Statement of

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Thank you, Congressman Rohrabacher and colleagues, for inviting the U.S. Geological Survey (USGS) to participate in this hearing to discuss the National Earthquake Hazards Reduction Program. I am Steve Hickman, Director of the Earthquake Science Center. Our center has been a flagship USGS research center in the West for over 50 years. We have offices in Menlo Park, Pasadena, Seattle, Anchorage, and Albuquerque. The USGS also hosts the National Earthquake Information Center (NEIC) in Golden, Colorado.

The USGS is a committed partner in the National Earthquake Hazards Reduction Program, or NEHRP, which is led by the National Institute of Standards and Technology (NIST) and includes the Federal Emergency Management Agency (FEMA) and the National Science Foundation (NSF). That commitment involves collaboration going beyond the four agencies to include other Federal partners, State, Tribal and local governments, academic institutions, and the private sector.

We appreciate the opportunity to provide you with an update on the program. Federal, State, and local agencies have continued to work together closely since the appropriations authority for NEHRP expired in 2009. Understanding earthquake hazards, quantifying earthquake risk, and helping to build more resilient communities is a part of each of our missions.

NEHRP was founded on the belief that while earthquakes are inevitable, there is much that we can do as a Nation to improve public safety, reduce losses and impacts, and increase our resilience to earthquakes and related hazards. There is a technical distinction between "hazards," which are the physical phenomenon of the earth shaking, versus "risks," which are the potential consequences from that shaking. While earthquakes do happen all across the country, about 80 percent of the risk they pose is in California—50 percent just in southern California. Within NEHRP each agency performs a distinct and complementary role essential for the overall success of the program. It is conducted with a high degree of cooperation and collaboration,

avoiding overlap and competition for responsibilities or resources. The heart of this partnership is a broadly shared commitment to translate the results of research, field studies, and seismic monitoring into implementation actions that can reduce earthquake losses.

The USGS role within NEHRP is to deliver the data and information tools that engineers, emergency managers, government officials, and the public need to prevent earthquake hazards from becoming disasters. USGS activities under NEHRP are implemented through the Earthquake Hazards Program and the Global Seismographic Network (see below). Along with its partners, the USGS provides rapid, authoritative information on the magnitude, location, shaking intensity and potential impacts of earthquakes, both in the United States and around the world. The Survey also develops national and regional hazard assessment maps and supports targeted research to improve these products. Lastly, the USGS works with a wide range of partners to help grow public awareness of earthquake hazards. I will share some examples of each of these activities and elaborate on the importance of NEHRP to making them possible.

As for the Global Seismographic Network, this Network enables fundamental geophysics research, and also supports national security objectives by monitoring and characterizing nuclear test detonations. It represents an important international component of NEHRP.

Earthquake information: The USGS NEIC, is a 24/7 operation, generating a broad suite of near-real time earthquake information products to provide situational awareness for emergency responders and the public. Over 409,000 users are signed up to receive USGS earthquake notifications. The Prompt Assessment of Global Earthquakes for Response, or PAGER alerts, provide rapid assessment of potential economic impacts and fatalities, while ShakeMap graphically depicts the intensity of shaking, which is useful for many applications, particularly post-event engineering assessments. These products are made possible by the earthquake monitoring networks that make up the Advanced National Seismic System (ANSS), including regional seismic networks that the USGS supports with its academic partners. Lastly, *Did-You-Feel-It?* is a widely used web-based crowd-sourcing tool that allows members of the public to describe their experience of an earthquake in a scientifically useful format. This citizen science data augments seismic data that the USGS collects from its monitoring networks. When you do feel an earthquake, please search for *Did-You-Feel-It?* online and provide the USGS with your own data.

Significant modernization improvements to the ANSS were made in 2010 and 2011, such as replacing outdated analog equipment and upgrading communications software. In FY18, we are continuing this by directing $5 million for deferred maintenance on the ANSS system and $23 million for the build-out of *ShakeAlert*, according to congressional direction. The ANSS includes instrumentation in buildings and other engineered structures to support research on their response to seismic shaking. The resulting data and models help structural engineers to design buildings with improved earthquake resistance. This Administration has emphasized the

importance of infrastructure to our national economy, and the ANSS is one such example of critical scientific infrastructure.

Assessments of earthquake hazards: About 142 million Americans live in areas with moderate to high earthquake hazards. In addition to national assessments, the most recent of which the USGS published in 2014[1] and will update again in 2018, we also publish more detailed urban assessments. The most recent maps were published for St. Louis, following on urban seismic hazard maps prepared for Seattle and Los Angeles, and new maps are expected for Salt Lake City in the next few years. These assessments are based on models that incorporate the best available science about faults, and prehistoric and historical records. The assessments in turn are used to inform building codes and community planning. In 2017 the USGS incorporated induced seismicity hazards into an assessment of short-term hazard from earthquakes in the Central and Eastern United States. There is significant domestic energy development potential in this region, and better understanding of this phenomenon enables states and the private sector to develop methods for improving safety.

Targeted research: USGS research is supplemented by external research which the USGS supports through grants and cooperative agreements, and it serves as a bridge from fundamental research supported by NSF into applications by the USGS and its other NEHRP partners. The Southern California Earthquake Center (SCEC) is an example of such research partnerships. Led from the University of Southern California, SCEC has received support from both the USGS and NSF for over 25 years, fostering a new generation of earthquake researchers. In the next few years, we expect USGS-supported research to tell us more about earthquakes in Puget Sound, near Reno, Las Vegas and Lake Mead, and develop methods to rapidly estimate damage from liquefaction.[2]

Public awareness: All the best earth science cannot guarantee that people are able to use the information to make informed decisions that will keep their families, their businesses, and their communities safe. Since 2003, the USGS has supported publication of *Putting Down Roots in Earthquake Country*, now available for eight different regions, including Alaska, Utah, Nevada, and the Central United States. These publications provide information about the threat posed by earthquakes in their respective regions and explain how residents can prepare, survive, and recover from these inevitable events. They have also been translated into Spanish, Chinese, Vietnamese, and Korean. Since 2008, the USGS has supported the annual Great ShakeOut exercise, which I will mention below. Last year, several thousand organizations, including local governments, hospitals, schools, places of worship, and businesses, have signed up, representing 20 million participants in the United States.

[1] USGS Open-File Report 2014-1091 available at https://pubs.er.usgs.gov/publication/ofr20141091
[2] 2018 research available at https://earthquake.usgs.gov/cfusion/external_grants/research.cfm

Close coordination among scientists, engineers, and emergency managers has clearly made the United States safer from earthquakes, however USGS offers several new considerations to improve the program going forward. For example, earthquake prediction was an original goal of the program, but is today considered scientifically unfeasible. Today, however it is possible for the USGS to issue early warnings of impending shaking from earthquakes that have already begun. Pursuant to USGS authority to develop an earthquake early system, Congress has appropriated funds in recent years to continue development of this system. The USGS is committed to working with Congress to determine the appropriate federal, state and local cost share associated with any future *ShakeAlert* developments.

Earthquake hazards here in California are well-known but, before I focus on California, I would like to highlight other earthquake hazards around the country. In recent decades, research[3] on the Cascadia Subduction Zone has highlighted the exceptional hazard in the Pacific Northwest. Subduction zones are areas where an oceanic tectonic plate is being forced under a continental plate thus forming a broad zone of seismic activity, in contrast to the plate boundary in most of California where the plates mainly slip horizontally. Subduction zones produce the largest earthquakes. For example, the Tohoku, Japan, earthquake of 2011 occurred on a subduction zone fault and it was over magnitude 9, making it one of the largest earthquakes ever recorded. Similarly, the largest recorded earthquake in North American history also occurred on a subduction zone fault off the coast of Alaska in 1964. These and other subduction zone earthquakes also have the potential to generate tsunamis that propagate across the ocean and can impact communities far from their epicenters.

Our Nation's exposure to earthquake hazards is not limited to the Pacific coast. Very large earthquakes have occurred in Virginia, South Carolina, Indiana, and the New Madrid zone in Missouri. The New Madrid zone deserves special mention. In 1811 and 1812, several earthquakes as large as 7.5 magnitude occurred there. At the time, human settlement in the area was relatively sparse, but today this represents an immediate hazard to over 200,000 people and a potential hazard to the Memphis region of 1.3 million people. Large earthquakes in this region happen infrequently, and most of the older buildings and infrastructure elements were not designed to resist strong shaking. In Delaware, in a region not previously known for active seismicity, a 4.1 magnitude earthquake struck in November 2017. This reminds us that earthquakes do happen nationwide.

Turning to California, since the great California earthquakes of 1868 and 1906 in the San Francisco Bay Area, we have learned much about earthquakes in California and translated that knowledge into better building codes, better emergency response plans and, in response to Congressional direction, into a world-class early warning system called *ShakeAlert*. We know that very large earthquakes happen here and, due to the complex nature of California's fault

[3] USGS Public Paper 1661-F available at https://pubs.usgs.gov/pp/pp1661f/

systems and geology, they have especially dangerous potential. While many critical pieces of infrastructure, such as hospitals, highway interchanges, and bridges, have been retrofitted to meet the highest earthquake engineering standards, other infrastructure has lagged, particularly the infrastructure of water and data distribution systems. Many seaports and some airports are built on land that is susceptible to liquefaction, where shaking causes the soil to temporarily lose strength and cohesion and flow laterally (temporarily behaving somewhat like quicksand). Additionally, there have been proposals to upgrade codes for residential and office buildings to make them not only "life-safe," that is, less likely to collapse, but also usable after the earthquake. This would reduce the time and costs of recovery and make communities more resilient.

The USGS has had an earthquake studies field office at Pasadena for over 40 years, working closely with partners at Caltech and elsewhere to develop and maintain state-of-the-art seismic and geodetic monitoring systems throughout southern California. The USGS has supported individual research projects at various academic institutions including Caltech, USC, UCLA, U.C. Irvine, U.C. San Diego and elsewhere. In 2017 the USGS commitment to these and other activities in the region was $4.5 million.

In northern California, the Hayward fault, which slices through the highly urbanized East Bay region, is one of the most dangerous faults in the state, with an estimated 1-in-3 probability of generating a damaging earthquake in the next 30 years. Last month, the USGS, along with approximately 60 partners, released a new assessment of such an earthquake, called the HayWired scenario.[4] It provides a realistic, highly detailed depiction of what may happen during and after a magnitude 7 earthquake with an epicenter in Oakland. This is an impact assessment, however, not a prediction. A real earthquake on the Hayward Fault could occur at any time and with a different pattern of shaking. Understanding the risk and getting ready for a large earthquake on the Hayward Fault like the one depicted in this scenario can help other at-risk communities prepare for similar events that are possible in their area. Overall, given the population and economic importance of California, and the known seismicity of the region, earthquake hazards remain a serious threat to all Californians' lives and livelihoods.

I would like to discuss a few other NEHRP activities that are of interest to Californians. The first and perhaps most relevant to California right now is the impending first stage roll out of *ShakeAlert*, the earthquake early warning system for the West Coast of the United States. Earlier, I called it "world-class" because the goal of the USGS and its partners is not to simply duplicate the early warning efforts of other countries, but to build the most advanced earthquake warning system in the world. To that end, Congress and the state of California have supported work to dramatically densify seismic and geodetic monitoring networks. Such dense network coverage is the backbone of *ShakeAlert*. The USGS has also worked with both public and

[4] USGS Scientific Investigation Report 2017-5013 available at https://pubs.er.usgs.gov/publication/sir20175013

private partners to develop notification delivery methods and automated response systems. For example, BART in northern California has integrated *ShakeAlert* into systems that automatically slow trains during earthquakes. Other users are developing similar operations for their infrastructure in many sectors including utilities, transportation, health care, and schools.

Cities and counties are also considering the best way to integrate early warning data into their own emergency response plans. Broad public notifications through wireless phones, similar to the weather alerts made possible by the NOAA National Weather Service, face technical challenges, but could possibly be available by the end of the year. Most importantly, when the first stage is announced, more users will be motivated to develop products and services to take concrete actions based on USGS early warning data, rather than only experimental or test actions. It is crucial that we roll out a system with minimal false alarms and that partners have done their due diligence to operationalize real-time seismic data. We want users to have confidence in the system and ensure that the USGS releases only the highest quality data and notifications. The long-term possibilities include an earthquake early warning across the West Coast, including Alaska.

Lastly, I want to remind the committee of the annual Great ShakeOut, which began in 2008 as part of a scenario for a major earthquake on the southern San Andreas Fault. This year's ShakeOut event happens on 10/18 at 10:18 am. People around the country and the world participate in drills to practice safe responses to an earthquake. Please consider enlisting your offices as participants at ShakeOut.org.

In summary, the Department of the Interior supports reauthorization of NEHRP, because it has been a successful interagency partnership that continues to make valuable contributions to the Nation's resilience to earthquakes and other hazards. On behalf of the USGS, thank you for this opportunity to testify today. I would be happy to answer any questions you may have.

Dr. Steve Hickman

Steve Hickman has been the Director of the USGS Earthquake Science Center since 2015. Among his accomplishments, he was Principal Investigator on the San Andreas Fault Observatory at Depth, a major component on the National Science Foundation's EarthScope project. He has also served as chair of the Science Advisory Group for the International Continental Scientific Drilling Program. Dr. Hickman received a bachelor's degree in geology from Earlham College and a PhD in solid-earth geophysics from MIT. His accolades include the Superior Service and Meritorious Service Awards from the Department of the Interior and the 2014 "Paul G. Silver Award for Outstanding Scientific Service" from the American Geophysical Union.