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The National Earthquake Hazards Reduction Program (NEHRP): Overview and Issues for Congress

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SUMMARY

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The National Earthquake Hazards Reduction Program (NEHRP): Overview and Issues for Congress

The National Earthquake Hazards Reduction Program (NEHRP) aims to understand earthquake hazards and reduce earthquake risks in the United States. Portions of all 50 states, as well as U.S. territories and the District of Columbia, are vulnerable to earthquake hazards and their associated risks, to varying degrees. Each region's risk is shaped by the frequency and scale of the hazard as well as by the population, infrastructure, and economic activity exposed to the hazard. Alaska is the most earthquake-prone state; it has experienced a magnitude 7.0 earthquake most years and a magnitude 8.0 earthquake every 13 years, on average, since 1900. Earthquakes can trigger damaging tsunamis, which can be particularly threatening for Alaska, Washington, Oregon, California, and Hawaii. California is the state with the greatest earthquake risk, because the state has frequent earthquakes that affect a dense built environment and a large population. The 1994 magnitude 6.7 Northridge earthquake in Los Angeles, Ventura, Orange, and San Bernardino counties is one of the costliest disasters in the United States.

Congress created NEHRP as a coordinated program through the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) and most recently reauthorized the program in 2018 (P.L. 115-307). Congress assigned the National Institute of Standards and Technology (NIST) as the lead agency for NEHRP in 1990. Four federal agencies have responsibilities related to earthquake hazards and risk reduction—the U.S. Geological Survey (USGS), the National Science Foundation (NSF), the Federal Emergency Management Agency (FEMA), and NIST. These agencies perform the four major NEHRP activities:

1. Develop effective measures for earthquake hazards reduction
2. Promote the adoption of earthquake hazards reduction measures
3. Improve understanding of earthquakes and their effects
4. Continue the development of the Advanced National Seismic System, a nationwide network of seismic stations operated by the USGS

The 2018 NEHRP reauthorization maintained the program's overall structure and established new priorities. For example, the legislation emphasized advancing earthquake early warning systems and promoting community resilience to earthquakes. An earthquake early warning system detects the start of an earthquake and sends an alert that intense and potentially damaging ground shaking will reach a nearby location within seconds to minutes of the alert's receipt. Various actions can enhance community resilience, such as building earthquake-resistant structures based on a location's seismic hazard and designing structures for *functional recovery*, meaning the structures can be reoccupied and function after an earthquake.

Since the 2018 reauthorization, NEHRP has addressed warning, resilience, and research, among other activities. An earthquake early warning system called *ShakeAlert* operates in California, Oregon, and Washington, providing actionable alerts to protect people and property from earthquake hazards. NIST and FEMA have supplied information and tools to build and retrofit structures for greater earthquake resistance and for functional recovery. NSF and the USGS support research and have initiated new research opportunities coordinated across NSF directorates or across agencies.

Issues for Congress about NEHRP include the program's effectiveness (i.e., how much and how well NEHRP reduces risks), the effectiveness of federal and nonfederal partnerships (i.e., how well the four agencies work together and with other partners), and the effectiveness of program management (i.e., how well the agencies plan, manage, and implement program objectives). The FY2022-FY2029 strategic plan for NEHRP and a Government Accountability Office report on the effectiveness of the program may inform congressional deliberations about NEHRP and consideration of extending the program's authorization of appropriations beyond FY2023. Legislation introduced in the 118th Congress would amend and, in some cases, reauthorize appropriations for NEHRP. In addition, according to NEHRP, FY2024 appropriations supported NEHRP activities at the four agencies at funding levels similar to FY2023 appropriations.

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Introduction

The United States is vulnerable to earthquake hazards and their associated risks.[1] Figure 1 shows the chance of damaging earthquake shaking over 100 years as calculated by the 2023 U.S. Geological Survey's (USGS's) 50-State Seismic Hazard Model. The figure also shows population density.[2]

Earthquake hazards occur more frequently in the western United States, particularly in California, Washington, Oregon, Alaska, and Hawaii.[3] Alaska is the most earthquake-prone state; it has experienced a magnitude (M) 7.0 earthquake most years and a M8.0 earthquake every 13 years, on average, since 1900.[4] Despite being the most earthquake-prone state, Alaska's relatively low population and built environment density mean the state has a smaller exposure to earthquake damage and a lower earthquake risk than some other states (Figure 1). For example, California has greater earthquake risk than Alaska, because of California's frequent seismic activity and comparatively larger population and built environment density.[5]

[1] The Federal Emergency Management Agency (FEMA) defines a *hazard* as a source of potential danger or an adverse condition. Earthquake hazards include ground shaking, ground displacement, and liquefaction. Earthquakes may trigger additional hazards, such as subsequent earthquakes, landslides, tsunamis/seiches, and/or volcanic activity. FEMA defines *risk* as the likelihood of sustaining a loss from a hazard event defined in terms of expected probability and frequency, exposure, and consequences, such as death and injury, financial costs of repair and rebuilding, and loss of use. Liquefaction occurs when loose, weak, or water-saturated soils or rocky materials lose their strength because of earthquake-caused ground shaking. When liquefaction happens around structural elements, such as buildings or bridges, these structures can be damaged or collapse. For more information about liquefaction, see U.S. Geological Survey (USGS), "What Is Liquefaction?," https://www.usgs.gov/faqs/what-liquefaction.

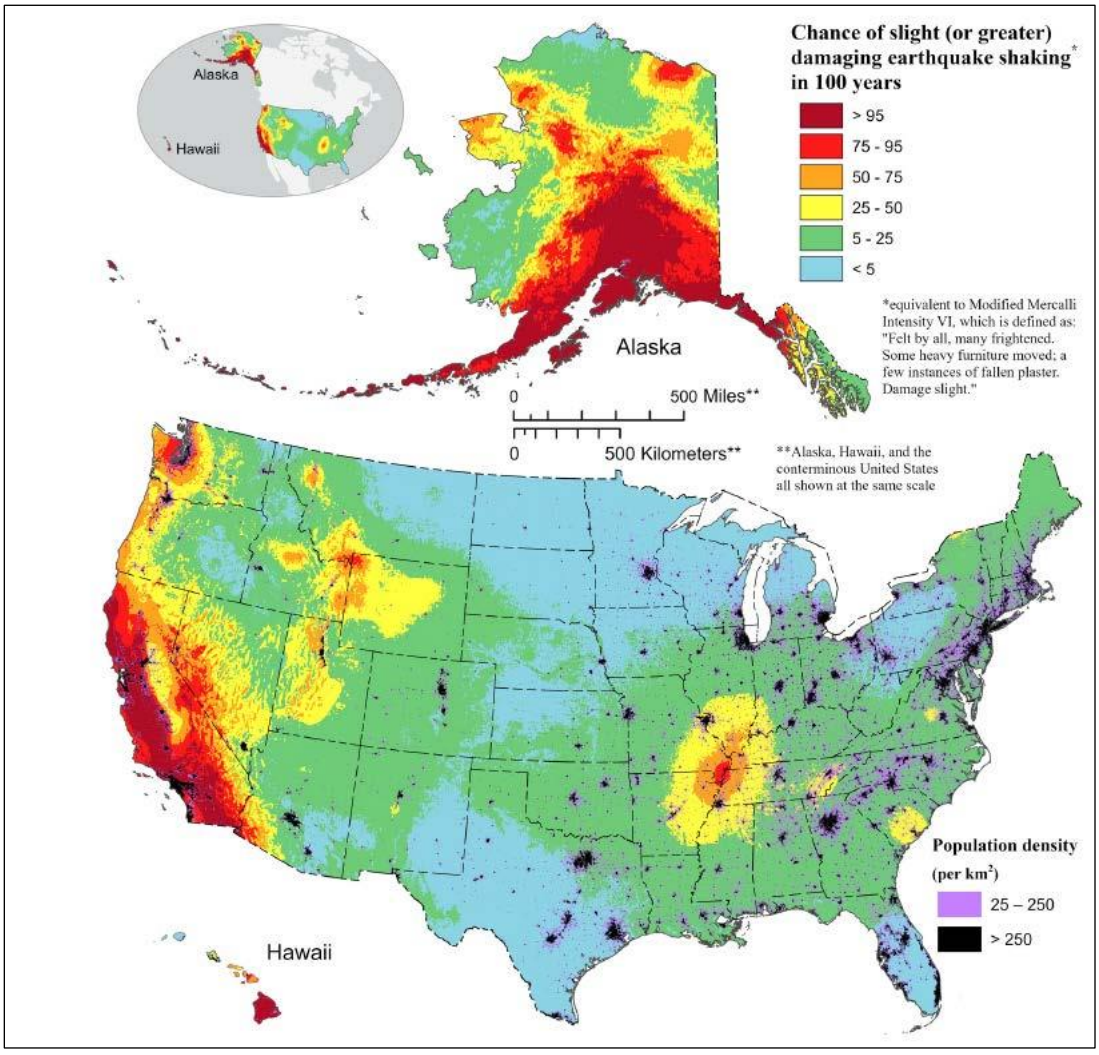
[2] The degree of earthquake *risk* is the combination of the degree of earthquake hazard and the extent of the affected population (which includes the built environment supporting that population). Large population centers may be at a higher risk than small population centers for the same degree of earthquake hazard, in general.

[3] The San Andreas Fault System in California; the Cascadia Subduction Zone offshore of Northern California, Oregon, and Washington; the Alaska-Aleutian Subduction System offshore of Alaska; the Denali Fault System in Alaska; and the Hawaiian Hot Spot Plume, volcanic activity, and volcanogenic fault system in Hawaii account for most of the greater earthquake hazards in the western United States. See Figure 1 and a more detailed explanation in Mark D. Petersen et al., "The 2023 U.S. 50-State National Seismic Hazard Model: Overview and Implications," *Earthquake Spectra* 2024, vol. 40, no. 1, pp. 5-88, https://doi.org/10.1177/87552930231215428.

[4] State of Alaska, Alaska Seismic Hazards Safety Commission, "Earthquake Risk in Alaska," http://seismic.alaska.gov/earthquake-risk.html.

[5] For estimates of earthquake hazards and risks displayed on maps divided into states, see the USGS's National Seismic Hazard Map. USGS, Earthquake Hazards, "Seismic Hazard Maps and Site-Specific Data," at " https://www.usgs.gov/natural-hazards/earthquake-hazards/seismic-hazard-maps-and-site-specific-data; and FEMA, *Hazus Estimated Annualized Earthquake Losses for the United States*, FEMA P-366, April 2017, Figure E-1.

Figure 1. USGS Seismic Hazard Model, 2023



Source: Mark D. Peterson et al., "The 2023 US 50-State National Seismic Hazard Model: Overview and Implications," *Earthquake Spectra*, vol. 40, no. 1 (2024), DOI: 10.1177/87552930231215428.

Some selected significant earthquakes in the United States serve to demonstrate the variable impacts on communities and identify some of the different risks.

- The most damaging and costliest earthquake in the United States was the 1994 M6.7 Northridge earthquake in the Los Angeles metropolitan region, which caused 60 fatalities and more than 7,000 injuries; displaced 22,000 people; damaged more than 40,000 buildings; and resulted in estimated residential damage of $20 billion in 1994 dollars (about $42 billion in 2024 dollars).[6]

[6] USGS, "Impact Summary," https://earthquake.usgs.gov/earthquakes/eventpage/ci3144585/impact; and California Earthquake Authority, "Northridge Earthquake Remembered as One of the Costliest Natural Disasters in U.S. History," press release, https://www.earthquakeauthority.com/Press-Room/Press-Releases/2019/Northridge-earthquake-remembered.

- The largest recorded magnitude earthquake in the United States, which triggered tsunami waves and landslides, was the 1964 M9.2 Anchorage earthquake.[7] The multi-hazard event caused 131 fatalities (122 tsunami-related and 9 earthquake-related) and an estimated property loss of $311 million in 1964 dollars (about $8.1 billion in 2024 dollars).
- The 1906 estimated M7.7 San Francisco earthquake ruptured a segment of the San Andreas fault for about 296 miles.[8] The earthquake is among the most well-studied seismic events in the United States and elsewhere. The earthquake precipitated extensive fires throughout a dense urban environment. The earthquake and fire hazards caused an estimated 700 fatalities (189 of these were reported outside of San Francisco), though experts believe this figure underestimates the actual loss of life due to the earthquake and fires in San Francisco.
- Among the least understood earthquake events in the United States is a sequence of earthquakes near New Madrid, MO. An estimated M7.5 event in December 1811, an estimated M7.3 event in January 1812, and an estimated M7.5 event in February 1812 created conditions on the ground that changed the flow of the Mississippi River and caused minor damage in what was a mostly undeveloped region in the early 1800s.[9] The USGS and others have identified the New Madrid seismic zone and the nearby Wabash Valley seismic zone, where earthquakes of small magnitude continue. How the possible fault systems generate earthquakes in these zones is poorly understood. The USGS and others continue to consider earthquake sequences and the possibility of one earthquake triggering another earthquake.[10]

A 2023 Federal Emergency Management Agency (FEMA)-USGS study notes that earthquake risks are rising and are a national problem. The study estimates annualized earthquake losses to the national building stock is $14.7 billion per year. The earthquake hazard has not changed, but the vulnerable population and infrastructure have grown. For example, recent earthquakes show a pattern of increasing damage and losses due to (1) substantial population and development growth in earthquake-prone urban areas, (2) higher contribution due to nonstructural damage, content, and functional losses, (3) vulnerability of aging building stock that was not built to more modern earthquake-resistant designs, and (4) increased economic impacts beyond the earthquake-damaged areas due to business supply and demand interdependencies.

In 1977, Congress directed the federal government to establish a national and coordinated program to assess and monitor earthquake hazards and to reduce earthquake risks in the United States. The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) was enacted on October 7, 1977, and has been reauthorized a dozen times as of November 2024 (**Table 1**). The federal agencies that comprise the National Earthquake Hazards Reduction Program (NEHRP) conduct

[7] USGS, "M9.2 Alaska Earthquake and Tsunami of March 27, 1964," https://earthquake.usgs.gov/earthquakes/events/alaska1964/.

[8] USGS, "The Great 1906 San Francisco Earthquake," https://earthquake.usgs.gov/earthquakes/events/1906calif/18april/.

[9] USGS, "1811-1812 New Madrid Missouri Earthquakes," https://www.usgs.gov/programs/earthquake-hazards/science/1811-1812-new-madrid-missouri-earthquakes.

[10] USGS, "Special Earthquakes, Earthquake Sequences, and Fault Zones," https://www.usgs.gov/programs/earthquake-hazards/special-earthquakes-earthquake-sequences-and-fault-zones.

research, assessments, and analysis to identify earthquake hazards and help reduce earthquake risks.

Table 1. Earthquake Hazard Reduction Act and Subsequent Reauthorizations

Date of Enactment	Public Law	U.S. Statute Citation
October 7, 1977	P.L. 95-124	91 Stat. 1098
October 19, 1980	P.L. 96-472	94 Stat. 2257
November 20, 1981	P.L. 97-80	95 Stat. 1081
January 12, 1983	P.L. 97-464	96 Stat. 2533
March 22, 1984	P.L. 98-241	98 Stat. 95
September 30, 1985	P.L. 99-105	99 Stat. 475
February 29, 1988	P.L. 100-252	102 Stat. 18
November 16, 1990	P.L. 101-614	104 Stat. 3231
October 19, 1994	P.L. 103-374	108 Stat. 3492
October 1, 1997	P.L. 105-47	11 Stat. 1159
November 13, 2000	P.L. 106-503	114 Stat. 2298
October 25, 2004	P.L. 108-360	118 Stat. 1668
December 11, 2018	P.L. 115-307	132 Stat. 4480

Source: NEHRP, *Strategic Plan for the National Earthquake Hazards Reduction Program, Fiscal Years 2022-2029*, April 2023, https://www.nehrp.gov/pdf/FY2022-29%20NEHRP%20Strategic%20Plan%20-%20Post%20Version.pdf.

The four major NEHRP activities are (1) develop effective measures for earthquake hazards reduction; (2) promote the adoption of earthquake hazards reduction measures; (3) improve understanding of earthquakes and their effects; and (4) continue the development of the Advanced National Seismic System (ANSS), a nationwide network of seismic stations. Today, four federal agencies responsible for earthquake risk reduction coordinate their activities under NEHRP: the USGS, National Science Foundation (NSF), FEMA, and National Institute of Standards and Technology (NIST). For an overview of each agency's responsibilities, see **Table 2**.

Table 2. National Earthquake Hazards Reduction Program (NEHRP) Agencies: Roles and Activities

Agency	Roles and Activities
NIST	• Is the lead agency for NEHRP and coordinates NEHRP activities • Conducts applied earthquake engineering research to provide the technical basis for building codes, standards, and building practices • Is responsible for research and development to close the gap between research and implementation of earthquake risk mitigation technologies
FEMA	• Assists other agencies and private-sector groups to prepare and disseminate building codes and practices for structures and lifeline infrastructure • Aids development of performance-based codes for buildings and other structures • Supports communication of earthquake early warning alerts via the Integrated Public Alert and Warning System and Wireless Emergency Alerts[a]

USGS	• Provides earthquake monitoring and notification, earthquake hazards assessments, earthquake hazards maps, and earthquake research • Operates the Advanced National Seismic System (ANSS), regional geodetic networks, and the National Earthquake Information Center (NEIC) to provide earthquake understanding, information, warning, and response[b]
NSF	• Supports basic research in the earth sciences, engineering, and social sciences to understand earthquakes, their hazards, and their risk reduction • Supports additional engineering research through the Natural Hazards Engineering Research Infrastructure (NHERI);[c] additional earth science research through the Seismological Facility for the Advancement of Geoscience (SAGE), the Geodetic Facility for the Advancement of Geoscience (GAGE),[d] the Cascadia Region Earthquake Science Center (CRESCENT),[e] and the Subduction Zones in Four Dimensions (SZ4D);[f] and additional social science research through the Natural Hazards Center (NHC)[g]
USGS and NSF	• Together, support the Global Seismographic Network (GSN),[h] regional networks, the Statewide California Earthquake Center,[i] earthquake research, earthquake early warning,[j] post-earthquake assessments, and education and outreach

Source: Activities summarized from NEHRP's website under, "About Us," https://www.nehrp.gov/about/agencies.htm.

Notes: FEMA = Federal Emergency Management Agency; NIST = National Institute of Standards and Technology; NSF = National Science Foundation; USGS = U.S. Geological Survey.

a. See FEMA, "Integrated Public Alert & Warning System," https://www.fema.gov/emergency-managers/practitioners/integrated-public-alert-warning-system; and FEMA, "Wireless Emergency Alerts," https://www.fema.gov/emergency-managers/practitioners/integrated-public-alert-warning-system/public/wireless-emergency-alerts.

b. For more information about ANSS, NEIC, GSN, and other USGS earthquake monitoring efforts see the USGS, Earthquake Hazards, "Monitoring," https://www.usgs.gov/natural-hazards/earthquake-hazards/monitoring.

c. See NSF's NHERI description at NSF, "Natural Hazards Engineering Research Infrastructure (NHERI)," https://new.nsf.gov/funding/opportunities/natural-hazards-engineering-research.

d. See NSF's award descriptions: NSF, "Award Abstract # 1724794 Enabling Discoveries in Multiscale Earth System Dynamics: Geodetic Facility for the Advancement of Geoscience (GAGE)," https://www.nsf.gov/awardsearch/showAward?AWD_ID=1724794, and NSF, "Award Abstract # 1851048 Enabling Discoveries in Multiscale Earth System Dynamics: Seismological Facility for the Advancement of Geoscience (SAGE) - EAR Scope," https://www.nsf.gov/awardsearch/showAward?AWD_ID=1851048.

e. Cascadia Region Earthquake Science Center, https://cascadiaquakes.org/.

f. SZ4D, "SZ4D," https://www.sz4d.org/.

g. See NSF's NHC description at Natural Hazards Center at https://hazards.colorado.edu/.

h. See the USGS's GSN description at USGS, "GSN—Global Seismographic Network," https://www.usgs.gov/natural-hazards/earthquake-hazards/gsn-global-seismographic-network.

i. For more information about the Statewide California Earthquake Center (SCEC), see https://www.scec.org. SCEC was established in 1991 as the Southern California Earthquake Center with funding from NSF, the USGS, and others. SCEC changed its name in 2023 consistent with its expanded geographic scope of the entire fault system in California.

j. For more information about the earthquake early warning system operating in California, Oregon, and Washington, see the ShakeAlert website at https://www.shakealert.org.

Major Changes to NEHRP Since 1977

In 1977, Congress passed the Earthquake Hazards Reduction Act (P.L. 95-124), establishing NEHRP as a *coordinated* earthquake hazards reduction program for the United States.[11] The legislation directed the President to establish a program to advance the following objectives:

- Development of earthquake-resistant construction
- Earthquake prediction and identification and assessment of seismic hazards
- Development and promotion of model codes for land use and building
- Development of earthquake preparedness, warning, response, and recovery
- Development of research to increase earthquake hazards and risks knowledge to reduce risks, deal with prediction consequences, assure insurance availability, and control seismic events

The law authorized appropriations for the USGS and NSF to carry out these objectives. Congress did not specify a lead agency or specific activities for other agencies. In 1978, NEHRP organized the Interagency Committee on Seismic Safety in Construction (ICSSC). ICSSC includes federal agencies engaged in construction, financing construction, or related activities.[12] In 1990, Congress directed the ICSSC to develop standards for assessing and enhancing the seismic safety of existing buildings constructed or leased by the federal government (P.L. 101-614). The most recent ICSSC standard guidelines were published in 2022.[13]

FEMA was created in 1979. In 1980, Congress amended the Earthquake Hazards Reduction Act in P.L. 96-472 to make FEMA the lead agency. Since 1980, NEHRP has been a coordinated program of four agencies: the USGS, NSF, FEMA, and NIST (formerly National Bureau of Standards). In 2004, Congress designated NIST as the lead agency for NEHRP in the National Earthquake Hazards Reduction Program Reauthorization Act of 2004, P.L. 108-360.

The USGS and NSF roles in NEHRP initially focused on research to understand and predict earthquakes. However, earthquake prediction proved insoluble,[14] and NEHRP shifted its focus beginning in 1990 to understanding, monitoring, assessing, and issuing early warnings soon after detection of an earthquake and responding to earthquakes.[15] Congress removed language from the

[11] Congress emphasized a *coordinated* program in the Earthquake Hazards Reduction Act (P.L. 95-124). It also requested management, budget, and implementation plans to explain how the program would carry out its objectives and to define the roles and responsibilities of federal agencies involved in the program. P.L. 95-124 directed the President to establish the program to include the USGS, the National Science Foundation (NSF), Department of Defense, Department of Housing and Urban Development, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Bureau of Standards, Energy Research and Development Administration, Nuclear Regulatory Commission, and National Fire Prevention and Control Administration. Congress also called for coordination and cooperation with state and local governments in P.L. 95-124; this directive remains part of the statute.

[12] National Earthquake Hazards Reduction Program, "About Us, Interagency Committee on Seismic Safety in Construction (ICSSC)," https://www.nehrp.gov/about/icssc.htm.

[13] National Institute of Standards and Technology (NIST), *Standards of Seismic Safety for Existing Federally Owned and Leased Buildings: ICSSC Recommended Practice 10 (RP 10-22)*, NIST Interagency Report, NIST IR 8458e2022, 2022, https://nvlpubs.nist.gov/nistpubs/ir/2023/NIST.IR.8458e2022.pdf.

[14] See, for example, the USGS, "Can You Predict Earthquakes?," https://www.usgs.gov/faqs/can-you-predict-earthquakes?qt-news_science_products=0#qt-news_science_products.

[15] The National Earthquake Hazards Reduction Program (NEHRP) shifted its focus from predicting earthquakes to issuing a warning after an earthquake is detected in the 1990s. Congress's initial, prediction-focused definition of *earthquake warning* in P.L. 95-124 arose because China had predicted and evacuated over a million people about five (continued...)

statutory authority of the program related to earthquake prediction in the National Earthquake Hazards Reduction Program Reauthorization Act of 2018 (P.L. 115-307).

Congress reauthorized NEHRP in 1990, 1997, 2000, and 2004 and changed the program's emphasis and oversight in various ways, as detailed below.

- In 1990, the National Earthquake Hazards Reduction Program Reauthorization Act (P.L. 101-614) directed the USGS to study faults and earthquakes to determine earthquake frequency, provide a seismic hazards assessment, and conduct research and development for earthquake-resistant structures. The amendments directed the USGS to establish a Center for International Exchange of Earthquake Information; operate a National Seismic Network; continue work on earthquake prediction, and conduct post-earthquake investigations with NSF. The law directed NIST to develop seismic standards for buildings and *lifelines* (i.e., essential utility and transportation systems).[16] It established a NEHRP Advisory Committee until September 30, 1993, to report on NEHRP activities and advise the program.[17] The act directed the Office of Science and Technology Policy (OSTP) to study and report on interagency collaboration.
- In 1997, P.L. 105-47 amended NEHRP to (1) direct the USGS to develop a prototype real-time seismic warning system,[18] (2) allow NSF to use competitive grants to develop earth science education materials for kindergarten through 12th grade, and (3) request FEMA to study and assess national earthquake emergency training capabilities.
- In 2000, P.L. 106-503 amended NEHRP to (1) direct the USGS to establish an Advanced National Seismic Research and Monitoring program and a Scientific Earthquake Studies Advisory Committee (SESAC) and (2) direct NSF to establish the George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES) program to research earthquakes' effects on structures and to develop improved designs for earthquake-resistant structures.[19] SESAC issued a

hours before a damaging earthquake struck on February 4, 1975 (see the USGS, Earthquake Hazards Program, "Repeating Earthquakes," https://earthquake.usgs.gov/learn/parkfield/eq_predict.php) and because research suggested prediction and imminent warning for earthquakes might be feasible. H.Rept. 95-286 Part 1, stated, "As defined in the act, an earthquake prediction is a prediction, in definite or probabilistic terms, of the time, place, and magnitude of an earthquake, whereas an earthquake warning means a recommendation that normal life routines should be changed for a time because an earthquake is believed imminent." However, to date, there is no feasible way to provide an earthquake prediction or a warning that an earthquake is imminent. Today, the terms *earthquake warning* and *earthquake early warning* typically are defined as a warning that damaging ground shaking may reach a warned location within seconds to minutes after an earthquake has been detected as starting.

[16] Within the earthquake community, the term *lifelines* generally has been replaced by the term *lifeline infrastructure*. See Earthquake Engineering Research Institute, "Improve Reliability of Lifeline Infrastructure Systems," white paper, April 5, 2016, https://www.eeri.org/wp-content/uploads/eeri-policy-lifelines.pdf.

[17] The NEHRP Advisory Committee was composed of experts outside of the NEHRP agencies. Congress intended the committee to review NEHRP and present its findings to Congress, while advising NEHRP about its review. Congress established a new Advisory Committee on Earthquake Hazards Reduction (ACEHR) in 2004. ACEHR is distinct from the previous committee, but the two share some aspects of committee structure and some objectives.

[18] This warning system refers to providing an automated alert to high-risk activities (e.g., stopping trains when an earthquake is detected) about damaging ground shaking after an earthquake starts.

[19] From FY2004 through FY2014, the George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES) program activities consisted of 15 experimental facilities and an information-technology infrastructure with a goal of mitigating earthquake damage by the using improved materials, designs, construction techniques, and monitoring tools. NSF ended NEES in FY2014 and started the Natural Hazards Engineering Research Infrastructure (NHERI) program (continued...)

special report to USGS in 2023 expressing concern about staff deficits "in critical scientific, technical, and administrative positions" in the USGS Earthquake Hazards Program.[20] The USGS submitted a renewed charter for SESAC to Congress in September 2024.

- In 2004, P.L. 108-360 established an Interagency Coordinating Committee (ICC) and an Advisory Committee on Earthquake Hazards Reduction (ACEHR).[21] The ICC consisted of the USGS, NSF, FEMA, NIST, OSTP, and the Office of Management and Budget.

NEHRP Reauthorization Act of 2018 (P.L. 115-307)

The NEHRP Reauthorization Act of 2018 (P.L. 115-307) kept the four-agency program intact. The act called for additional oversight, management planning, and strategic planning to enhance coordination, cooperation, and efficient progress on objectives. The act expanded emphasis on earthquake early warning systems and earthquake-resistant construction and requested support for resilience, such as earthquake-resistant structures that continue to function after an event and communities that are prepared to respond effectively to and recover efficiently from a seismic event.[22]

Changes to Findings, Purposes and Definitions (Section 2)

Starting in the 1990s, NEHRP activities shifted from earthquake prediction to earthquake warning after an earthquake is detected. The 2018 NEHRP reauthorization act codified that shift by removing references to earthquake prediction throughout the act. For example, Section 2 of the 2018 act modified the congressional findings section (42 U.S.C. 7701) by removing the linkage between seismological research and earthquake prediction, substituting the finding that "a well-funded seismological research program could provide the scientific understanding needed to fully implement an effective earthquake early warning system."[23]

Section 2 of the 2018 act introduced the concept of *resilience* to earthquake hazards.[24] For example, Section 2 cited a National Research Council study with objectives for achieving

in FY2015. NHERI is a distributed, multiuser, national facility that provides research infrastructure for the natural hazards research community, including earthquake and wind engineering experimental facilities, cyber infrastructure, computational modeling and simulation tools, and research data. A description of NHERI facilities and opportunities is available at NSF, "Natural Hazards Engineering Research Infrastructure (NHERI)," at https://new.nsf.gov/funding/opportunities/nheri-natural-hazards-engineering-research-infrastructure.

[20] USGS, "Scientific Earthquake Studies Advisory Committee," https://www.usgs.gov/programs/earthquake-hazards/scientific-earthquake-studies-advisory-committee-sesac.

[21] ACEHR is composed of 11 outside experts on earthquake hazard risk reduction from science, engineering, and industry standards organizations; financial organizations; and state and local governments. ACEHR is to provide the following assessments in biennial reports to Congress: (1) trends and developments in the science and engineering of earthquake hazards reduction; (2) effectiveness of NEHRP; (3) the need to revise NEHRP; and (4) NEHRP's management, coordination, implementation, and activities. ACEHR is distinct from the congressionally established 1990 NEHRP Advisory Committee, which ended its service in 1993.

[22] CRS Report R47121, *The ShakeAlert Earthquake Early Warning System and the Federal Role*, by Linda R. Rowan; and CRS Report R47215, *Hazard-Resilient Buildings: Sustaining Occupancy and Function After a Natural Disaster*, by Linda R. Rowan.

[23] For a discussion of prediction and warning and the changes in the meaning of a warning system see footnote 15.

[24] The term *resilience* in discussions regarding reducing earthquake risk and resilience typically refers to better preparations, better situational awareness, and more earthquake-resistant structures that lead to less damage and faster (continued...)

national earthquake resilience.[25] Section 2 amended the congressional statement-of-purpose section (42 U.S.C. 7702) to add the purpose of increasing communities' resilience to future earthquakes to the existing purpose of reducing risks to life and property. The definitions section of the 2018 act defined *community resilience* as "the ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to seismic events" (42 U.S.C. 7703). Section 2 of P.L. 115-307 called for resilience to include building design and construction, so that structures are built to potentially continue functioning or be reoccupied despite earthquake damage. Section 2 introduced the language of "re-occupancy, recovery, reconstruction."

In addition, P.L. 115-307 added the states of Oregon and Tennessee, along with the Commonwealth of Puerto Rico, to the states the law named as facing significant earthquake risk.[26] The 2018 law noted that 39 states face major or moderate seismic risk (42 U.S.C. 7701; **Figure 1**).

Changes to Program Activities and Agency Responsibilities (Section 3)

Section 3 of the 2018 NEHRP reauthorization act added new duties for the ICC. P.L. 115-307 required the ICC to develop a strategic plan for NEHRP, a management plan to implement the strategic plan, and a coordinated interagency budget on a biennial basis. The ICC completed a strategic plan for FY2022-FY2029 and noted eight focus areas:

1. Advance earthquake science for subduction zone regions[27]
2. Develop enhanced performance-based seismic design procedures and metrics for functional recovery of buildings and infrastructure
3. Advance performance-based seismic design and assessment methods to implement multisystem coordination
4. Further expand earthquake early warning capabilities
5. Develop consistent performance guidance for lifeline infrastructure
6. Enhance guidance to ensure information and tools effectively support the needs of those who implement mitigation, preparedness, and recovery measures
7. Advance the science of earthquake sequence characterization[28]

recovery from an earthquake. *Earthquake-resistant structures* are structures that are capable of withstanding, with less damage, an earthquake that could harm people and property and that are capable of reoccupation and function right after an earthquake.

[25] National Research Council (NRC), *National Earthquake Resilience, Research, Implementation, and Outreach*, 2011, http://www.nehrp.gov/pdf/nrc2011.pdf, (hereinafter, NRC, *Earthquake Resilience*, 2011).

[26] The act specifies 15 states—Alaska, California, Hawaii, Illinois, Massachusetts, Missouri, Montana, Nevada, Oregon, New Jersey, New York, South Carolina, Tennessee, Utah, and Washington—and the Commonwealth of Puerto Rico as facing significant earthquake risks.

[27] Subduction zone regions are areas where tectonic plates converge and one plate slides beneath the other plate (called subduction by geoscientists). In general, these regions have earthquakes and volcanic activity. Earthquakes and volcanic activity may trigger other hazards such as tsunamis and landslides. USGS, "Introduction to Subduction Zones: Amazing Events in Subduction Zones," https://www.usgs.gov/special-topics/subduction-zone-science/science/introduction-subduction-zones-amazing-events.

[28] Earthquake sequence characterization refers to understanding how earthquakes are related to each other in space and time. In general, the largest magnitude earthquake in a sequence is called the mainshock while smaller magnitude earthquakes that occur before the mainshock are called foreshocks and after the mainshock are called aftershocks. Personal communication between USGS and CRS, July, 2023.

8. Enhance risk reduction strategies for federal agencies[29]

In addition, P.L. 115-307 required the ICC to develop memoranda of understanding with any relevant federal agencies (such as the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration) on data sharing and resource commitments in the event of an earthquake disaster.

Further, the ICC shall coordinate with the Secretaries of Agriculture and the Interior on the use of federal lands for monitoring, research, and data collection. The ICC shall coordinate with the Secretaries of Transportation and Housing and Urban Development on earthquakes' effects on transportation and building stocks (including the lifeline infrastructure). The 2018 act required the NEHRP ICC to coordinate with its counterpart committee on the National Windstorm Impact Reduction Program,[30]—as well as with other natural hazards coordination committees, as determined appropriate—to share data and best practices.

Section 3 of P.L. 115-307 modified FEMA's duties and required FEMA to enter into cooperative agreements or contracts to establish demonstration projects on earthquake hazards modification, link research and mitigation efforts with emergency management programs, and prepare educational materials for national distribution (substituting the word "shall" in the enacted language for the word "may" in existing law).

Section 3 of P.L. 115-307 removed statutory language requiring the USGS to develop procedures for making earthquake predictions and replaced it with language for developing procedures to issue earthquake alerts and early warnings. The 2018 act inserted language to "continue the development of the ... [ANSS], including earthquake early warning capabilities," as part of 42 U.S.C. 7704(a)(2)(D).[31] Further, P.L. 115-307 required the USGS, in the event of an earthquake, to issue an alert and a warning, when necessary and feasible, to FEMA, NIST, and state and local officials. The act required the USGS to publish maps of active faults and folds, plus maps of areas that are susceptible to specific earthquake hazards (e.g., liquefaction or landslides).[32]

The 2018 NEHRP reauthorization act removed language in existing law that required NSF to support earthquake-related research using NEES. Instead, P.L. 115-307 referred to using "experimental and computational facilities."[33] Section 3 of P.L. 115-307 added a new subsection to existing law requiring NSF to identify and track NEHRP grant funding.[34]

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[29] The eight focus areas are not in order of priority. Laurie Locascio et al., *Strategic Plan for the National Earthquake Hazards Reduction Program*, Fiscal Years 2022 to 2029, April 2023, https://www.nehrp.gov/pdf/FY2022-29%20NEHRP%20Strategic%20Plan%20-%20Post%20Version.pdf.

[30] See NIST, Engineering Laboratory/Materials and Structural Systems Division, "National Windstorm Impact Reduction Program Office," https://www.nist.gov/el/materials-and-structural-systems-division-73100/national-windstorm-impact-reduction-program-nwirp.

[31] In Section 8 (Technical Corrections) of P.L. 115-307, the act deleted references in the *U.S. Code* to the Advanced National Seismic System (ANSS) predecessor—the Advanced National Seismic Research and Monitoring System. For more on ANSS, see the "Management of Advanced National Seismic System (Section 6)" section of this product. Also note that *earthquake early warning* means providing an alert about potential ground shaking after the start of an earthquake is detected, which is the modern definition and usage of the term (as opposed to the meaning of warning in the 1977 act, see footnote 15).

[32] See USGS, "Faults" https://www.usgs.gov/programs/earthquake-hazards/faults and USGS, "Seismic Hazard Model, Maps, and Site-Specific Data," https://www.usgs.gov/programs/earthquake-hazards/seismic-hazard-model-maps-and-site-specific-data. See footnote 1 for an explanation of liquefaction.

[33] See footnote 19.

[34] See NEHRP, "Grants & Contracts," https://www.nehrp.gov/contracts/awards.htm for some examples of NEHRP funding from NSF and the NIST-NSF funded Disaster Resilience Research Grant program. See also **Table 2**.

Review of NEHRP (Section 4)

Section 4 of P.L. 115-307 required the Government Accountability Office (GAO) to review NEHRP and report its findings within three years of enactment.[35] In 2022, GAO completed its review and recommended seven actions:

1. Conduct a national risk assessment to identify progress and remaining gaps in earthquake resilience in communities
2. Increase awareness among tribes about earthquake risk reduction initiatives
3. Assess the need for state, local, territorial, and tribal input about research priorities to meet community needs
4. Develop strategies to better communicate program priorities to research entities
5. Develop performance measures and monitor research to achieve research priorities
6. Leverage program resources to achieve research priority outcomes
7. Implement a plan to make state, local, territorial, and tribal stakeholders aware of practices for disseminating research[36]

According to GAO, NEHRP is working on these recommended actions and aims to address these actions.[37]

Seismic Standards (Section 5)

Section 5 of P.L. 115-307 replaced language in current law (42 U.S.C. 7705b) that called for the adoption of seismic safety standards for buildings constructed or leased by the federal government. The 2018 NEHRP reauthorization act required, instead, an assessment and recommendations for improving the built environment and critical infrastructure, specifically "to reflect performance goals stated in terms of post-earthquake reoccupancy and functional recovery time." This language highlighted one of the changes in NEHRP emphasis to enhance resilience.

The NIST Director and the FEMA Administrator appointed a committee of experts, representing federal agencies, nongovernmental organizations, the private sector, disaster management associations, engineering associations, and construction and homebuilding industry associations, to prepare such a report for Congress.[38] NIST and FEMA jointly published the committee of

[35] P.L. 115-307 required GAO to submit the report to the Senate Committees on Commerce, Science, and Transportation; Energy and Natural Resources; and Homeland Security and Governmental Affairs, and to the House Committees on Science, Space, and Technology; Natural Resources; and Homeland Security. See also CRS Report R47215, *Hazard-Resilient Buildings: Sustaining Occupancy and Function After a Natural Disaster*, by Linda R. Rowan.

[36] U.S. Government Accountability Office, *Earthquakes: Opportunities Exist to Further Assess Risk, Build Resilience, and Communicate Research*, GAO-22-105016, May 4, 2022, https://www.gao.gov/products/gao-22-105016.

[37] See the section on "Recommendations" for the seven recommendations and the status of the program response at GAO, "Earthquakes," https://www.gao.gov/products/gao-22-105016.

[38] P.L. 115-307 required the expert committee to submit a report to Congress with recommended options no later than June 30, 2020. The committee submitted the report to the Senate Committees on Commerce, Science, and Transportation; Energy and Natural Resources; and Homeland Security and Governmental Affairs, and to the House Committees on Science, Space, and Technology; Natural Resources; and Homeland Security.

experts' report in January 2021.[39] The report recommended seven actions for communities to enhance resiliency:

1. Develop a framework for post-earthquake reoccupancy and functional recovery objectives
2. Design new buildings to meet recovery-based objectives
3. Retrofit existing buildings to meet recovery-based objectives
4. Design, upgrade, and maintain lifeline infrastructure systems to meet recovery-based objectives
5. Develop and implement pre-disaster recovery planning focused on recovery-based objectives
6. Provide education and outreach to enhance awareness and understanding of earthquake risk and recovery-based objectives
7. Facilitate access to financial resources needed to achieve recovery-based objectives

Management of Advanced National Seismic System (Section 6)

ANSS is a nationwide network of seismic stations operated by the USGS. It consists of a "backbone" network of about 100 seismic stations throughout the United States, the National Earthquake Information Center, the National Strong Motion Project, and 15 regional seismic networks operated by the USGS and partner institutions.[40] The 2018 NEHRP reauthorization act required a new five-year management plan for ANSS. The USGS submitted a five-year management plan for ANSS to Congress in November 2021.[41] The plan prioritized core ANSS activities including monitoring, 24/7 reporting, rapid assessment, and earthquake early warning.

Authorization of Appropriations (Section 7)

Section 7 of P.L. 115-307 authorized appropriations for NEHRP activities over a five-year period, FY2019-FY2023. The act apportioned the same authorized amount per agency each year. The total authorization of appropriations broken down by agency was as follows:

- USGS: $83.4 million per year, $417.0 million total[42]
- NSF: $54.0 million per year, $270.0 million total
- FEMA: $8.76 million per year, $43.8 million total
- NIST: $5.9 million per year, $29.5 million total

[39] NIST and FEMA, *Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time*, NIST-FEMA Special Publication FEMA P-2090/NIST SP-1254, January 2021, https://doi.org/10.6028/NIST.SP.1254.

[40] For more information, see the USGS, Earthquake Hazards Program, "ANSS—Advanced National Seismic System," https://www.usgs.gov/natural-hazards/earthquake-hazards/anss-advanced-national-seismic-system. See also USGS, *Advanced National Seismic System—Current Status, Development Opportunities, and Priorities for 2017-2027*, USGS Circular 1429, 2017, https://pubs.usgs.gov/circ/1429/circ1429.pdf.

[41] The USGS, Earthquake Hazards Program, *Advanced National Seismic System 5-Year Management Plan*, November 2021.

[42] P.L. 115-307 required $30 million of the annual authorized amount for the USGS be made available for completion of ANSS.

The total five-year NEHRP authorization of appropriations was $760.3 million for FY2019-FY2023, or about $152.1 million annually. The findings section (Section 2) of P.L. 115-307 noted that the National Research Council (NRC) in 2011 recommended funding of more than $300 million annually for 20 years (in 2009 dollars);[43] that amount is about twice the average annual amount authorized for appropriations in P.L. 115-307. **Table 3** shows the enacted funding for NEHRP agencies from FY2005 through FY2024.[44]

Table 3. Enacted Funding for NEHRP, FY2005-FY2024

(in millions of current dollars)

Fiscal Year	USGS	NSF	FEMA	NIST	Total
FY2005	58.3	53.1	14.7	0.9	**127.0**
FY2006	54.5	53.8	9.5	0.9	**118.7**
FY2007	55.4	54.8	9.1	1.7	**121.0**
FY2008	58.1	55.6	6.1	1.7	**121.5**
FY2009	61.2	55.3	9.1	4.1	**129.7**
FY2010	62.8	55.3	9.0	4.1	**131.2**
FY2011	61.4	53.3	7.8	4.1	**126.6**
FY2012	60.4	53.2	7.8	4.1	**125.5**
FY2013	55.6	52.2	7.8	3.9	**119.5**
FY2014	58.7	51.0	7.8	3.9	**121.4**
FY2015	64.4	52.2	7.4	3.9	**127.9**
FY2016	67.0	54.2	8.5	5.2	**134.9**
FY2017	71.0	54.2	8.5	5.2	**138.9**
FY2018	90.1	65.7	8.5	5.2	**169.5**
FY2019	90.1	60.5	8.7	5.2	**164.5**
FY2020	92.1	53.4	8.9	4.8	**159.2**
FY2021	92.6	52.2	8.9	4.8	**158.5**
FY2022	97.2	54.0	8.5	4.8	**164.5**
FY2023	99.9	52.0	8.5	4.8	**165.2**
FY2024	99.7	50.0	8.5	5.3	**163.5**

Sources: Enacted funding FY2005 to FY2024 from NEHRP, "2005-2024 NEHRP Agency Budgets," https://www.nehrp.gov/pdf/FY2005-2024%20NEHRP%20Budgets_NIST-FEMA-USGS_NSF%20actuals.pdf.

Notes: According to the NEHRP office, the FEMA and NIST budgets are those agencies' allocations for NEHRP activities from the total agency appropriations through FY2024. The NSF budget is the foundation's estimated expenditure for NEHRP activities from total agency appropriations through FY2024. Beginning in FY2018, the USGS budgets included congressional "one-time" funding additions for ShakeAlert but excluded the $8.0 million supplemental funding for seismic network restoration following Hurricane Maria. Amounts are reported to the nearest $0.1 million. Funding not adjusted for inflation.

[43] NRC, *Earthquake Resilience*, 2011, p. 4.

[44] Enacted appropriations for FY2005-FY2009 totaled $617.9 million, or 68% of the total amount of $902.4 million authorized in P.L. 108-360 over the five-year span. P.L. 115-307 authorized a total of $760.3 million for NEHRP activities summed over the five-year span FY2019-FY2023, approximately $142 million less than the total amount authorized by P.L. 108-360 (not adjusted for inflation).

NEHRP Progress Since Reauthorization in 2018

Since NEHRP's reauthorization in 2018, the program has focused on earthquake early warning systems, improved building codes and building standards, functional recovery methods for structures, pathways to community resilience, and continued basic research to understand earthquake hazards and risks. ACEHR reviews NEHRP progress and recommends actions to make NEHRP more effective in biennial reports to Congress, as mandated by P.L. 108-360.[45] The 2021 ACEHR report identified the following three NEHRP activities as noteworthy and continued priorities:

1. ShakeAlert, the earthquake early warning system operating on the West Coast[46]
2. The joint NIST-FEMA report on reoccupancy and functional recovery, which made seven recommendations and detailed four options for Congress to carry out these recommendations[47]
3. The significance and status of basic research on earthquakes and earthquake-resistant structures through traditional grants and cooperative agreements, plus the addition of three new coordinated research opportunities.

Earthquake Early Warning: ShakeAlert

The first *operational* earthquake early warning system in the United States,[48] called ShakeAlert, alerts users in California, Oregon, and Washington about the arrival of ground shaking from a detected earthquake.[49] Several studies estimate that earthquake early warning systems are cost-effective—that is, the cost savings in terms of risk reduction is greater than the actual cost of the system.[50] One study estimated that early warnings reduce injuries from earthquakes by more than 50%.[51] Today, after an earthquake starts, ShakeAlert warns users in California, Oregon, and

[45] The ACEHR, established by Congress (P.L. 108-360), provides comprehensive biennial reports on NEHRP progress. Two reports, covering FY2018-FY2019 and FY2020-FY2021, respectively, provide more details on recent NEHRP activities: NEHRP, *ACEHR Report on NEHRP Effectiveness FY18-FY19: A Report from the Advisory Committee on Earthquake Hazards Reduction*, September 27, 2019, https://www.nehrp.gov/pdf/September_2019_ReporttotheNISTDirector.pdf; and NEHRP, *ACEHR Report*, 2021.

[46] CRS Report R47121, *The ShakeAlert Earthquake Early Warning System and the Federal Role*, by Linda R. Rowan.

[47] NIST-FEMA, Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time, NIST-FEMA Special Publication FEMA P-2090/NIST SP-1254, 2021, https://doi.org/10.6028/NIST.SP.1254 (hereinafter NIST-FEMA, Post-Earthquake Options).CRS Report R47215, *Hazard-Resilient Buildings: Sustaining Occupancy and Function After a Natural Disaster*, by Linda R. Rowan.

[48] *Operational* means the system sends warnings to technical users who have agreements with ShakeAlert (and, in some cases, hardened communications that allow for the most rapid and secure alerting) and to individuals who signed up for ShakeAlert messaging through their state emergency management agencies. In some areas, the system is not fully operational because there are not enough sensors to monitor for earthquakes, and in some cases, the communications of alerts are not established to provide adequate warning before the shaking arrives.

[49] Users include government and nongovernmental organizations that partner with ShakeAlert to receive warnings so they can take specific actions to reduce risks. Some of these actions are automated, such as the Bay Area Rapid Transit System (BART) automatically slowing or stopping trains because of an earthquake alert. Other users include individuals who sign up to receive the alerts through the California, Oregon, or Washington emergency management agencies. Alerts to individuals suggest protective actions based on the severity of the shaking. Action standards were developed by the Southern California Earthquake Center and other authorities.

[50] NEHRP, *ACEHR Report*, 2021, p. 13; and J. A. Strauss and R. M. Allen, "Benefits and Costs of Earthquake Early Warning," *Seismological Research Letters*, vol. 87, no. 3 (May-June 2016), pp. 765 -772 (hereinafter cited as Strauss and Allen, "Benefits and Costs").

[51] Strauss and Allen, "Benefits and Costs."

Washington that intense ground shaking may reach their location in seconds to minutes. This warning allows users to take actions to protect people and property before shaking occurs and thereby reduce the risk of damage to structures, lifelines, transportation, construction, medical procedures, business operations, educational services, and other activities. Several organizational users, such as train systems and large buildings, have programmed their infrastructure to take certain automated actions upon receipt of a warning.[52] Nonautomated responses by individuals include executing the drop, cover, and hold on maneuver and stopping school activities, vehicles, and hazardous activities.[53] A review of the status and performance of ShakeAlert from October 17, 2019, to September 1, 2023, noted 95 alerts were created for earthquakes of magnitude 4.5 or greater, with one false event and six earthquakes poorly located by the system.[54] According to the review, most users received alerts through cell phone applications. Some alerts distributed via FEMA's wireless emergency alert had delivery times slower than the expected system performance requirements.

Reoccupancy Recommendations and Building Codes

NEHRP generates improved design guidance products, model building code proposals, national consensus building standards, and construction guidelines to reduce earthquake risks.[55] **Figure 2** shows how the NEHRP agencies contribute to more earthquake-resilient designs, codes, and standards and how NEHRP's work may contribute to model building code development and to adoption and enforcement of building codes at the state and local levels.[56] A 2019 study by the National Institute of Building Sciences estimated that the development and adoption of seismic provisions in building codes since the advent of modern seismic design provisions have produced a national average benefit-cost ratio of 12 to 1 (i.e., $12 saved in avoided losses for every $1 invested in earthquake requirements for buildings).[57] The study estimated that retrofitting older buildings to earthquake-resistant standards provides a national average benefit-cost ratio of 13 to 1.

[52] See footnote 49 for an example of an automated alert.

[53] For a list of actions to take before, during, and after an earthquake, including a description of drop, cover, and hold on, see Ready.gov, "Earthquakes," https://www.ready.gov/earthquakes.

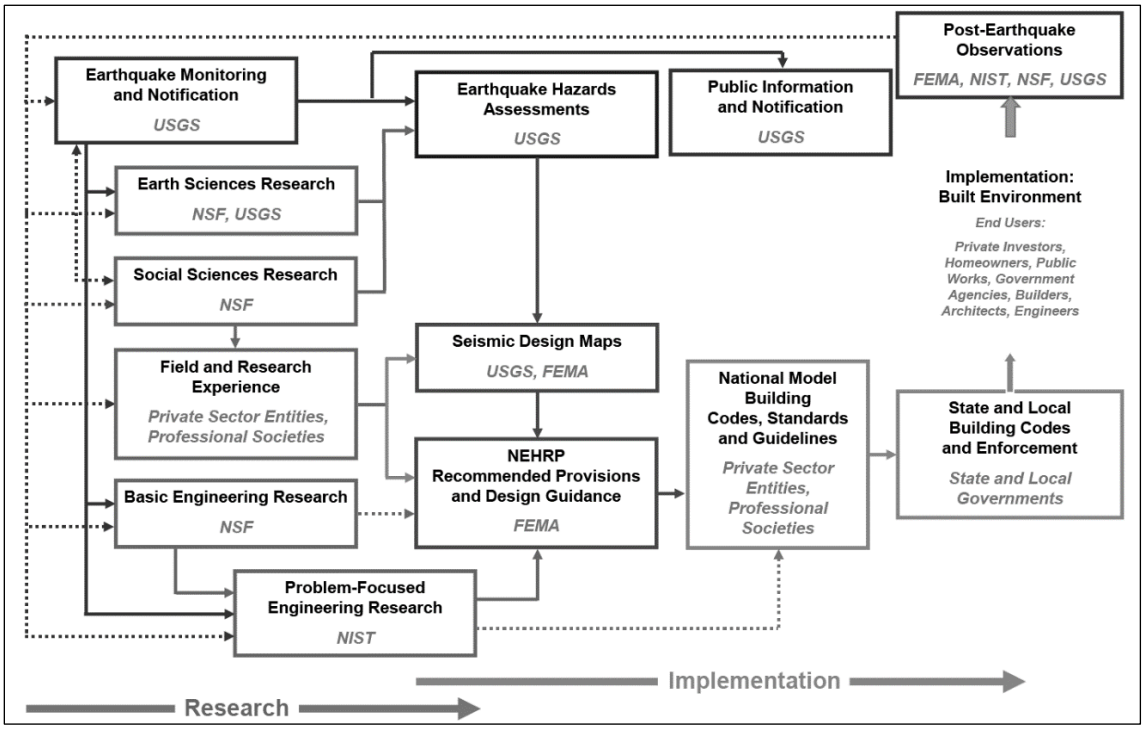
[54] Angela I. Lux et al., "Status and Performance of the ShakeAlert Earthquake Early Warning System: 2019-2023," *Bulletin of the Seismological Society of America*, 2024, doi: 10.1785/0120230259.

[55] CRS Report R47215, *Hazard-Resilient Buildings: Sustaining Occupancy and Function After a Natural Disaster*, by Linda R. Rowan; CRS Report R47665, *Building Codes, Standards, and Regulations: Frequently Asked Questions*, coordinated by Linda R. Rowan; and CRS Report R47666, *Infrastructure Codes, Standards, and Regulations: Frequently Asked Questions*, coordinated by Linda R. Rowan.

[56] CRS Report R47665, *Building Codes, Standards, and Regulations: Frequently Asked Questions*, coordinated by Linda R. Rowan.

[57] National Institute of Building Sciences, *Natural Hazard Mitigation Saves*, 2019, see https://nibs.org/projects/natural-hazard-mitigation-saves-2019-report.

Figure 2. NEHRP Agency Responsibilities and End Users of NEHRP Design and Standards Products



Source: National Earthquake Hazards Reduction Program (NEHRP) program office at http://www.nehrp.gov/pdf/ppt_sdr.pdf (modified by CRS).

Notes: FEMA = Federal Emergency Management Agency; NIST = National Institute of Standards and Technology; NSF = National Science Foundation; USGS = U.S. Geological Survey.

The 2021 ACEHR report encouraged NEHRP to follow through on the recommendations in the 2020 joint NIST-FEMA report on reoccupancy and functional recovery.[58] The 2021 ACEHR report suggested four options for Congress to help NEHRP follow through on the recommendations:

1. Support technical development of recovery-based regulations and retrofitting of buildings and lifeline infrastructure systems
2. Incentivize action (e.g., through FEMA's Building Resilient Infrastructure and Communities grants)[59] by encouraging state and local jurisdictions to adopt recovery-based codes, standards, and practices

[58] NIST-FEMA, Post-Earthquake Options.

[59] FEMA introduced a new program in FY2020, the Building Resilient Infrastructure and Communities (BRIC). The priorities for BRIC in FY2021 are to incentivize natural hazard risk reduction activities that mitigate risk to public infrastructure and disadvantaged communities; projects that mitigate risk to one or more community lifelines; projects that incorporate nature-based solutions; projects that enhance climate resilience; and adoption and enforcement of the latest published editions of building codes. FEMA, "Building Resilient Infrastructure and Communities,"]https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities. See also CRS Insight IN11515, *FEMA Pre-Disaster Mitigation: The Building Resilient Infrastructure and Communities (BRIC) Program*, by Diane P. Horn.

3. Encourage the executive branch to develop recovery-based seismic design and retrofit requirements for federally owned and leased buildings
4. Lead the development and implementation of a federal education campaign around earthquake risk and recovery-based objectives.

Basic Research

The 2021 ACEHR report considered basic research the foundation for making progress on earthquake early warning systems and improving earthquake-resistant building codes, standards, and construction practices. Together, research, warning, and standards enhance resilience, and resilience is a congressional objective emphasized in the NEHRP law. Much of the basic research occurs through grants and cooperative agreements awarded in three of the NSF's directorates: Geosciences; Engineering; and Social, Behavioral, and Economic Sciences. The 2021 ACEHR report highlighted three new research initiatives involving these NSF directorates and other agencies. One of these initiatives, a cross-directorate opportunity known as Coastlines and People Competition, funds a research hub to examine Cascadia Subduction Zone hazards and mitigation, among other projects.[60] The other initiatives, NSF-NIST Disaster Resilience Research Grants (DRRG) and the NSF-Department of Homeland Security Civic Innovation Challenge (CIVIC), are interagency-coordinated competitions that aim to strengthen earthquake resilience by improving fundamental knowledge of earthquakes and their effects.[61] NSF announced the end of DRRG in June 2024 and noted that DRRG had granted $14.7 million for 38 projects since June 2020.[62]

2023 ACEHR Report to Congress

ACEHR submitted its most recent biennial report to Congress on September 30, 2023.[63] The report includes six recommendations for NEHRP and congressional consideration:

1. Understand and communicate the research-to-practice pipeline
2. Build on functional recovery efforts toward community resilience
3. Promote and expand the use of earthquake scenarios
4. Prioritize essential research and problem-focused studies
5. Review international earthquake response and lessons learned
6. Prioritize research on earthquake insurance to make it more affordable and attainable

[60] The Cascadia Subduction Zone is a major tectonic plate boundary that lies just offshore of southwestern British Columbia, the Pacific Northwest and northern California. At the plate boundary, the Juan de Fuca oceanic plate subducts beneath the North American crustal plate causing earthquakes and volcanic activity, among other hazards. See NSF Award Description: Large-Scale CoPe: The Cascadia Coastlines and People Hazards Research Hub https://www.nsf.gov/awardsearch/showAward?AWD_ID=2103713&HistoricalAwards=false.

[61] NEHRP, *ACEHR Report*, 2021, pp. 8-9 and 14-15.

[62] NSF, "Dear Colleague Letter: Sunsetting the NSF-NIST Disaster Resilience Research Grants (DRRG) Funding Opportunity," https://www.nsf.gov/pubs/2024/nsf24105/nsf24105.jsp.

[63] ACEHR, *A Report from the Advisory Committee on Earthquake Hazards Reduction on NEHRP Effectiveness from FY22-23*, September 30, 2023, https://www.nehrp.gov/pdf/2023%20ACEHR%20Report%20-%2030%20Sept%20(FINAL).pdf.

Issues for Congress

Congress established NEHRP in 1977 to understand earthquake hazards and reduce their risks. NEHRP has aimed to address congressional objectives for earthquake warning, risk reduction, and resilience. Congress may consider several issues regarding NEHRP, including the following:

- **Program Efficacy.** How much and how well does NEHRP reduce risks?
- **Federal and Nonfederal Partnerships**: How well do the four agencies work together and with other partners?
- **Program Management**: How well do the agencies plan, manage, and implement program objectives?

Congress may consider the ICC's FY2022-FY2029 strategic plan for NEHRP and GAO's report on the effectiveness of earthquake hazards risk reduction as part of its deliberations on and oversight of NEHRP. Congress also may consider the reports to Congress and other products produced by three committees established under NEHRP: ACEHR, SESAC, and ICSSC.

In 2011, an NRC report recommended more than $300 million annually over 20 years for NEHRP based on an estimate of annual program costs.[64] Congress directed NEHRP to develop an interagency plan that includes budgets for program components, but an interagency plan has not been completed. In addition, the authorization of appropriations for NEHRP expired on September 30, 2023. Congress may consider funding levels for NEHRP and whether to authorize appropriations beyond FY2023 (P.L. 115-307).

Legislation introduced in the 118th Congress (H.R. 626, S. 3606 and H.R. 9375) would amend NEHRP. H.R. 626 and S. 3606 would also reauthorize appropriations for NEHRP. The Senate Committee on Commerce, Science, and Transportation reported S. 3606 as amended in September 2024.

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[64] NIST asked the NRC to conduct the study and asked the council to "recommend a roadmap of national needs in research, knowledge transfer, implementation, and outreach to provide the tools to make the United States more earthquake resilient." In addition, NIST asked the council to update and validate the Earthquake Engineering Research Institute's annual program cost projections over 20 years. NRC, *Earthquake Resilience*, 2011, especially Table 4.1 and Earthquake Engineering Research Institute, *Securing Society Against Catastrophic Earthquake Losses: A Research and Outreach Plan in Earthquake Engineering*, 2003, https://www.nehrp.gov/pdf/securing_society_2003.pdf.

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