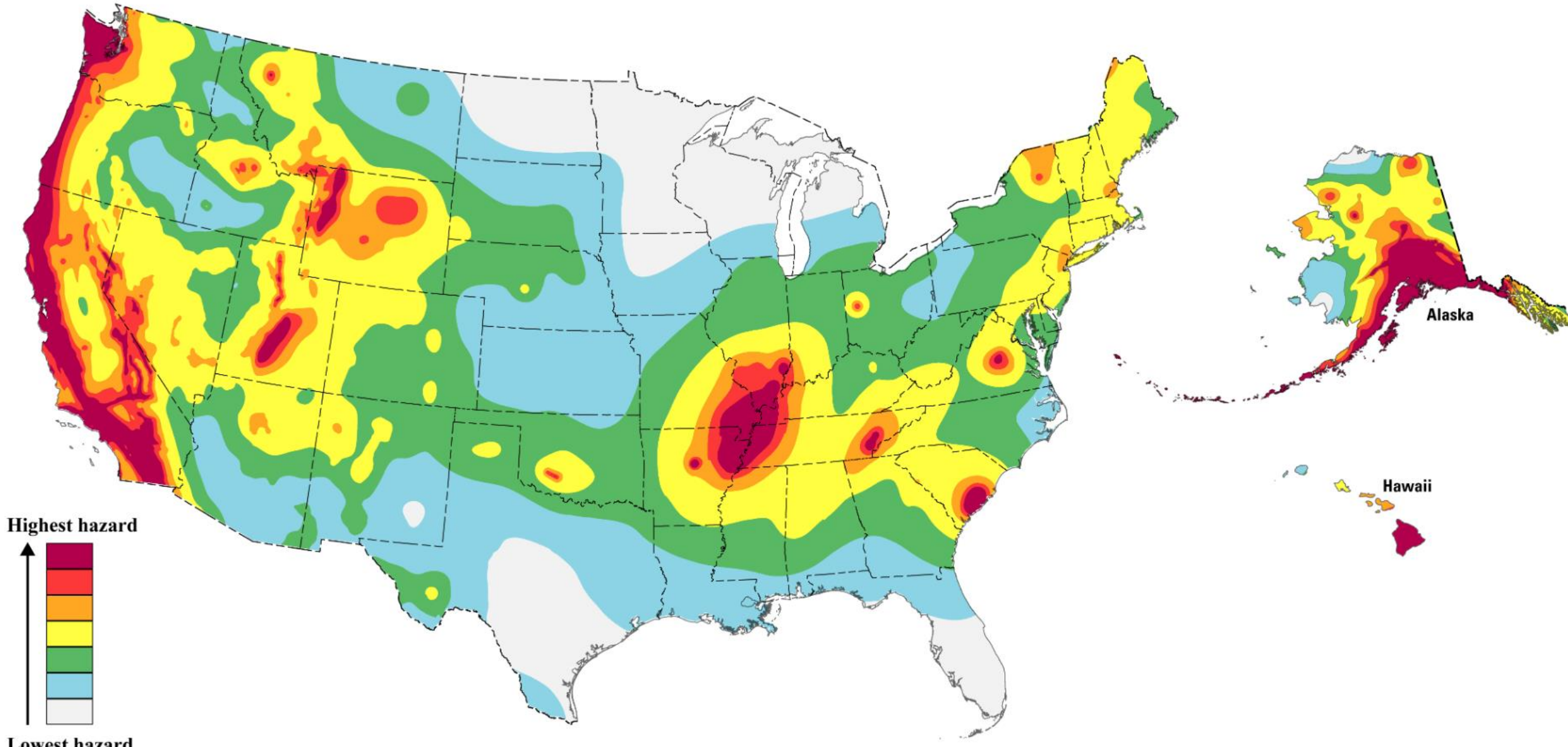
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Pub Number	Proponent	Title	Pub Date	Latest Review	Info
ER 1110-2-103	CECW-EC	Strong-Motion Instruments for Monitoring and Recording Earthquake Motions	1/3/2024		
ER 1110-2-1802	CECW-EC	Post-Earthquake Inspections and Reporting for Civil Works Structures	12/21/2023		
ER 1110-2-1806	CECW-CE	Earthquake Design and Evaluation for Civil Works Projects	5/31/2016		



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SEISMIC HAZARD REGIONS





SPECIAL POST-EARTHQUAKE INSPECTIONS



- To be conducted if damage is observed, ground motion is felt at the dam, or in accordance with the following table:

Earthquake Magnitude	Epicenter Distance From Dam (Miles) (Inspect dam if epicenter is within this distance to dam)
4.0	30
5.0	60
6.0	125
7.0	250
8.0	375
8.5	500

ER 1110-2-1802



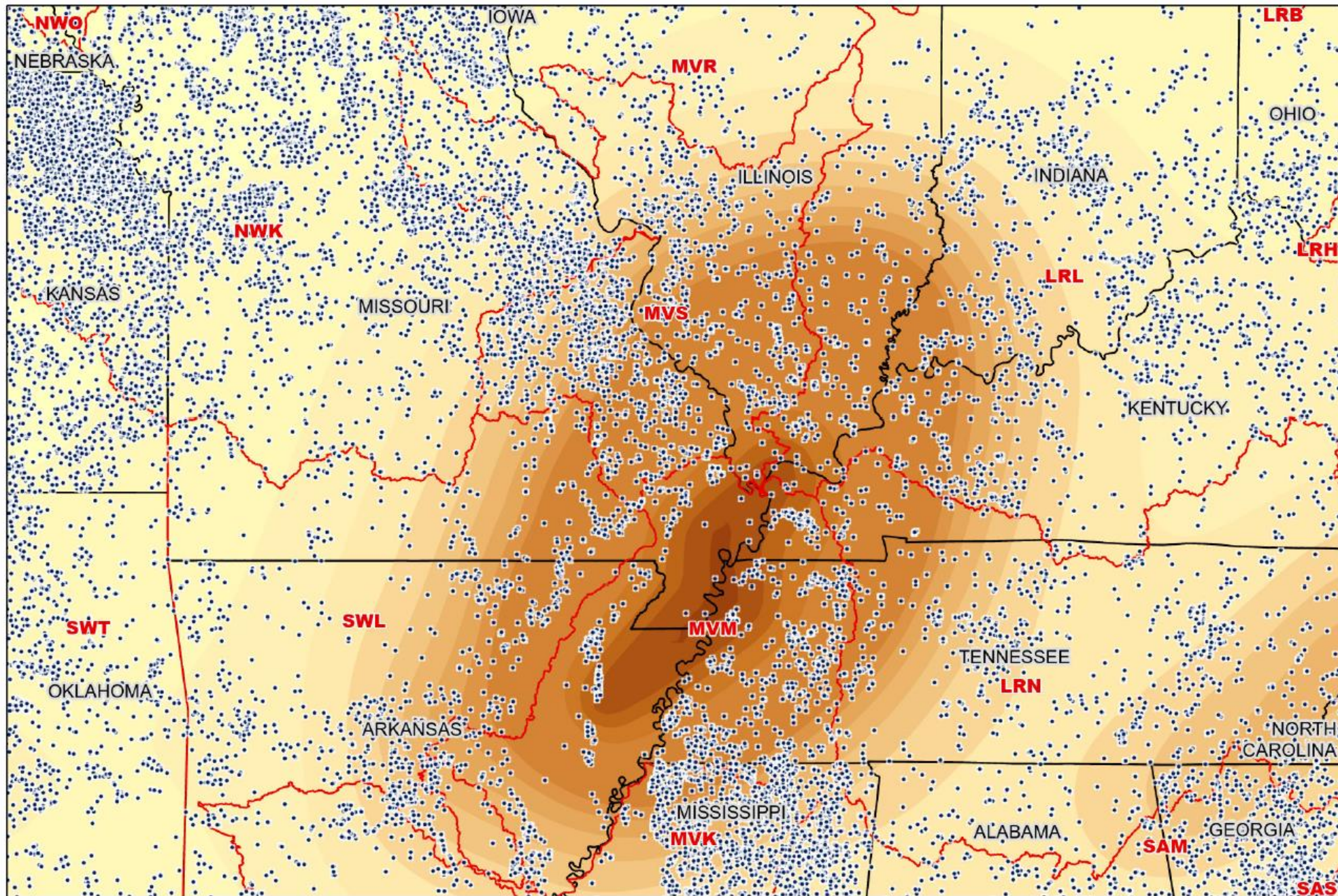
SPECIAL POST-EARTHQUAKE INSPECTIONS



- Inspection team deployed to site as soon as practicable when:
 - PGA at project is greater than 0.15g
 - Potential distress identified or potential impact to safe project operations
- Prioritization and timeliness of response
 - Risk associated with loss of project purpose
 - Project susceptibility to seismic damage
 - PGA and magnitude/distance from epicenter
 - Plan in place prior to an event (EAP)
- Visual Inspection checklists
 - Project-specific (main features and appurtenant structures)
 - Failure modes of concern

Inspection Checklist
• Cracking
• Bulging
• Deformation
• Boils and seepage
• Misalignment
• Instrumentation

New Madrid Seismic Zone - National Inventory of Dams - All



Legend

- NID Data
- ▭ USACE Districts
- ▭ States

Earthquake Risk

0 - 1
1 - 2
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 15
16 - 20
21 - 25
26 - 30
31 - 40
41 - 60
61 - 80
81 - 100

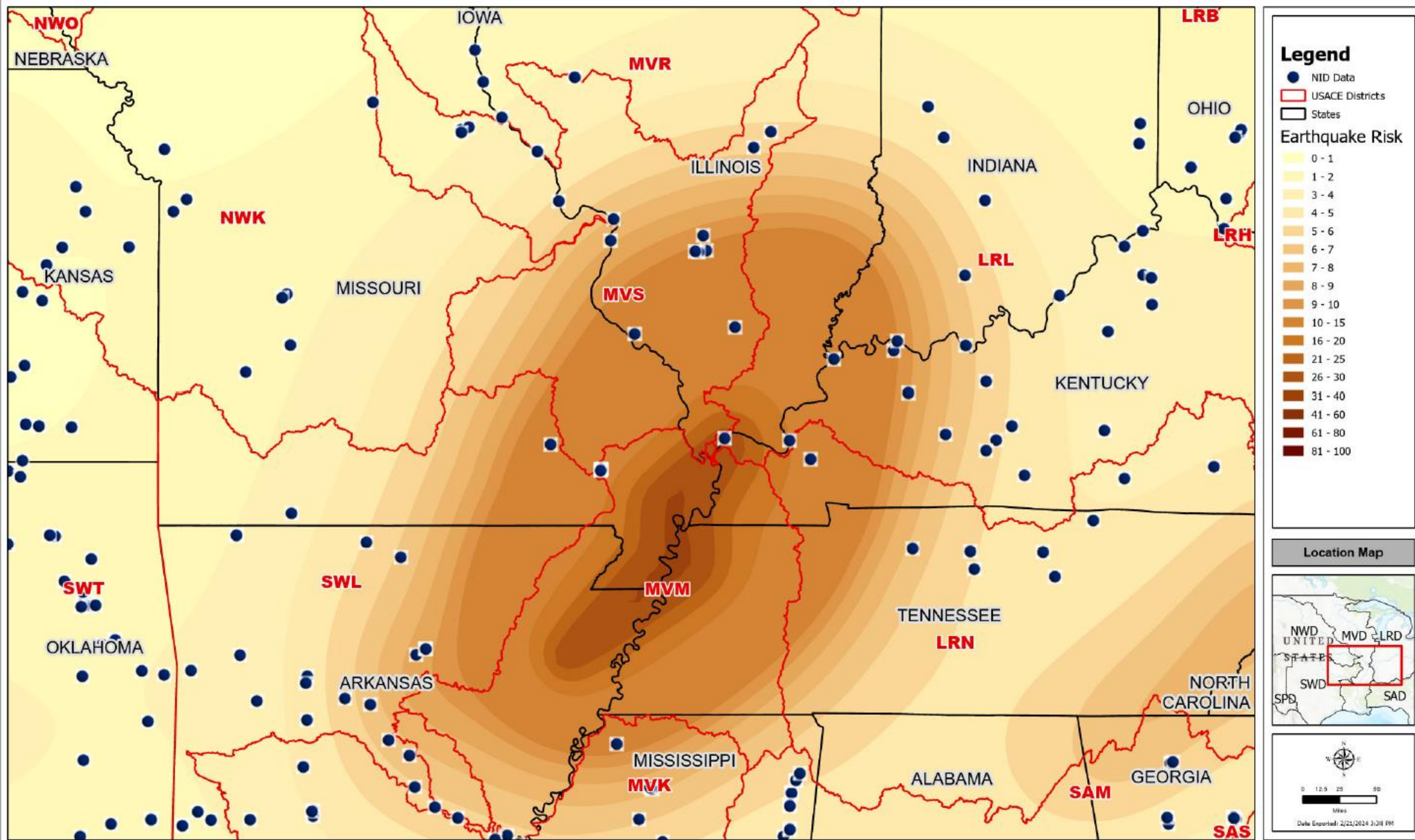
Location Map

Scale

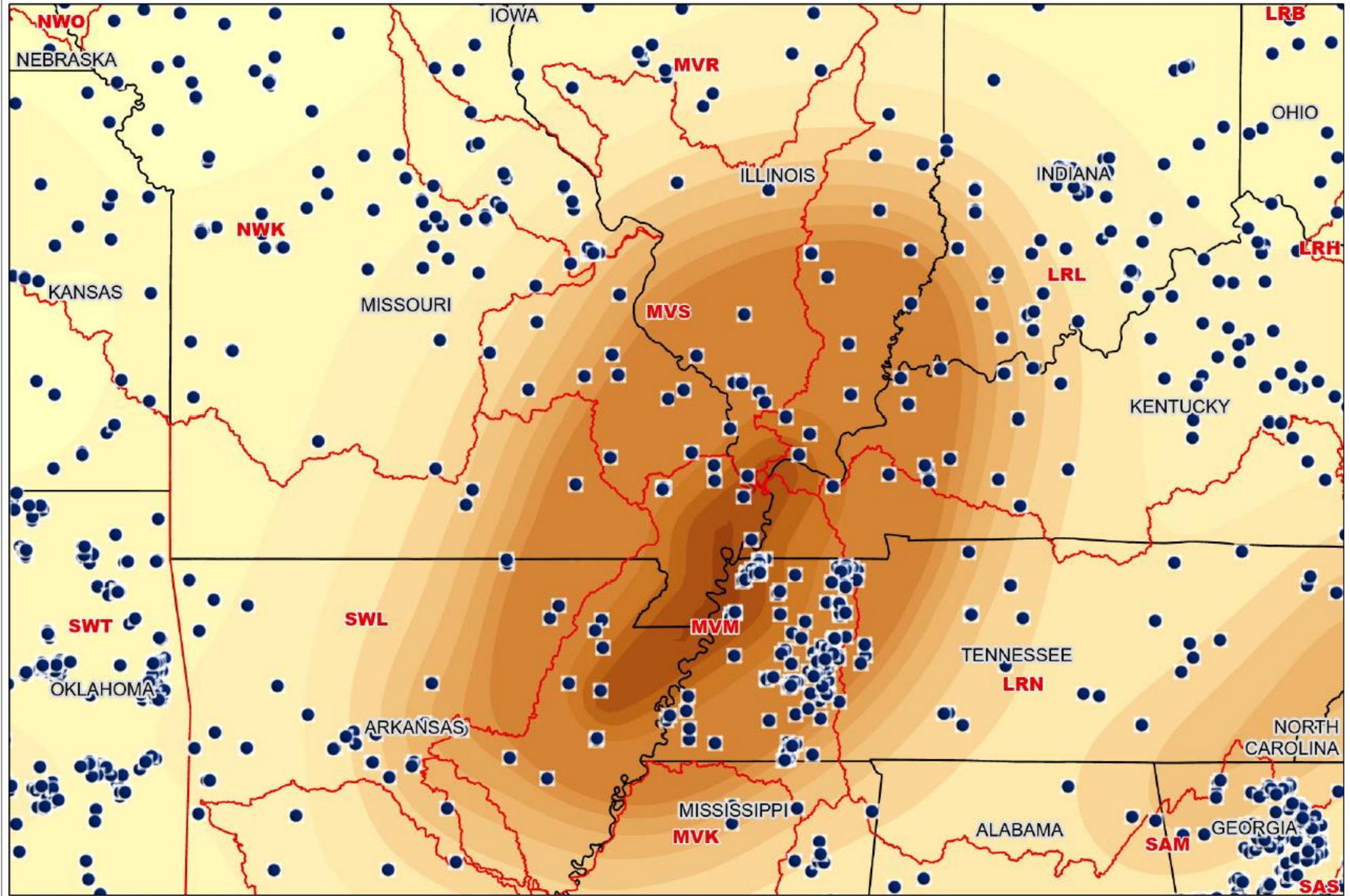
0 12.5 25 50 Miles

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New Madrid Seismic Zone - National Inventory of Dams - Corps



New Madrid Seismic Zone - National Inventory of Dams - State



Legend

- NID Data
- ▭ USACE Districts
- ▭ States

Earthquake Risk

0 - 1
1 - 2
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 15
16 - 20
21 - 25
26 - 30
31 - 40
41 - 60
61 - 80
81 - 100

Location Map

The location map shows the United States with a red box highlighting the New Madrid Seismic Zone region. Labels for NWD, MVD, LRD, SWD, and SAD are present.

Scale: 0, 12.5, 25, 50 Miles
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Questions, Comments, or Discussion?

Thank you for your attention.