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April 18, 2006

The Honorable Senator Jim DeMint
Chairman, Subcommittee on Disaster Prevention and Prediction
U.S. Senate Committee on Commerce, Science, and Transportation
Washington, DC 20515-6125

Dear Chairman DeMint and Subcommittee Members:

Subject: Testimony for the Subcommittee on Disaster Prevention and Prediction of the Senate Committee on Commerce, Science, and Transportation Hearing, April 18, 2006, San Francisco, California

Thank you for the invitation and opportunity to present testimony to this distinguished Subcommittee. I have been involved with earthquake science and engineering for the past 45 years in an effort to better understand earthquake hazards and their effects, and to work with the earthquake science and engineering community to develop mitigation measures to minimize damage during future earthquakes. I was elected to the National Academy of Engineering in 1978 for my contributions to seismic safety world wide. I have served as the president of the Earthquake Engineering Research Institute, the Seismological Society of America, and the Association of Engineering Geologists. I was the Utilities Commissioner on the California Seismic Safety Commission form 1985 through 1999 and was the commission chairman for two terms (1988-1990 and 1996-1998). I was also a member of the Newmark-Stever Committee that led to the Congressional establishment the National Earthquake Hazards Reduction Program (NEHRP). Therefore, I have first-hand knowledge of its value and accomplishments toward the reduction of earthquake risks and the overall value of NEHRP to the earthquake safety of our nation.

Enclosed please find: my testimony; a copy of a relevant report describing the U. S. Geological Survey's NEHRP earthquake hazards research activities, from the *2005 Report of the Scientific Earthquake Studies Advisory Committe*e, a committee mandated by Congress, of which I am Chairman; also, I am attaching a copy of a relevant report for today's commemorative activities, prepared specifically for the 1906 Earthquake 100th Anniversary, *Managing Risk in Earthquake Country Estimated Losses for a Repeat of the 1906 San Francisco Earthquake and Earthquake Professionals' Action Agenda for Northern California*; and my resume.

Sincerely,

Lloyd S. Cluff

Enclosures

Testimony of Lloyd S. Cluff Director,
Geosciences Department and PG&E's Earthquake Risk Management Program
Pacific Gas and Electric Company
San Francisco, California
and
Chairman of the Congressionally Mandated Scientific Earthquake Studies Advisory Committee
for the Hearing of the
Subcommittee on Disaster Prevention and Prediction of the Senate
Committee on Commerce, Science, and Transportation
April 18, 2006, 10:15 A.M.
Room 133 of the Moscone Center
San Francisco, California

For my testimony today, I have been asked to speak from various viewpoints; from the perspective of Chairman of the congressionally mandated Scientific Earthquake Studies Advisory Committee (SESAC). The SESAC was appointed by the Secretary of the Interior to advise on activities of the U.S. Geological Survey for the National Earthquake Hazards Reduction Program (NEHRP). The most recent SESAC report to Congress, dated November 23, 2005, is appended to my testimony. In addition, I have been asked to speak from the perspective of Director of Earthquake Risk Management Program for Pacific Gas and Electric Company in San Francisco, one of the nation's largest-investor owned gas and electric utilities. I will discuss PG&E's activities in preparation for major earthquakes, and measures PG&E has taken to mitigate and minimize the impact of major earthquakes, as well as the ability of the utility to restore power, and PG&E's coordination with research efforts of the US Geological Survey.

Today, April 18, is the day of commemoration of the 100th Anniversary of the 1906 San Francisco Earthquake. Therefore, I am appending a relevant report, *Managing Risk in Earthquake Country Estimated Losses for a Repeat of the 1906 San Francisco Earthquake and Earthquake Professionals' Action Agenda for Northern California.* I adopt the contents, conclusions, and recommendations of the report and I am making this report part of my testimony. This document has been prepared in advance of the 100th Anniversary Conference to provide conference leaders and speakers with a concise summary of the study performed to estimate potential losses for a repeat of the 1906 San Francisco Earthquake, as well as the Earthquake Professionals' Agenda of actions that we must undertake to ensure that Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake. The report was prepared by an affiliation of earthquake scientists, engineers, and emergency managers; the Earthquake Engineering Research Institute (EERI), the Seismological Society of America (SSA), the Disaster Resistant California (DRC), and the California Governors Office of Emergency Services (OES).

Scientific Earthquake Studies Advisory Committee -The complete 2005 report of the SESAC is appended to my testimony and I would like to emphasize three recommendations as quoted below that are relevant to today's hearing:

1. *The SESAC strongly encourages the USGS, the Secretary of the Interior, the Office of Management and Budget, and Congress to move forward vigorously with the Natural Hazards Initiative in the USGS fiscal year 2007 budget. Recent events have spotlighted natural hazards, and the Committee believes the USGS, through its Natural Hazards Initiative, has a major growth opportunity to take the leadership in creating a disaster-resistant country. We recommend the USGS undertake a complete analysis of the consequences of catastrophic earthquakes in the San Francisco Bay Area and in Southern California and integrate the complete picture, from rupture on the fault, wave propagation into buildings and other structures, the response of all levels of our infrastructure, the emergency response, and continuing to the full recovery of our society. The purpose of this exercise would be to identify where and when the breaking points for an extreme earthquake disaster in California will be. The lessons learned in this demonstration project would be applicable to all national extreme disasters.*

This recommendation is extremely relevant for today's hearing because assuming the 1906 earthquake was repeated today, as described in the appended report, *Managing Risk in Earthquake Country Estimated Losses for a Repeat of the 1906 San Francisco Earthquake and Earthquake Professionals' Action Agenda for Northern California,* the extremely saturated condition of the land in the San Francisco Bay Region, due to the more than six weeks of almost continuous rainfall, would further compound and exacerbate the catastrophic consequences. One prime example would be the failure of the Delta Levees. Given a major earthquake on any of the Bay Area faults (San Andreas, Hayward, or Calaveras) would result in massive failure of many of the levees. This single consequence has been reported by the California Department of Water Resources to result in direct economic losses of $50 billion, including substantial losses to the agriculture industry, loss of significant water-supply to southern California, and many of the San Francisco Bay Area communities.

2. *In support of the above recommendation, the Committee continues to strongly recommend to the Director of the USGS that full funding of the ANSS at the level authorized in the current NEHRP legislation be appropriated. The USGS must make a commitment to work through the Department of the Interior and the Office of Management and Budget to ensure this objective is met. Full deployment of the ANSS offers the potential to substantially reduce earthquake losses and their consequences by providing critical information for land-use planning, building design, insurance, warnings, and emergency preparedness and response. A 2005 report by the National Research Council reiterates that the potential benefits far exceed the costs*

3. *The Committee reemphasizes the USGS must reestablish the National Earthquake Prediction Evaluation Council to serve as the forum to review predictions and resolve scientific debate prior to public controversy or misrepresentation, so decision makers are not mislead by unfounded short-term earthquake predictions.*

The Committee encourages the USGS to support an active NEPEC equipped with adequate resources to perform this role.

I am pleased to report that since the SESAC submitted it's 2005 report to the USGS and Congress this recommendation has now been implemented. Many of the earthquake predictions that have been in the news during the past year or two could have become a disservice to society triggering unintended losses due to the "cry wolf or the sky is falling syndrome." Therefore, I am confident that the NEPEC will be of great service to society to forestall short-term earthquake prediction false alarms.

During the three decades since the National Earthquake Hazards Reduction Program was established, the NEHRP has provided insightful scientific and engineering leadership toward reducing earthquake risks. This leadership has resulted in major advances in identifying and characterizing active faults (earthquake sources) and understanding the destructive effects of earthquakes that will eventually be released by slip on these faults. Twenty-five years ago, there was hope that short-term earthquake predictions would have been realized by now. Although that capability has not been realized, reliable estimations of the locations of future major earthquakes, their size, their likelihood of occurrence, and the character and extent of their effects are now possible.

Additionally, a wealth of information has been developed to enhance our knowledge of the vulnerabilities of the built environment to earthquakes. We now better understand the factors that influence good as well as poor earthquake performance of utilities and transportation systems, as well as specific types of structures and buildings. This improved knowledge has resulted in useful tools that, if applied, have the potential to bring unacceptable risks under control to protect the public and minimize catastrophic consequences.

However, the risk is growing faster than our ability to provide effective mitigation. In spite of the increased knowledge and the good work that has been done, particularly in regions of high seismic exposure, earthquake risk continues to grow nationwide. This is largely due to (1) uncontrolled growth in earthquake-prone areas, (2) the lack of effective land-use planning in the hazardous areas, (3) the lack of implementation and enforcement of appropriate building standards, and (4) the high cost of strengthening the existing built environment. This trend has positioned the nation in an unacceptable situation, one that will eventually result in catastrophic losses. Studies such as the 1999, National Research Council publication, *The Impacts of Natural Disasters: A Framework For Loss Estimation*, show the per-event costs could reach thousands to tens of thousands dead, hundreds of thousands injured and homeless, and direct and indirect economic losses that could exceed $200 billion. This trend will not be reversed until the earthquake-prone communities in all 39 vulnerable states understand the threat and take action to mitigate unacceptable risks.

Pacific Gas and Electric Company's (PG&E) Earthquake Risk Management Program - In addition to its concern for employee and customer safety during earthquakes, Pacific Gas and Electric Company has a strong economic interest in "keeping the lights on." PG&E has vast resources in dams and power plants, transmission and distribution systems, and administrative buildings. Although protecting these resources from earthquake damage is important, equally important is functionality following an earthquake. The ability to continue to provide, or quickly restore utility service to customers, will assist emergency response efforts and reduce recovery time for the community, as well as assure a continuing income stream to northern California businesses during a particularly challenging time. Functionality also affects the communities PG&E serves, as businesses having gas and electricity can recover quickly, lessening the overall economic impact to the community.

PG&E has been able to leverage their efforts to improve earthquake safety and reliability of their gas and electric systems through the development of user-driven, public/private research partnerships, co-funded in part by state and national agencies. Three examples are presented below.

PG&E/U.S. Geological Survey CRADA - The 1989 Loma Prieta earthquake provided an opportunity and motivation for PG&E to focus on better understanding the nature and character of earthquake hazards in Central and Northern California, PG&E's service territory. After extensive discussions with the USGS Menlo Park office in 1992, PG&E entered into a non-financial Cooperative Research and Development Agreement (CRADA) with the USGS. We agreed to cooperate on research on earthquake hazards throughout the greater San Francisco Bay Area. Based on the success of this effort, in 1996, the agreement was modified into a financial CRADA. Over the next few years PG&E provided $4.4 million in funding for projects with USGS scientists that would focus on PG&E's needs for system safety and reliability improvements, throughout our service territory. Generally, the projects include studies to better understand the location and characteristics of specific active faults, the effects of strong ground shaking, local site effects known to influence the degree of damage at particular locations, and the nature of ground failure mechanisms (landslides and liquefaction). Many projects have been completed, and the results are being used to help reduce earthquake risks not only to PG&E facilities, but also to PG&E's industrial customers, private homeowners, and the public at large.

Pacific Earthquake Engineering Research Center (PEER) - The research results from the PG&E/USGS cooperative program feeds directly into another user-driven, applied research, public/private partnership that PG&E played a major role in establishing, the Pacific Earthquake Engineering Research Center (PEER) Lifelines Research Program. Program partners include PG&E, Caltrans, and the California Energy Commission (CEC), under the auspices of the Pacific Earthquake Engineering Research Center (PEER), at the University of California at Berkeley.

In 1996, PG&E and the University of California entered into an agreement to focus applied research efforts toward improving the earthquake performance (safety and reliability) of gas and electric systems in California. The concept of the users driving the research agenda, in collaboration with the best earthquake researchers available, was the focus of this initial partnership. PG&E engineers are intimately involved in selecting research topics, as well as guiding the research so that research results will be in a form that can be used in improving operations. This collaboration provides a mechanism for research results to be immediately implemented to improve PG&E's system seismic safety and performance during earthquakes.

The initial funding from PG&E to jumpstart the program was $3.5 million, however, the user-driven concept interested Caltrans for their earthquake safety and reliability research program for bridges and highways, and a matching funding arrangement was established. Also, the California Energy Commission realized the merits of this program that would benefit all California Gas and Electric systems. The combined leveraged funding from PG&E, Caltrans, and the CEC to support the PEER Lifelines Research Program is now at about $15 million, through 2005. We are seeking additional partners to participate in the benefits of future research and to join in future funding of user-focused applied research. Additional matching funding from NEHRP funding agencies would also provide opportunities to enhance the user-driven research approach.

American Lifelines Alliance (ALA) - The formation in 1997 of the American Lifelines Alliance **(**ALA) initially by FEMA and the American Society of Civil Engineers (now with the Multihazard Mitigation Council within the National Institute of Building Sciences (NIBS) is in direct response to needs for improved lifeline performance that were identified more than ten years ago, and was specifically required in the 1990 reauthorization of the NEHRP. Leaders from lifeline organizations strongly endorsed the need for developing and adopting seismic design guidance for lifelines in a 1997 Lifeline Policymakers' Workshop.

The ALA's objective is to facilitate the creation, adoption, and implementation of design and retrofit guidelines and other national consensus documents that, when implemented by lifeline owners and operators, will systematically improve the seismic safety and performance of lifelines during natural hazard and human threat events. The current participants in the partnership include FEMA, NIBS, U.S. Geological Survey, U.S. Bureau of Reclamation, PG&E, Rohn Industries, Pima County, Arizona, and various private sector consultants.

Although the formation of the ALA was closely tied to concerns regarding earthquake threats, the consideration of multiple hazards was determined necessary by the ALA to facilitate decisions on design and retrofit measures to achieve improvements in reliability on a national scale, where the level of risk from various natural hazards is highly variable. The initial focus of ALA guidance development was on all natural hazards, including earthquakes, floods, windstorms (including hurricanes and tornados), icing, and ground displacements (including landslides, frost heave, and settlement). However, following the September 11, 2001, terrorist attacks, FEMA directed the ALA to address

hazards posed by human threats, including blast, chemical, biological, radiological, and cyber threats. The utility and transportation systems appropriate for the ALA process include electric power transmission and distribution, natural gas transmission and distribution, potable water conveyance and distribution, wastewater transportation and processing, oil and liquid fuel handling, transport, and storage, highways, railroads, ports and inland waterways, air transportation, and telecommunications.

The ALA is working closely with the Lifelines Subcommittee of the Interagency Committee on Seismic Safety in Construction, which is charged with assisting Federal departments and agencies to develop and incorporate earthquake hazard reduction measures in their ongoing construction programs. The ALA's efforts to develop national consensus guidance documents are aligned with many of the objectives of the Lifelines Subcommittee. ALA products will provide appropriately qualified seismic guidance, and the Lifelines Subcommittee can help in the preparation and adoption of such guidance by Federal agencies. The ALA has developed matrices that define the current status of natural and manmade hazards guidance available in the United States for lifeline system operators and other interested parties.

ALA guidelines published in the last two years include Seismic Fragility Formulations for Water Systems, Guidelines for the Design of Buried Steel Pipe, Seismic Design and Retrofit of Piping Systems, Extreme Ice Loads from Freezing Rain, and Guidelines to Define Natural Hazards Performance Objectives for Water Systems. Guidelines currently in preparation include those to evaluate the performance of electric power, oil and natural gas pipelines, and waste water systems during natural hazard and terrorist threat events.

In spite of these successes, ALA has recently lost its funding support from FEMA due to budget cuts during the past year, creating a leadership vacuum for helping to prepare the nations critical infrastructure systems for natural disasters. And now there is no clear direction about how to address infrastructure performance in a multi-hazard environment. There is an urgent need to coordinate the activities of NEHRP and Wind Hazard Reduction Program.

Misplaced Complacency _ Many public policy makers know that earthquakes are infrequent and assume they can be safely ignored in favor of more pressing issues; but they can be assured that when a catastrophic earthquake occurs on their watch, the truth will be revealed. Public perception, it could be said, might be that the United States is not that vulnerable to earthquakes, because the number of lives lost has been exceptionally low compared with that in other countries. The fact is, it has been a matter of luck that earthquake deaths have not been higher in the United States. Thirty-nine states have an earthquake threat, and it is just a matter of time before disaster strikes. We cannot afford to rely on good fortune to minimize earthquake loss of life. Let's look at a few examples.

1971 San Fernando, California Magnitude 6.7 Earthquake - The San Fernando earthquake was a direct hit beneath the San Fernando Valley, a few miles north of

downtown Los Angeles. The earthquake occurred at 6:00 A.M., when most people were safe at home. The Lower San Fernando Dam was severely damaged and would have experienced massive failure, except the reservoir had been drawn down for maintenance a few days before the earthquake. We were lucky that the duration of the shaking was short. Had the earthquake lasted a few more seconds, the dam would have massively failed, releasing the water in the reservoir onto the 80,000 people living directly downstream. The first floor of the outpatient facility at the new Olive View Hospital massively collapsed, but it was unoccupied because of the early morning hour of the earthquake; later in the day, the facility would have had hundreds of patients.

1989 Loma Prieta, California Magnitude 7.1 Earthquake - In spite of the fact that a major earthquake struck the San Francisco Bay Area on October 17, 1989, losses were minimal; there were only 63 deaths. We take credit for the fact that we had an aggressive program of seismic safety improvements throughout the Bay Area, and that helped limit the losses. However, we were lucky. The center of the energy release along the San Andreas fault was in the Santa Cruz Mountains, 30 to 60 miles from the major cities. Had the earthquake been closer, damage, particularly to the older building stock that had not been seismically upgraded, would have been disastrous. It occurred at 5:04 P.M., commute time, the worst time of day for an earthquake according to earthquake scenarios, and because the streets are filled with people and the freeways are jammed with traffic. An upper section of the Bay Bridge dropped onto the lower deck, and the Cyprus double-decker freeway in Oakland massively collapsed. These two structural failures could have been the source of hundreds of deaths. But we were lucky. The World Series Earthquake, as it has been called, occurred at the beginning of the third game of the World Series between the two Bay Area teams, the San Francisco Giants and the Oakland Athletics. The freeways and bridges were eerily empty while people were inside, watching the game. It was also fortunate that, because of the game, we had media coverage of the earthquake that lasted more than two weeks, helping to raise awareness of the earthquake threat.

1994 Northridge, California Magnitude 6.7 Earthquake - The Northridge earthquake also occurred during the early morning hours, 4:31 A.M., on Martin Luther King Day. Had the earthquake occurred only a few hours later on the national holiday, the near-massive collapse of the Bullocks Department Store in Northridge would have resulted in more deaths in that one building than all the deaths (57) in the entire region affected by the earthquake. Thousands of commercial buildings were badly damaged and many collapsed, and many freeway bridges collapsed, but they were all virtually empty at the time of the earthquake.

2001 Nesqually, Washington Magnitude 6.8 Earthquake - The February 28, 2001 earthquake that struck the Nesqually district of Seattle, Washington resulted in only minor casualties and localized damage. The lack of significant damage and casualties were due to two important factors: the focal depth of the earthquake of was two to three times deeper (55 km) than most damaging earthquakes, and for the past few decades the Seattle region has adopted an aggressive seismic safety improvement program, particularly with support from FEMA's Project Impact during the 1990s. However, just

prior to the earthquake, due to Mardi gras-related riots in Pioneer Square and the Sodo District, the police had barricaded the area to public access. We were lucky because in this old part of the city, unreinforced masonry walls fell into the streets when the earthquake struck, and would have resulted in many casualties had people been allowed normal access.

2002 Denali Fault, Alaska Magnitude 7.9 Earthquake - The second largest earthquake ever to strike the United States, the magnitude 7.9 earthquake on November 3, 2002 on the Denali fault, was a media non-event. This was partly because the earthquake struck a very remote region of Alaska. We were lucky this large earthquake was released on a fault in Alaska, rather than along one of the many faults close to major population centers in California. A similar earthquake along any of the faults associated with the San Andreas fault would have resulted in thousands of deaths and direct and indirect economic losses that could have easily exceeded $200 billion.

But it was also a media non-event because the only significant structure situated in the path of this potentially devastating earthquake did not fail. It was *not* a matter of luck that the Trans-Alaska Pipeline performed so well. It was exceptional scientific assessment of the earthquake hazards and innovative engineering design that prevented an oil spill. The Denali fault experienced 18 feet of horizontal and 2.5 feet of vertical displacement at the pipeline crossing of the fault. Thirty two years ago, I organized a state-of-the-art scientific team to complete seismic hazard evaluations of the pipeline route. We worked with an innovative pipeline engineering design team, under the direction of Newmark and Hall, and the result was that when the maximum design earthquake occurred directly beneath the pipeline, not a drop of oil was spilled because the pipeline was well prepared to accommodate the fault displacement and related earthquake effects.

Seventeen percent of U.S. crude oil flows through the Trans-Alaska Pipeline. The State of Alaska depends on the pipeline for eighty percent of its revenue. If damaged, the pipeline could have been disabled for many months, causing gas prices to soar. It is possible that if the pipeline had broken, the resulting environmental disaster would cause the pipeline never to be restored.

Earthquake programs and hazard-reduction priorities are too important to risk being lost among competing demands and priorities. In California, important earthquake programs were but a small portion of the overall responsibilities of departments responsible for emergency response, geologic hazards, and structural engineering. The State responded by establishing a Seismic Safety Commission as an independent and single-minded body charged with making certain that earthquake safety is never overlooked. At the present time the Commission is threatened by bureaucratic elimination.

along the lines of the overdue, but recently published, NEHRP Strategic Plan. The Strategic Plan outlines a course of action for the best use of existing funding and prioritizes opportunities for accelerating the program as additional funding becomes available. It outlines a balanced and accelerated approach that calls for Federal-level

A strong, viable earthquake risk reduction effort must include proactive implementation through increased funding, incentives for risk reduction, new public policy, and inspired leadership. As pointed out in the recent Earthquake Engineering Research Institute report, *Securing Society Against Catastrophic Earthquake Losses* (Earthquake *Engineering Research Institute, Oakland, California, 2003), at current funding levels, it will likely take 100-plus years to secure the nation against unacceptable earthquake risks. Based on EERI's research and outreach plan, implementing an expanded program that has three times the funding and includes full appropriations for ANSS and NEES, will provide the needed earthquake risk reduction results in the next 20 to 30 years. The next major earthquake will demonstrate that 100 years is much too long to wait.*

Unless seismic safety is afforded a priority that is now lacking throughout most of the 39 states that have significant earthquake exposure, the United States will experience unacceptable yet avoidable deaths and economic losses from future earthquakes. We have been lucky, we cannot afford to base our earthquake public policy on dumb luck.

I recommend the Subcommittee consider the many lessons contained in my testimony, as well as lessons presented in activities of this 1906 San Francisco Earthquake 100 year Anniversary Commemoration, and take prudent action to minimize our earthquake risks

Thank you for the opportunity to address the subcommittee.

APPENDIX A
SCIENTIFIC EARTHQUAKE STUDIES ADVISORY COMMITTEE 2005 REPORT