STATEMENT OF
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BEFORE THE
COMMITTEE ON OVERSIGHT AND GOVERNMENT REFORM
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Chairman Chaffetz, Members of the Subcommittee, thank you for inviting the U.S. Geological Survey (USGS) to testify at this hearing on "Tsunami Warning, Preparedness and Interagency Cooperation: Lessons Learned."

The USGS role in natural hazard assessment and alerting

The U.S. Geological Survey (USGS) is tasked by the President under the Stafford Act to issue forecasts and warnings for earthquakes, volcanic eruptions, and landslides. For tsunami, wildfire, flood and hurricane hazards, the USGS provides critical support to the National Oceanic and Atmospheric Administration (NOAA) and other agencies tasked with warning responsibility. In order to carry out these mandates, the USGS requires a monitoring infrastructure that includes local, national and global networks; reliable and redundant telecommunications; modern computing centers for data analysis and dissemination; and a skilled staff of analysts, technicians, scientists, and network support personnel. To ensure that publicly funded monitoring networks and education programs are targeted to regions at highest risk, the USGS performs assessments at a national scale of the distribution and extent of each natural hazard for which we have primary responsibility—and, in high-hazard urban areas, at a local scale. To improve the accuracy and timeliness of warnings and to minimize false alarms, we perform (and fund university and State partners to perform) targeted research to understand the underlying processes and their predictability. To maximize the extent to which hazard information is received and acted upon by appropriate individuals when disasters strike, we pursue and foster links with local governments, emergency management agencies and the media. We target our work to the areas with the highest hazard and the greatest risk.

The USGS provides hazard alerts to a broad suite of Federal, State, and local government agencies, private-sector entities, including the media, and foreign entities. We use a broad range of technologies to distribute earthquake alerts and notifications, including the Internet, text messaging, pager, phone, NOAA Weather Wire, and briefings to media. Currently, more than 250,000 persons and entities subscribe to the USGS Earthquake Notification Service. Last year, the USGS served almost 50 million unique visitors for earthquake information.

The scope of our notification process depends on the severity, extent, location, and possible impact of the hazard at hand. Targeted distribution also proceeds to key users that can include the Department of Health and Human Services, U.S. Environmental Protection Agency, the

Nuclear Regulatory Commission, State departments of transportation and water management agencies, local emergency managers, national and international disaster response organizations, and over 200 foreign agencies. The USGS also shares earthquake data and analysis products with tsunami warning centers in Japan, Chile, and Russia.

USGS support for NOAA tsunami warnings and hazard assessments

To monitor earthquakes in the United States and abroad, the USGS operates the *Advanced National Seismic System* (ANSS) and, in partnership with the National Science Foundation (NSF), the *Global Seismographic Network* (GSN). The ANSS includes a 100-station national "backbone" plus 14 regional seismic networks in high-hazard areas and is operated through partnerships with universities and state governments. The GSN is a constellation of 150 globally distributed, modern seismic and other sensors, operated by USGS and the *Incorporated Research Institutions for Seismology* (IRIS). Seismic data from the GSN flow in real time to the USGS *National Earthquake Information Center* (NEIC) in Golden, Colorado, where they are analyzed. ANSS and GSN seismic data are also relayed in near-real time to the NOAA tsunami warning centers, enabling those centers to respond within minutes after a major earthquake. The USGS and NOAA exchange earthquake locations and magnitude estimates, with USGS providing the final authoritative magnitudes of events.

Using $9.6 million allocated by Congress under the American Recovery and Reinvestment Act (ARRA), the USGS and NSF are modernizing the Global Seismographic Network. Although the GSN is nearly complete, the ARRA-funded upgrades are being used to maximize the performance and efficiency of the existing network. The USGS is also using ARRA funds to modernize the ANSS. When the ARRA investments are completed at the end of this year, the ANSS will be approximately 25% completed.

The USGS also participates in the *National Tsunami Hazard Mitigation Program* (NTHMP), a partnership among NOAA, the USGS, FEMA, NSF, and the 28 coastal U.S. States and Territories. The NTHMP reduces the impact of tsunamis through hazard assessment, warning guidance, and mitigation. The USGS invested $2.3 million in FY 2010 in research and assessment activities supporting the goals of the NTHMP. The NTHMP is coordinating the preparation of tsunami inundation maps for high-risk coastal communities in Alaska, California, Hawaii, Oregon, and Washington. The USGS provides guidance in the preparation of these maps by analyzing and interpreting deposits from historic and prehistoric tsunamis to estimate inundation limits, flow velocities, and recurrence intervals. The USGS works with the NTHMP partners to develop education and outreach programs that turn our scientific understanding of tsunamis into easily-understood explanations of tsunami hazards facing American coasts. The USGS, along with NOAA, NASA, FEMA, and the Army Corps of Engineers, also contributes capabilities to survey coastal and near-shore bathymetry and topography. Finally, to determine the effects of tsunami inundation on land, USGS maps the run-up elevation and distance, flow-speed and direction indicators, and patterns of sedimentary deposition.

Tsunami threats in the Pacific

The West Coast of the United States, Hawaii, and the Pacific Territories are all at risk for damage from tsunamis generated by distant earthquakes. U.S. shores also host two subduction zones that are capable of magnitude-9 earthquakes: one off shore from Alaska, which last ruptured in 1964, and the other in the Pacific Northwest, known as Cascadia, which last ruptured in 1700.

Earthquakes in the Alaska and Aleutian subduction zones generated tsunamis in 1938, 1946, 1948, 1957 and 1964. Overall, approximately 16 tsunamis of all sources with inundations over three feet have occurred in Alaska since 1853. Alaska's famous fjords are also the source for another type of "tsunami": one in which landslides perched on the steep walls of fjords catastrophically fail and splash into the water, generating extreme wave heights. An example is the 1958 Lituya Bay tsunami, which was caused by an earthquake-triggered landslide. Local inundation reached 1,720 feet above sea level. These are localized phenomena and they do not produce distant tsunamis.

While the Cascadia subduction zone has not produced a great earthquake in the past 300 years, recent investigations of offshore deposits indicate that the zone may have produced magnitude 9-size earthquakes perhaps 20 times in the past 10,000 years, and more frequently magnitude 8-size earthquakes, at least in its southern extent. More research is therefore needed to fully document and assess the earthquake and tsunami potential of the Cascadia zone.

Hawaii also has a long recorded history of tsunamis, not only from distant sources but from earthquakes and landslides near Hawaii, termed local tsunamis. In the 20th century, an estimated 221 people were killed by tsunamis on the islands of Hawaii. One of the largest and most devastating tsunamis Hawaii has ever experienced was in 1946 from an earthquake along the Aleutian subduction zone. Run-up heights reached 33 to 55 feet and 159 people were killed. That tsunami caused more than $26 million in damage (not adjusted for inflation).

Tsunamis are not solely produced by earthquakes. Approximately 5 percent of tsunamis that occurred in the past 250 years were produced by volcanoes. Some of these are among the most destructive tsunami events known. Volcano-induced tsunamis are generated in various ways but the largest, most destructive tsunamis have been caused by explosive eruptions and flank collapse events on island and coastal volcanoes. There is a demonstrated volcanic tsunami hazard in Alaska and Hawaii and a likely one in the Commonwealth of the Northern Mariana Islands. Improved volcano monitoring systems and response planning at volcanoes that have a potential tsunami hazard would help provide better mitigation.

Tsunami threats in the Atlantic

With respect to the U.S. Atlantic coast, nearby subduction zones are present only in the Caribbean Sea region (see below). But the Atlantic Ocean is not immune to tsunamis. A tsunami following the great 1755 Lisbon earthquake devastated coasts of Portugal and Morocco, reached the British Isles, and crested as high as 20 feet in the Caribbean. However, this tsunami did not affect the east coast of North America because of the perpendicular orientation of the plate boundary to the coast.

The large 1929 Grand Banks earthquake triggered a submarine landslide and tsunami that struck Newfoundland's sparsely settled coast, where it killed 27 people. An event like this, involving a submarine landslide, may be the most likely scenario for the Atlantic coast. Scars of past large submarine landslides abound on the continental slope off the Atlantic coast. As in the 1929 Grand Banks event, some of the slides probably resulted from large earthquakes. If earthquakes are the primary initiator of the observed landslide features, the hazard to the Atlantic coast is limited, as large earthquakes rarely occur in the vicinity of the Atlantic coast of North America—perhaps once a century, on average (Boston area, 1755; Charleston, 1886; Newfoundland, 1929). Additionally, this type of tsunami would affect a much smaller geographical area than one generated by a large subduction-zone earthquake, and its flooding effect and inundation distance would be limited by its shorter wavelength. However, more work is needed to more fully understand the triggering of submarine landslides and the extent of that threat in the Atlantic.

Tsunami threats in the Caribbean

The Caribbean is subject to a broader range of processes that have the potential to generate tsunamis. The sediments of the Netherlands Antilles yield evidence for large, prehistoric tsunamis from about 400 to about 3500 years ago. Three severe tsunamis have occurred at or near U.S. territories in the past 150 years: St. Thomas, 1867, several deaths; Puerto Rico, 1918, 42 deaths; and the Dominican Republic, 1946, 1,790 deaths by some reports.

The Caribbean Plate boundary is prone to tsunamis because it has all the tsunami-generating sources within a small geographical area:

1. Subduction-zone earthquakes of the type that generated the Japanese tsunami found along the Lesser Antilles and the Puerto Rico trench and the Hispaniola trench (1946 tsunami);
2. Other moderately large earthquakes due to more local tectonic activity that take place probably once a century, such as in Mona Passage (1918 tsunami) and in the Virgin Islands basin (1867 tsunami);
3. Moderate earthquakes that can trigger an undersea landslide;
4. An active underwater volcano ("Kick'em Jenny" near Grenada) where sea floor maps show previous episodes of flank collapse;
5. Above-water volcanic activity, wherein the Lesser Antilles periodically generates landslides that enter the sea to cause tsunamis; and
6. Distant tsunami from the African-Eurasian plate boundary, such as the great Lisbon earthquake of 1755, which produced 20 to 25 foot-high waves in the Lesser Antilles.

In 1867, a 9 foot high tsunami wave entered St. Thomas' Charlotte Amalie at the same time that a 21 to 30 foot wave entered St. Croix's Christiansted Harbor. Were that to occur again today significant infrastructure and population would be at immediate risk. According to UNESCO, if several cruise ships are in Charlotte Amalie when the 1867 event re-occurs, direct economic damage of between $500 million and $1 billion is possible.

International coordination

Significant progress has been made in international coordination of tsunami warnings since the Indian Ocean tsunami disaster of 2004. With NOAA leading tsunami warnings for the United

States, the USGS participates in regional tsunami coordination efforts, organized by the United Nations Educational, Scientific and Cultural Organization (UNESCO), in the Pacific, Indian Ocean, Caribbean, and Atlantic/Mediterranean regions. These efforts have led to the development of regional warning systems, data sharing, and the standardization of tsunami information products and coordination mechanisms.

Lessons learned from the March 11 earthquake and tsunami in Japan

Through our National Earthquake Information Center, the USGS provided rapid, accurate, authoritative and actionable earthquake information for the Japanese earthquake and its aftershocks, and their potential for damage. Technical coordination between the NOAA Tsunami Warning Centers and the USGS National Earthquake Information Center was exemplary. Following the earthquake, the USGS led inter-agency coordination activities under the National Earthquake Hazards Reduction Program (NEHRP). Still, there are several key lessons to be learned from the Tohoku earthquake:

- Scientists must thoroughly document the prehistoric record of large earthquakes, in order to fully assess the probabilities and consequences of the largest earthquakes.
- While tsunami damage and loss of life were heavy, preliminary information indicates that the investments made by Japan in monitoring and warning systems, earthquake resistant construction, and public information and preparedness activities dramatically limited damage and loss of life.
- Tsunamis can be generated very near the coastline. For tsunami warnings to be most effective, they must be generated and transmitted to the affected coastline as quickly as possible after detection.

Conclusion: Becoming more resilient to large earthquakes and tsunami

The United States could reduce tsunami risks and improve public hazard notification and warning of tsunami and their causative earthquakes in three basic areas:

- Continued public education, through ongoing efforts for the U.S. Pacific States and Territories, particularly in Hawaii and the Pacific Northwest.

- Completion of the Advanced National Seismic System, including the enhancement of the seismic network in the eastern United States, and the development of earthquake "early warning" capabilities (which were in place in Japan) along the West Coast of the United States. For earthquakes located near the coast, the requirement for rapid and accurate analysis is most pronounced.

- Enhanced research into the frequency and effects of prehistoric tsunamis. The recorded history in the Western Hemisphere is too short to provide adequate probabilities for such events to happen. Seismic characterization of tsunamigenic faults and study of past landslides on the sea floor and paleo-tsunami deposits on land are needed.

Mr.Chairman, this concludes my remarks. I will be pleased to answer any questions you or the Committee may have.

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Responsibilities: Dr. Leith is the Acting Associate Director for Natural Hazards. In this position, he oversees the geologic hazards programs of the USGS and coordinates the scientific research and hazard response activities for earthquakes, volcanic eruptions, landslides, geomagnetic storms, floods, severe storms, and wildfires.

Career History and Highlights: Dr. Leith joined the USGS in 1986. He served as Chief of the USGS Special Geologic Studies Group from 1990 to 2000, and as Senior Technical Advisor to the Assistant Secretary of State for Verification and Compliance from 2001 to 2003. Between 2003 and 2010, Bill served USGS as the Coordinator of the Advanced National Seismic System. He also served as Associate Program Coordinator for the Earthquake Hazards, Geomagnetic Hazards, and Global Seismographic Network Programs.

He is a member of the American Geophysical Union, the Seismological Society of America, and the Earthquake Engineering Research Institute.

Education: Dr. Leith received a bachelor's degree in geology from the University of California at Berkeley, and master's and doctoral degrees from Columbia University. After receiving his doctorate, he served as a Research Associate at the Lamont-Doherty Earth Observatory.