DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CECW-EG

*ER 1110-2-1802

Regulation
No. 1110-2-1802

28 July 2017

Engineering and Design
REPORTING EARTHQUAKE EFFECTS

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1. Purpose. This regulation states policy, defines objectives, assigns functions, and establishes procedures for assuring the structural integrity and operational adequacy of major Civil Works structures following the occurrence of significant earthquakes. It primarily concerns damage surveys following the occurrences of earthquakes that will help inform decisions on prioritization of resources for any necessary follow-on actions.

2. Applicability. This regulation is applicable to all field operating agencies having Civil Works responsibilities.

3. Distribution Statement. Approved for public release, distribution is unlimited.

4. References.

a. CESPK Office Memorandum (OM) 1110-2-4, Post-Earthquake, Pre-Flood, and Periodic Inspections and Continuing Evaluations of Completed Civil Works Structures. This document is posted to the Geotechnical and Materials (G&M) Community of Practice (CoP) Technical Excellence Network (TEN) sites.

b. Engineer Regulation (ER) 500-1-1, Emergency Employment of Army and Other Resources, http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_500-1-1.pdf

c. ER 1110-2-1156, Safety of Dams – Policy and Procedures, http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf

d. ER 1110-2-1806, Earthquake Design and Evaluation of Civil Works Projects, http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1806.pdf

e. ER 1130-2-530, Flood Control Operations and Maintenance Policies, http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1130-2-530.pdf

5. Policy. In the event of an earthquake, all U.S. Army Corps of Engineers (USACE) Civil Works structures that could fail or partially fail, endanger lives, and/or cause

*This engineer regulation supersedes ER 1110-2-1802 dated 25 July 1979.

substantial property damage will be evaluated afterwards to ensure continued structural stability, safety, and operational adequacy. These structures include dams, navigation locks and channels, levee systems, floodwalls, power-houses, and appurtenant structures (e.g., intakes, outlet works, bridges, pump stations, drainage structures, buildings, tunnels, paved spillways, and similar facilities) in which the Corps of Engineers is fully or primarily responsible for their maintenance and operation, or structures that the Corps of Engineers constructed and has subsequently transferred to local interests to maintain and operate. Structural evaluations will be based on post-earthquake inspections to detect conditions of significant structural distress and to prioritize resources for timely restoration and remediation.

6. Post-Earthquake Inspections and Evaluation Surveys.

a. Limitations of Present Knowledge. The design of structures for earthquake loading is limited by the infrequent opportunity to compare actual performance with the design. Significant damage is unlikely if peak ground acceleration (pga) is below 0.1g; nevertheless, structural integrity cannot be assumed if earthquake loadings occur below the design criterion. For example, earthquakes have occurred in several parts of the country where significant seismic activity was not expected, and where earthquake-induced loads may therefore not have been adequately considered in the design of older structures.

b. Types of Reportable Damage. Many types of structural damage can be induced by ground motion from earthquakes. Any post-earthquake change in appearance or functional capability of a major Civil Works structure should be evaluated and reported. Examples are symptoms of induced stresses in buildings made evident by cracked plaster, windows or tile, or in binding of doors or windows. Major structural stress is indicated by cracked or shifted bridge pier footings or other concrete structures, cracks in concrete dams or earth embankments, and misalignment of hydraulic control structures or gates. Induced dynamic loading on earth dams or levees may result in loss of freeboard by settlement, or cause localized liquefaction within the embankment sections or earth foundations leading to deformation of the embankment. Hydrologic changes also can indicate the potential for subsurface deformation, such as abrupt changes in static water levels in wells and increased turbidity. The appearance of surface seeps can indicate the formation of new seepage paths within the foundation or embankment section. Ground motion-induced landslides may occur in susceptible areas of reservoir rims, causing embankment overtopping by waves and serious damage. All such unusual conditions should be evaluated and reported.

7. Inspection and Evaluation Programs. The following characteristics can be useful for prioritizing the sequence of structural inspections and damage evaluation.

a. Significant Damage to Structures in the Vicinity. If the project is located in the vicinity of an earthquake that results in significant structural damage, the District Chief

of Engineering should be notified immediately and an engineering evaluation and inspection team should mobilize to the project. Project operations personnel will conduct and document an initial damage survey inspection of the project without delay. The project's emergency operations plan should be invoked. Actions during emergency operations should include consideration of the effects of potential aftershocks.

b. No Significant Damage to Structures in the Vicinity. If an earthquake is felt at the project during normal working hours, but causes no or insignificant damage to structures in the vicinity, project operations personnel should make an immediate inspection. If the event occurs after normal business hours, the project operations manager (e.g., Park Manager; Dam Operator; or Tender, Area Engineer) will determine the need for the immediacy of the inspection but in no case will it be delayed beyond the beginning of the following day (if the next day is a holiday or other non-work day, the inspection will not be delayed). This inspection should determine and document (1) whether there is evidence of earthquake damage or disturbance; and (2) whether seismic instrumentation, where present, has detected ground motion. Districts should initiate a Post-Earthquake Safety Emergency Notification process and follow those reporting procedures. Appendix B provides a dam safety specific example. If damage is observed and is considered to threaten the immediate safety or operational capability of the project, immediate action should be taken as covered in Paragraph 7a above.

c. Combinations of Magnitude and Distance.

(1) Criteria listed below and shown in Appendix C, "Earthquake Inspection Criteria - Simplified Model," allow operations managers to assess the immediate need for site inspections and evaluations based on earthquake magnitude and proximity to an earthquake epicenter. If the magnitude and distance fall within the specified ranges, project operations personnel will conduct an inspection and check all seismic instruments and alarms, if any are present at the project. If no seismic instruments are located at the project, then earthquake magnitude and epicenter data can be obtained from the U.S. Geological Survey (USGS) at http://earthquake.usgs.gov/. (Appendix D shows a seismic hazard map of the United States.) USACE personnel can sign up for customized earthquake alert messages from the USGS at https://ssleearthquake.usgs.gov/ens/.

(2) If any of the seismic alarms indicate a pga of 0.05g or greater, or if damage is identified, an inspection led by the District Engineering Division should be performed. Inspection results by the project staff will be reported immediately to the designated personnel per the District or project specific Post-Earthquake Safety Emergency Notification Flow Chart:

(a) Magnitude 4.5 through 4.9 within 16 km (10 mi).

(b) Magnitude 5.0 through 5.9 within 80 km (50 mi).

(c) Magnitude 6.0 through 6.9 within 120 km (75 mi).

(d) Magnitude 7.0 through 7.9 within 200 km (125 mi).

(e) Magnitude 8.0 or greater within 320 km (200 mi).

(3) Districts are encouraged to prepare maps for each project with concentric circles using these criteria to efficiently determine the need for an inspection based on the Threshold pga. The magnitude and distance ranges will differ in the Eastern and the Western United States.

8. Post-Earthquake Inspection (Engineering).

a. The District Chief of Engineering, in consultation with the District Chief of Operations and/or the Dam Safety Officer (DSO) or Levee Safety Officer (LSO) as applicable, may determine whether an on-site inspection by qualified District personnel is required. The decision will be based on, but not be limited to, the physical characteristics of the earthquake event including the magnitude of the earthquake, the distance between the epicenter and the project, the peak horizontal ground acceleration (either calculated or measured at the site), the condition of the structure or embankment as documented by project personnel, and the structure or embankment performance history. Inspection results will be reported back to the District Chief of Engineering, the DSO and/or LSO (if applicable). If notable earthquake-induced damage is identified, notification will be made per the District's Post-Earthquake Safety Emergency Notification Flow Chart. (See Appendix B for an example). Such notification will include the District Commander, District Emergency Operations Center (EOC), and Major Subordinate Command Dam Safety Program Manager (MSC DSPM) and/or Levee Safety Program Manager (LSPM) if regarding a dam or levee. The appropriate higher headquarters Points of Contact (POCs) will be kept informed through ENGLink Situation Reports (SITREPS), which will be issued by the EOC.

b. Consistency with Dam and Levee Safety Inspection Requirements. For dams, the structures of concern following an earthquake generally are those same structures that are covered under the inspection program defined in ER 1110-2-1156. Whenever feasible, on-site instrumentation data will be incorporated into the post-earthquake safety evaluation programs to fulfill inspection requirements defined in all Engineer Regulations. Additional special types of instrumentation should be incorporated in selected structures to improve measurement of forces, pressures, loads, stresses, strains, displacements, deflections, or other conditions relating to damage and structural safety and stability in case of an earthquake. Inspection of features not visible on the surface, such as conduits, tunnels, and galleries, should be performed with particular attention to the use of proper confined space protocols. Damage or differential movement of these features could lead to delayed adverse effects. Where determined necessary, a detailed, systematic engineering inspection should be made of the post-earthquake condition of each structure, taking into account its distinctive features. Levee system inspections should use the Levee Inspection System developed by the

U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL).

c. Inspection of Underwater, Navigation, and Other Structural Features. Inspections of underwater project features should be performed, to include positional surveys of structures and/or channels as necessary. Surveys of navigational channels should determine whether or not ship passage safety has been compromised by underwater slope failure. For structures that have incurred earthquake damage, a formal technical report should be prepared in a format similar to inspection reports for dams required under ER 1110-2-1156. The report should include summaries of the instrumentation and other observation data for each inspection, for permanent record and reference purposes. This report will form a basis for major remedial work when required. Where accelerometers or other types of strong motion instruments have been installed, data and interpretations from these instruments should also be included in the report. The report should contain recommendations for remedial work when appropriate, and should be transmitted to the MSC for review and approval, and to Headquarters, U.S. Army Corps of Engineers (HQUSACE) for reference. For structures incurring no damage, a simple statement to this effect will be all that is required in the report, unless seismic instrumentation at the project is activated (see Paragraph 7c.)

9. Responsibilities.

a. U.S. Army Engineer Research and Development Center. The U.S. Army Engineer Research and Development Center (ERDC) is responsible for analysis and interpretation of project earthquake data. Data from strong motion accelerometers at Corps of Engineers projects should be collected following an earthquake occurrence. Procedures may vary regionally, depending on the responsible party that should collect the data (U.S. Geological Survey, District staff, or other). However, whenever an earthquake record is obtained from seismic instrumentation at a Corps project, the District will send a report of all pertinent instrumentation data to the Geotechnical and Structures Laboratory at ERDC. The report on each project should include a complete description of the locations and types of instruments, and a copy of the instrumental records from each of the strong motion accelerometers activated.

b. District and MSC Commanders. District and MSC Commanders are responsible for issuing any supplementary regulations necessary to adapt the policies and instructions herein to the specific conditions within their District and/or MSC, respectively.

c. Engineering Division. Each District Engineering Division office should develop an inspection program, select structures for special instrumentation for earthquake effects,

review and monitor data collection, conduct post-earthquake inspections, process and analyze data obtained from instrumentation and other observations, evaluate the resulting condition of the structures, and prepare the inspection reports. They will also be specifically responsible for promptly informing the HQUSACE and MSC POC when evaluation of the condition of the structure or analyses of the instrumentation data indicates that the stability of a structure has been compromised. The District Engineering Division will be responsible for providing the training discussed in Paragraph 10.

d. Construction Division. The District Construction Division will be responsible for the installation of the earthquake instrumentation devices, and for data collection if an earthquake occurs in any area where construction activity is taking place.

e. Operations Division. The District Operations Division will be responsible for the immediate assessment of earthquake damage, and for notifying the appropriate District POC (e.g., Chief of Engineering, DSO, and/or LSO) and Chief of Operations as discussed in Paragraph 8. The Operations Division also will be responsible for assisting and participating in post-earthquake inspections, and for collecting earthquake data after any construction activity consistent with USACE instrument monitoring requirements.

f. Emergency Operations Center (EOC). The District EOC will be responsible for coordinating all emergency response and reporting activities.

10. Training. The dam safety training program defined in ER 1110-2-1156 should include post-earthquake inspections and the types of damage that Operations personnel should investigate. This training is also applicable to post-earthquake inspection of major levees or other structures.

11. Funding. Funding for the evaluation and inspection program will be provided under the Appropriation 96X3123, Operations and Maintenance, General. Funds required for the inspections, including travel and per diem costs incurred by personnel of the MSC office or HQUSACE, will be provided from allocations made to the various projects for the fiscal year in which the inspection occurs.

FOR THE COMMANDER:

4 Appendices
(See Table of Contents)

JEFFREY A. ANDERSON
COL, EN
Chief of Staff

Appendix A

Acronyms and Abbreviations

Term	Definition
CoP	Community of Practice
ERDC-CRREL	U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory
DSO	Dam Safety Officer
DSPM	Dam Safety Program Manager
EOC	Emergency Operations Center
ER	Engineer Regulation
G&M	Geotechnical and Materials
HQUSACE	Headquarters, U.S. Army Corps of Engineers
LSO	Levee Safety Officer
LSPM	Levee Safety Program Manager
MSC	Major Subordinate Command
OM	Office Memorandum
POC	Point of Contact
SITREPS	Situation Reports
TEN	(USACE) Technical Excellence Network
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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Appendix B

Post-Earthquake Safety Emergency Notification Flow Chart

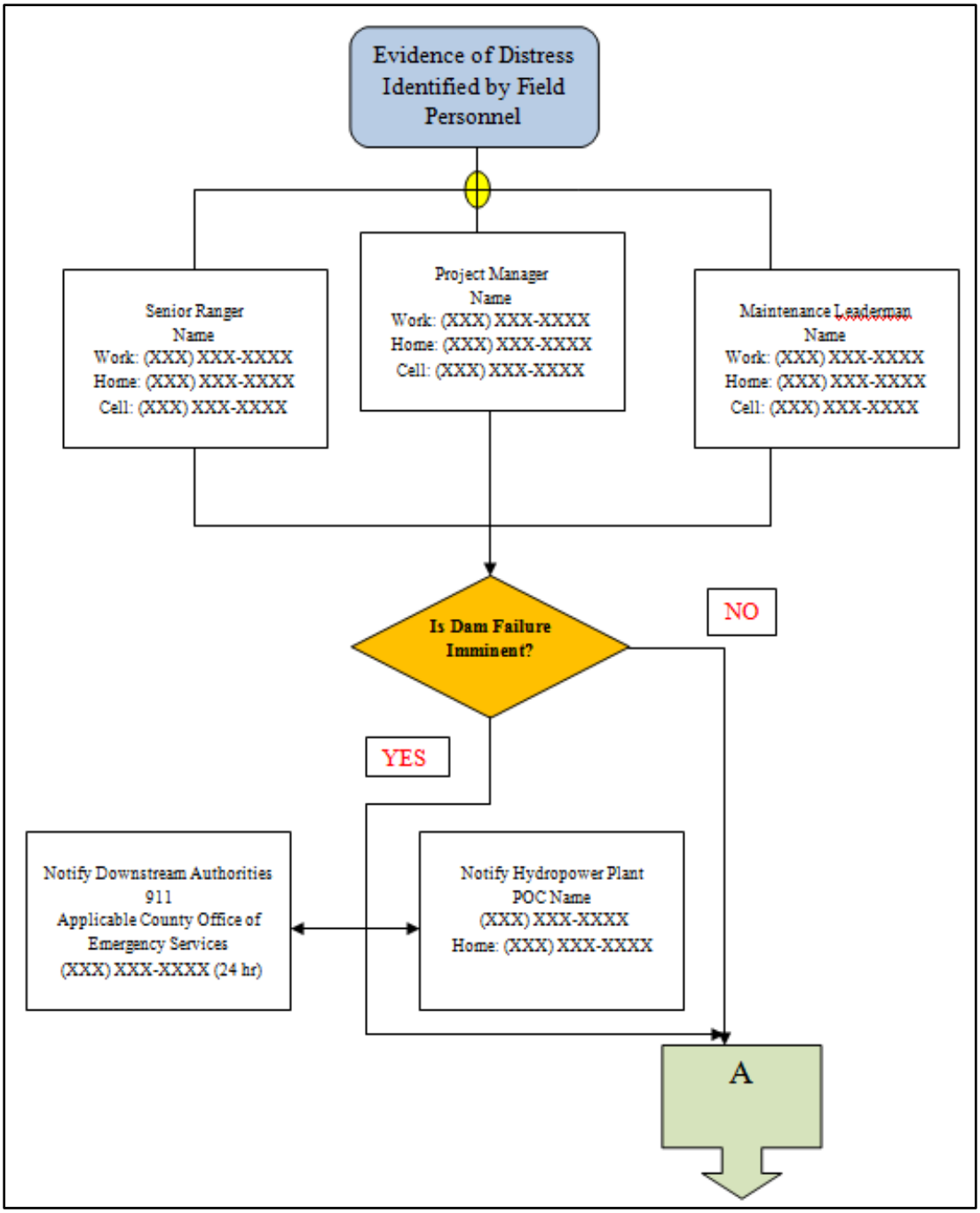
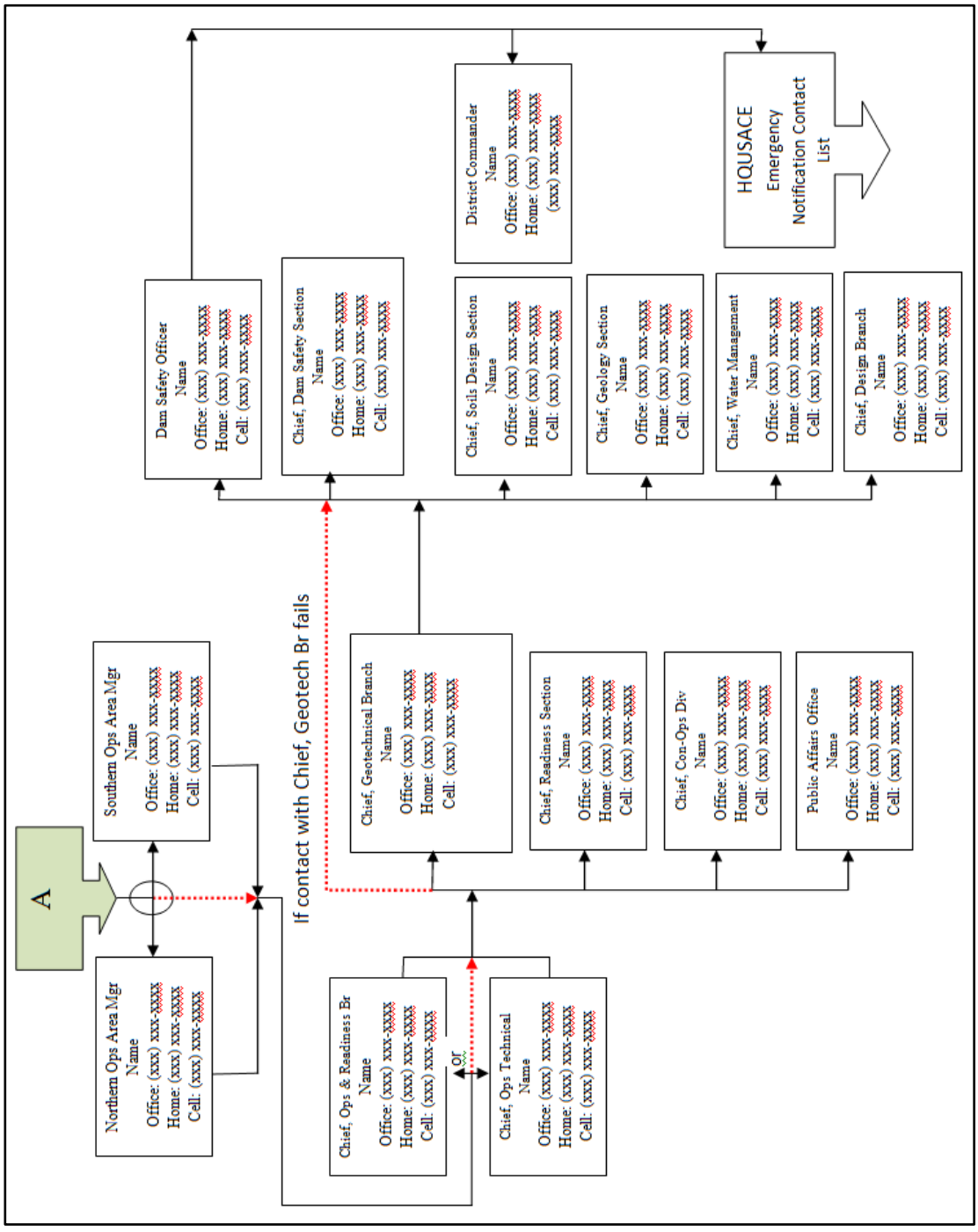


Figure B-1. Post-Earthquake Safety Emergency Notification Flow Chart (Example for a Dam).



(POC names and process will differ for other types of projects.)

Figure B-2. Post-Earthquake Safety Emergency Notification Flow Chart (Generic Example for Dams)
— Reporting Evidence of District to District.

Appendix C

Earthquake Inspection Criteria – Simplified Model

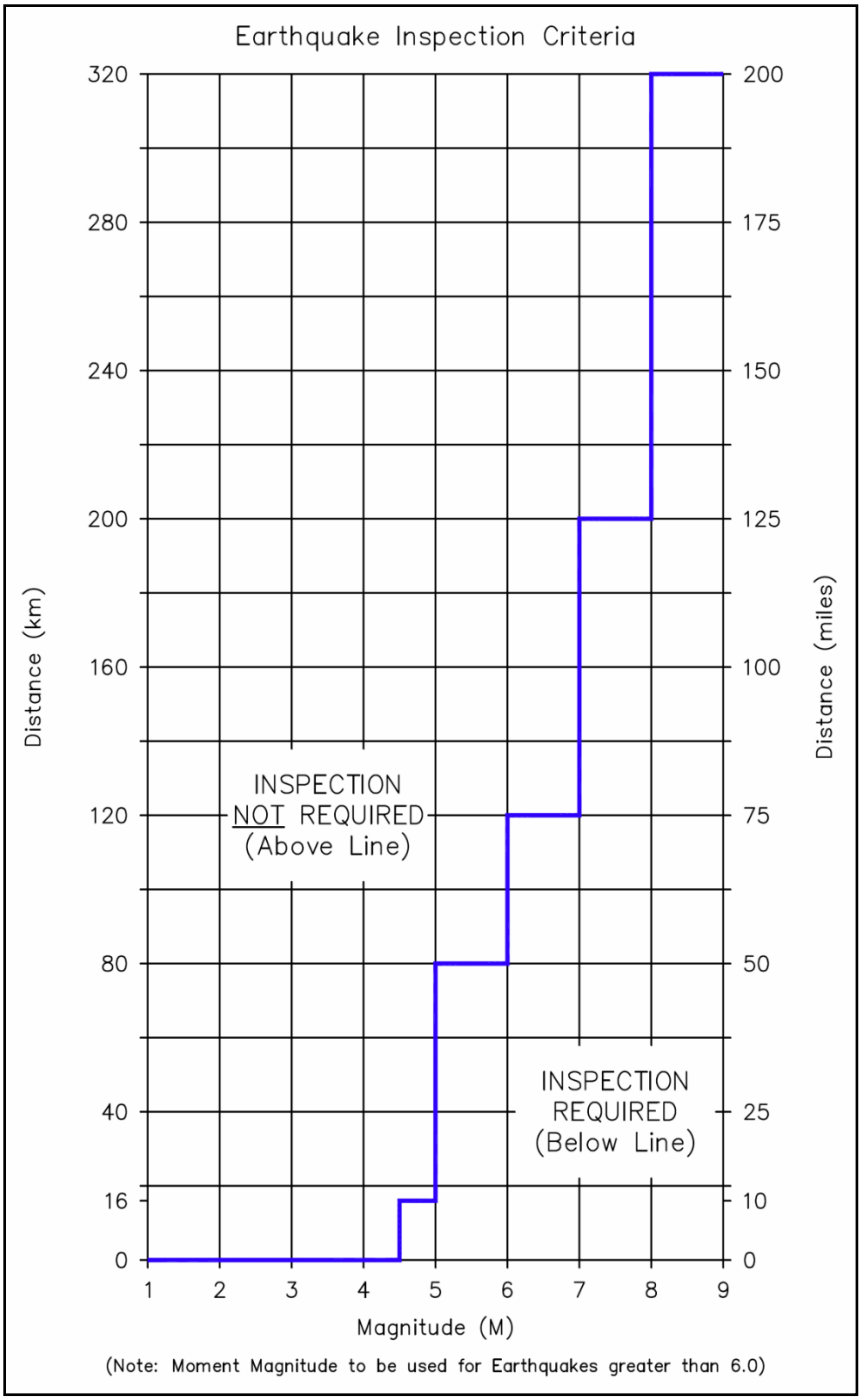


Figure C-1. Earthquake Inspection Criteria – Simplified Model.

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Appendix D

Seismic Hazard in the United States.

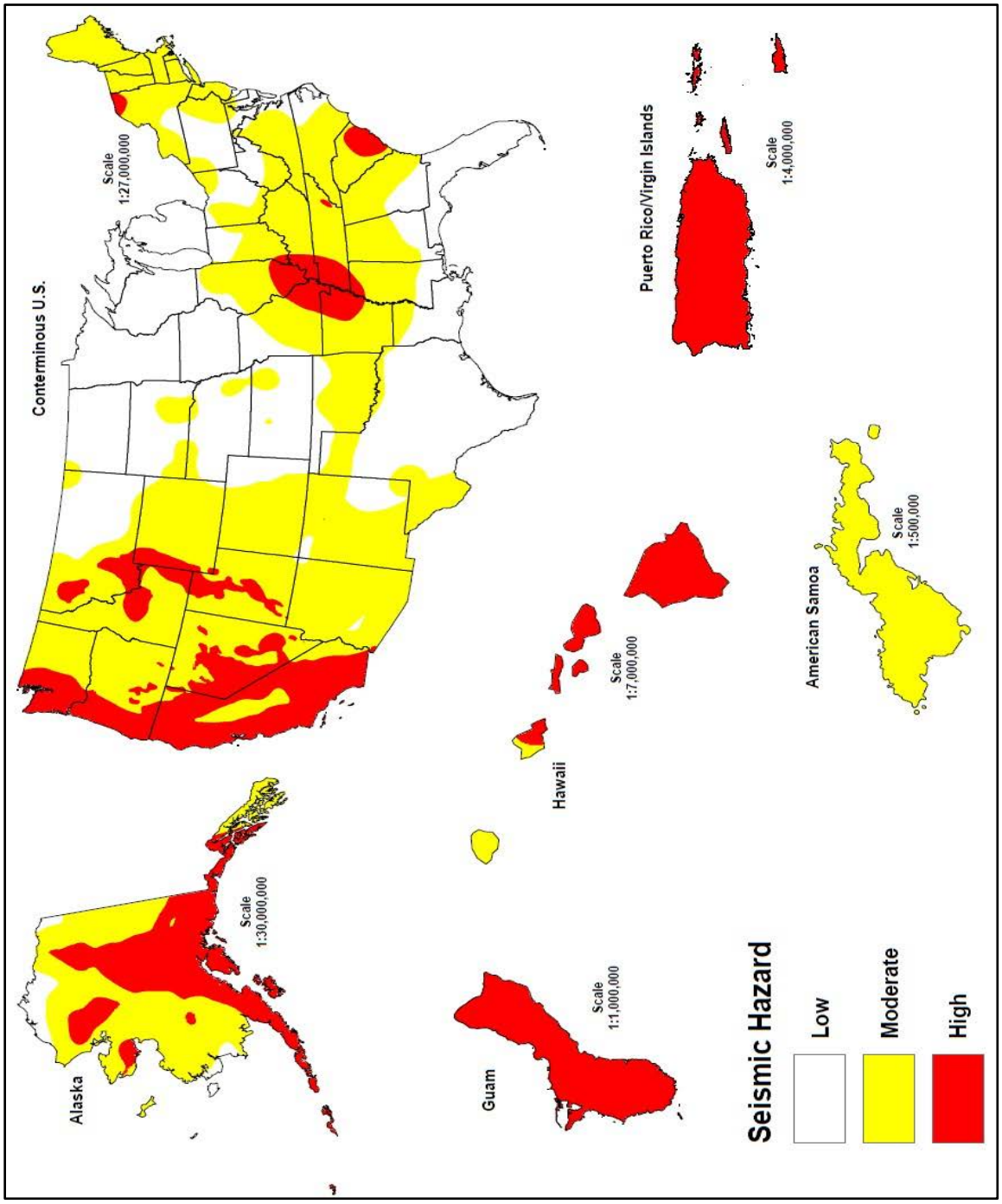

Figure D-1. Seismic Hazard in the United States (Based on USGS maps of 2013).

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