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Good morning Chairman Lamborn, Ranking Member Holt and members of the subcommittee. I appreciate the opportunity to speak to you this morning about our nation's earthquake history, the progress we have made in blunting the dangers posed by earthquakes, and a proposed path forward to safeguard the future of our nation, specifically the West Coast. In particular, I would like to address the situation in the Pacific Northwest, where a major earthquake will one day occur that is much like the 1964 Great Alaska earthquake. My name is John Vidale. I am the Washington State Seismologist, and a Professor in the University of Washington's College of the Environment, and director of the Pacific Northwest Seismic Network. I am responsible for reporting on significant seismic events in Washington and Oregon, and work with city planners, engineers and emergency managers to mitigate seismic hazard, and conduct basic earthquake research.

Background: Great subduction earthquakes

While many earthquakes are great in the sense of tragic to the public, only those with magnitude bigger than 8 receive the title "great" from the experts. This lofty status leaves out, for example, the deadly Haiti quake of 2010 (M7.0), the earthquake that leveled Christchurch in 2011 (M6.3), and even the 1906 San Francisco earthquake (M7.8).

The 1964 earthquake in Alaska that we are discussing is even one step larger, an M9, with vastly wider reach and nearly unimaginable power. These M9 earthquakes threaten only two places in the US – Alaska and the Pacific Northwest coast – and only the Pacific Northwest is heavily populated and industrialized.

The M9 coming to the Pacific Northwest might not come for centuries or it might come tomorrow, but it is overripe. More than 300 years after the last great earthquake, we are within its likely window of recurrence, and we know that enough energy has already built up as strain in the rocks around the fault to power an M9. When it comes, the severely shaken region will extend from northern California up the coast to Canada, including the entire coastlines of Oregon and

Washington. An M9 would wallop the Willamette Valley and the Puget Sound, devastating the urban populations and menacing the economic well-being of Portland and Seattle.

To address this devastation, I would like to highlight two special opportunities; earthquake early warning and seafloor monitoring, and discuss why the Cascadia subduction zone needs to be a special focus, and argue the strong motivation to strengthen the National Earthquake Hazard Reduction Program.

Earthquake early warning (EEW) for the West Coast

One new advance in earthquake research is the development of Earthquake Early Warning systems (EEW). These use seismometers and GPS monitors to recognize an earthquake within a few seconds, then broadcast a warning that shaking is coming to vulnerable areas. The system requires delicate instruments, fast communications, and well-tested evaluation and notification protocols, but in essence it is very simple and well established; it is not rocket science. These warnings will be disseminated to the public via text messages and other public emergency broadcast systems.

Our opinion at the Pacific Northwest Seismic Network (PNSN) is that high-performance EEW for the US West Coast is at most 5 years away, and once it is here, its value will be clear to all. An EEW system would provide several key advantages that help to mitigate earthquake risks and public apprehension. In terms of life safety, an early warning will stop trains to prevent derailments, abort airport take-offs and landings, halt surgeries, allow for bridges to clear, shutdown elevators, open critical doors, warn schools and the population in general, and allow for faster tsunami warnings.

In the private sector, companies can mitigate losses by battening down factories, fortifying and shifting computer operations, and shutting off pipelines.

Emergency responders can jump-start emergency operations while mass communications still work, and maps of predicted devastation can be more quickly and effectively disseminated.

The sooner it is implemented, the sooner we can reassure the people and corporations that we are taking all prudent steps to reduce earthquake vulnerability. The longer EEW has been in operation and proven to work, the broader will be the range and effectiveness of the mitigation steps it enables.

An EEW system is ideally suited for the impending M9 on the Pacific Northwest coast. The earthquake will rupture along more than 600 miles of coastline, with the ground breaking for four to six minutes or more.

Depending on whether the earthquake starts near or far from critical spots like Portland or Seattle, we expect one to five or more minutes of warning time prior to the arrival of the severe shaking. We would also gain valuable extra minutes and accuracy in tsunami warnings.

Many other countries exposed to earthquakes have already built EEW systems, including Mexico, Korea and Romania. Japan is spending upwards of $1 billion on their monitoring and warning system, and China and Taiwan hundreds of millions of dollars. Active systems in Japan and Mexico have already demonstrated the practicality of these systems. The 2011 M9 Tohoku earthquake provided clear evidence of strong benefits of EEW for both preparing for shaking and very quick warning of tsunami risk.

The USGS has made a detailed implementation plan for EEW for the entire West Coast, finding that $16.1 million per year would build and operate a system, providing warning for the most dangerous regional faults. In the meantime, the regional seismic networks run from Caltech, UC Berkeley, and the University of Washington have been experimenting with prototype EEW systems.

The next step - monitoring of the seafloor

In the Pacific Northwest, the performance of the EEW system would be greatly bolstered by adding seismic instrumentation offshore, on the seafloor, where the unfolding magnitude 9 earthquake could be most quickly and accurately observed. This information would increase the warning time and make warnings more accurate. The offshore instruments would also watch for long-term signs of tectonic unrest, and accelerate scientific research and hazard mitigation.

The technology for ocean bottom seismometers and water pressure sensors is well established. By attaching these instruments to a cable system, the data would reach processing centers immediately. Methods for recording long-term seafloor motion under the sea, such as GPS, are more difficult to implement, and are the subject of instrument development.

Again, Japan is now spending close to $1 billion to monitor on the seafloor their faults that generate great earthquakes; we should do likewise. Japan is partly motivated by the observation that during the 2 days before their great earthquake, unusual motions of the seafloor were seen, and could only be seen with seafloor instruments. The University of Oregon, Oregon State University, and the University of Washington have scientists and technicians who are experts in these issues, and are poised to move us forward.

Important to devote adequate attention to Cascadia

The annual expected loss from all earthquakes in Oregon and Washington is $1 billion a year, a large fraction of the total exposure for the United States. The discovery of the risk is recent, with the seismogenic nature of the Cascadia Fault first appreciated in the 1990's, and the dangers of the Seattle Fault and other activity along the I-5 corridor from Vancouver to Portland coming even more recently. We do not have the many-decades history of study enjoyed by the San Andreas system and some fault systems farther east. Worse, much of the evidence is hidden in forests or under miles of ocean, or wiped clean by the glaciers that have scoured the Pacific Northwest landscape. Our most frequent strong earthquakes are tens of miles deep, tied to no fault at the surface that can be mapped.

The USGS should devote **sufficient resources to identify and quantify earthquake risk in the Pacific Northwest**. The largest earthquake scientists expect in the Pacific Northwest will be 30 times more energetic than the largest anticipated earthquake in California. Our problem is not simply an extension of San Andreas faulting, and needs more devoted study within the region.

A strong NEHRP (National Earthquake Hazard Reduction Program) is imperative

One lesson from recent earthquakes is that research into earthquake hazard is not yet complete. Each earthquake has come with a deadly and expensive surprise. 1996 Kobe brought fire and liquefaction of port facilities, 2004 Sumatra and 2011 Japan disobeyed geological wisdom in important ways, 2011 Japan also uncovered poorly designed reactors, 2011 Christchurch unexpectedly knocked out New Zealand's second largest city with downtown liquefaction.

Our cities in America have not been tested since the relatively mild 1994 Northridge earthquake. The next major event that occurs beneath one of our cities will surely present a nasty surprise, and continued investment in earthquake mitigation research through the USGS (US Geological Survey) and NEHRP will pay dividends many times over.

Reauthorization of NEHRP is needed to assure continued effort to characterize poorly understand hazards. The funding level should be high enough to accommodate new developments such at earthquake early warning and seafloor monitoring. The level should be at least at high as the previous levels, most recently set in 2010. We should not make the mistake of forgetting about the earthquake threat because it has been 20 years since the last urban US earthquake.

Summary

The Great Alaska Earthquake of 1964 is a forerunner of an eventual plate boundary earthquake in the Pacific Northwest. To responsibly prepare, we should build an earthquake early warning system, design and emplace seafloor monitoring, maintain a vigorous earthquake science and engineering effort within the Pacific Northwest, and this also requires a re-authorized strong NEHRP program.