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1. INTRODUCTION

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to present testimony on the reauthorization of the National Earthquake Hazards Reduction Program (NEHRP) and the role of the U.S. Geological Survey (USGS) in this national program.

Let me state at the onset that the Administration strongly supports the reauthorization of NEHRP, a critical national program.

As we enter the new millennium, NEHRP will enter its 23rd year. I believe the NEHRP agencies can look back with pride over the accomplishments of the past two decades. When the program began in 1978, the awareness of seismic hazards was low in many earthquake prone areas of our country. In some regions, public discussion of earthquake hazards was considered detrimental to economic growth and development. Others felt that the earthquake threat was so overwhelming and inevitable that nothing could be done to mitigate it. Today, because of programs and activities supported by NEHRP, there is not only a general awareness of the earthquake danger in threatened areas of the country, but, more importantly, actions are being taken to reduce the impact of this menace.

We in the USGS have noticed a particular change in the willingness of local and state governments, and private interests to engage in dialogues and joint projects to address earthquake hazards. Twenty years ago we were the “bad news” people and were not always received warmly when we presented evidence of large earthquakes in the past, ongoing seismicity, and the probabilities of future damaging events. Today, we are stretched to keep up with the demands for more descriptive and more timely notifications of earthquake occurrences and their impact, more precise statements on the probabilities of future earthquakes and associated ground shaking, and more information and research on the effects of earthquakes. We have tried, with considerable success, to engage those with common concerns to work jointly in addressing common problems. The willingness of the non-federal sector to work in concert with us has been one of the most gratifying developments during the past several years of NEHRP. This success tells us that our message about earthquake hazards in the country is getting out, being heard and listened to, and being acted upon. My testimony today will highlight several examples of these partnerships.

2. USGS ROLES IN NEHRP

The purpose of NEHRP is to reduce the risks of life and property from future earthquakes in the United States. Other agencies involved in NEHRP are the Federal Emergency Management Agency, the National Science Foundation, and the National Institute of Standards and Technology.

Simply put, the USGS roles in NEHRP are:

- to produce products such as earthquake hazard assessments and national seismic hazard maps for earthquake loss reduction,
- to provide timely and accurate notifications of earthquakes and information on their location, size, and damage potential, and
- to carry out studies and research on earthquake occurrence and effects.

In practice, these roles involve many complex functions and activities, a few of which I briefly describe below. In these descriptions I shall emphasize the new directions we are taking and the partnerships we are developing under the aegis of NEHRP.

3. PRODUCTS FOR EARTHQUAKE LOSS REDUCTION

Earthquake Hazard Assessments. These are quantitative statements on the severity of ground shaking that can be expected at a location during a given period of time, usually stated in decades. The most effective application of these statements is seen in their use in model building codes. Two years ago we reported the development of new national seismic hazard maps. The maps show the maximum shaking likely to occur over 50, 100, and 250 year time periods. They bring together current nationwide knowledge gained from seismic monitoring, mapping and study of active faults, and studies of how the intensity of ground shaking decreases with distance from the earthquake source. Preparation of these maps involved extensive collaboration with NEHRP researchers, practicing design engineers, and State and local governments across the country. We continue to collect new data, review the national maps in light of new information, and shall revise them as necessary. About 30% of the funds appropriated to the Earthquake program are directed toward earthquake hazards assessments and related loss reduction products such as earthquake scenarios for loss estimation, maps of active faults, and uniform ground shaking spectra.

Getting Geology into the (Building) Codes. Once the maps were completed, our next task was to help "get the geology into the codes". During the past two years we have been working with the Building Seismic Safety Council (BSSC) and with the Federal Emergency Management Agency (FEMA) to translate the results of our maps into seismic design maps that are included in model building codes. It is important to note that we did not merely hand over our hazard maps to the engineering community; but we worked closely and in partnership with BSSC to ensure that this major product of the USGS program is understood and interpreted correctly. The USGS

maps will form the basis for the seismic design provisions of the new International Building Code due to be published in 2000.

We also have worked with other state and professional organizations in the development and application of our national seismic hazards maps. These groups include the Structural Engineers Associations of Utah, Washington, and Oregon, the California Division of Mines and Geology, the American Society of Civil Engineers, the Western States Seismic Policy Council, and the American Association of State Highway and Transportation Officials.

One final point on this topic – a paper map is a difficult medium from which to extract quantitative data. Both our earthquake hazards maps and the derivative seismic design maps are being produced in digital format on CD-ROMS and available on the Internet. This will allow engineers and others to use a personal computer to specify a location (latitude and longitude) or a postal ZIP code and retrieve the appropriate seismic design information for a location of interest.

New Directions

Focus on Urban Areas. The national scale hazard maps cannot incorporate all of the geological factors that can extend or amplify ground shaking in urban areas, where the population and risks are greatest. During 1999 – 2001 our program will devote particular attention to the Puget Sound, Memphis, Tennessee, and San Francisco Bay regions. In these areas, using the national maps as a baseline, we shall develop more detailed, larger scale products that depict the variation of expected ground shaking across the urban area. The results will be used to develop local maps showing probabilities of earthquake occurrence, amplification or extension of shaking caused by geologic deposits and structures, and susceptibility of these deposits to liquefy and slide during an earthquake. Earthquake hazard scenarios are being developed for public planning, and predictions of severe ground motion are being developed for engineering applications. In conjunction with these studies, we are conducting workshops with local engineers, civic officials, and members of the local business community during the projects to ensure the usefulness of the results and their effective application to mitigation practice.

Project IMPACT – Oakland, California, and Seattle, Washington**.** To provide additional focus to our urban efforts, we are supporting FEMA's Project IMPACT by working with the cities of Oakland and Seattle in the assessment of earthquake hazards. Because Project IMPACT relies on community-based efforts, our involvement provides us initial contact and continuing involvement with community leaders interested in earthquake hazard mitigation. Project IMPACT provides an effective and efficient means of introducing and applying our loss reduction products.

In Oakland we are using a field technique that penetrates up to 100 feet into the soil to determine material properties of the upper geologic layers. Based on this information, the amplification or attenuation of seismic shaking by the soil layers can be calculated. We have also installed seismometers on the lowlands near San Francisco Bay to directly measure soil amplification

factors from small, ambient earthquakes in the area.

In contrast to the San Francisco Bay region, the prehistoric earthquake pattern is difficult to assess in Seattle where the surface expressions of active faults are few and less obvious. Recently, a surface expression of the Seattle fault was found on Bainbridge Island using high-resolution laser ranging techniques, and we are working to assess the impact of this fault on the
existing earthquake hazard assessment of the Seattle area. As in Oakland, we are working with the City of Seattle to determine the effects of local geology on the amplitude and duration of seismic shaking.

4. EARTHQUAKE NOTIFICATION AND INFORMATION

Seismic Monitoring. The USGS is responsible for monitoring and reporting on earthquakes occurring within the United States. We are expected to obtain and distribute accurate and timely information on any earthquake large enough to be felt in any part of the country. This work is routine and yet demanding, it is conceptually simple yet technically complex, and it requires constant vigilance and attention to detail. This task includes the maintenance of hundreds of seismometers in the field, the continuous transmission of data to central locations, rapid data analysis, and rapid dissemination of information on earthquake location, magnitude, and damage potential. Seismic monitoring and reporting is important to emergency response and to public awareness and safety. In addition, seismic monitoring is of longer-term importance. It tells us the rates and levels of earthquake activity on active faults, and thus provides an essential building block for regional and national hazard assessments. To carry out this function we operate the USGS National Earthquake Information Center, the National Seismograph Network, and support the operation of 13 regional seismic networks operated by universities. These activities are known collectively as the National Seismic System. The work of the national and regional networks and data centers is coordinated by the Council of the National Seismic System, which the USGS established and continues to support. About 40% of the funds appropriated to the Earthquake Program are used for earthquake monitoring and reporting.

USGS National Earthquake Information Center (NEIC). The USGS NEIC continues to be the primary source for public information on earthquakes in the nation and worldwide. The USGS is responsible for notifying federal and state emergency management officials of potentially damaging earthquakes within minutes of their occurrence. It also is the primary source of information on foreign earthquakes for the State Department, Red Cross, and other international relief organizations. USGS information on foreign earthquakes is used by government and private interests in the U.S. engaged in development or construction projects overseas. During the past year over 22,000 earthquakes were located and reported by USGS. In addition to its operational monitoring and notification activities, our NEIC serves the nation as an educational and information resource. The USGS NEIC Web-site sustains about 2 million “hits” per month, over 60,000 per day, and provides information on recent seismic activity and general information on earthquake occurrences, earthquake effects, and seismicity maps.

Regional Earthquake Monitoring – Regional networks are used to monitor active tectonic structures in much greater detail than is possible with the national scale network. Each region has a local data center where the data are processed, earthquake notifications are prepared and disseminated, and catalogues (or listings) of regional earthquakes are produced. These regional centers also provide a local distribution point for information about earthquakes and earthquake mitigation practices. Finally, the regional centers at universities provide training facilities and research opportunities for students representing the next generation of seismologists.

The data and information collected and distributed by various earthquake monitoring networks and data centers supported by the USGS will be used in the Disaster Information Network (DIN) proposed in the Presidential Fiscal Year 2000 budget. Although this initiative does not fall under the aegis of NEHRP, it will, if approved, improve the capacity of the USGS to store, transfer, and integrate data on natural disasters of all types. DIN will provide a single, central location or node at which officials, managers and the public can obtain the most current geospatial and other scientific data needed to prepare for and respond to natural disasters.

New Directions in Seismic Monitoring

Monitoring Urban Areas for "Real-time" Earthquake Assessments. A new application for seismic monitoring is developing in urban areas and a pilot project, "TriNet" is well underway in southern California. Project TriNet is a cooperative earthquake monitoring effort involving the California Institute of Technology, the California Division of Mines and Geology, and the USGS. The project receives support from FEMA through the California Offices of Emergency Services. Under this project several hundred seismometers are being installed in the Los Angeles urban area. These seismometers are capable of recording very strong earthquake shaking and have transmitters that instantaneously send data to a Caltech/USGS data center for analysis. With new data and analysis procedures, an innovative product called "shakemap" can be produced within ten minutes of any earthquake in the region. These maps show the severity and distribution of ground shaking caused by the earthquake. Because of geologic factors, these patterns are not simple " bulls eyes" centered on the earthquake epicenter, but typically have irregular shapes showing pockets or zones of concentrated shaking. Emergency response officials, transportation and utility infrastructure managers, and police and fire officials are using these maps to plan and execute their response to earthquake emergencies. For example, the maps will immediately tell the emergency manager the nature and magnitude of the disaster at hand, and indicate the areas likely to have sustained the heaviest damage.

5. RESEARCH ON EARTHQUAKE OCCURRENCE AND EFFECTS

Earthquake Occurrence. A major focus of USGS earthquake research is in understanding earthquake occurrence in space and time. Ongoing USGS investigations seek to understand: a) the physical conditions for earthquake initiation and growth; b) processes of earthquake triggering; c) how individual faults in the same region interact; d) why some faults slip without earthquakes while others always generate earthquakes when they fail; and e) the factors that control variations of recurrence intervals of earthquakes along the same fault. Although at a reduced level, our research continues to address the problem of short-term warnings in the days or hours before damaging earthquakes. The ongoing USGS earthquake prediction experiment at Parkfield, California may permit not only the recording of pre-earthquake signals, but also the possibility of understanding their origin. USGS research has important applications in forecasting earthquake aftershocks and is of great value to citizens and public safety officials in the aftermath of large earthquakes.

Earthquake effects. Improving current techniques for forecasting the effects of strong ground motion will greatly improve seismic hazard maps for urban regions and is critical to cost-effective earthquake hazard mitigation. USGS earthquake research in this area addresses how complexities in the earthquake source, Earth's crust, and near-surface soils and deposits influence seismic wave propagation and strong ground motion. Identifying and understanding the behavior of weak liquefiable sediments is also a priority. Research on ground failure in collaboration with structural and geotechnical engineers will lead to improved design of earthquake-resistant infrastructure. Approximately 30% of our appropriated funds are used for research on earthquake occurrence and earthquake effects.

Continuous Monitoring of Earth Movement in Southern California. In another major partnership, the USGS, National Science Foundation, National Aeronautics and Space Administration, and the Southern California Earthquake Center are installing a state-of-the-art geodetic network to monitor fault movements and Earth strain. The Southern California Integrated GPS Network (SCIGN) makes use of the Global Positioning System (GPS), a satellite navigation system operated by the Department of Defense, which permits points on the Earth's surface to be located to a precision of a millimeter. When complete, the network will track the movement of 250 stations concentrated along a corridor through the Los Angeles basin, but also extending south to the Mexican border and east to the Colorado River. The data will improve understanding of the large-scale tectonic processes responsible for earthquakes and of the framework of faults on which tectonic stresses are relieved in earthquakes. These measurements will provide indications of how fast strain is building up, where it is concentrated, and where earthquakes might occur in the near future. SCIGN is operated primarily by three institutions: the USGS, Caltech's Jet Propulsion Laboratory, and the University of California--San Diego's Scripps Institution of Oceanography.

New Directions

Addressing Special Problems of Geologic Basins. Geologic basins filled with recent, loose sediments are known to amplify and extend seismic shaking from earthquakes. Unfortunately, these basin settings make attractive places for development. Mexico City in 1985 and Leninakan, Armenia, in 1988 are examples of severe earthquake damage to cities built over geologic basins. More than 10,000 people were killed in each of these cities when a large earthquake occurred. USGS scientists have developed theoretical techniques for predicting seismic wave propagation that explain the general features of amplification and extension of shaking in basins. To confirm and apply these techniques we have initiated a pilot field experiment near Santa Clara, California. In this experiment dozens of portable seismometers have been recording small earthquakes that occur frequently in the region. These recordings will be used to develop a geologic model for the basin and produce seismic response maps for various earthquake scenarios. These maps will show the sites within Santa Clara Valley that may be subject to particularly strong shaking during a large earthquake. Buildings occupying these sites may need strong reinforcement, and new buildings may need to be constructed with designs that exceed conventional building code requirements. If these pilot studies prove successful, the methods can be repeated at other densely populated cities built on geologic basins.

Bay Area Paleoearthquake Experiment. The USGS is working with the Pacific Gas and Electric (under a Cooperative Research and Development Agreement) and the Lawrence Livermore National Laboratory (LLNL) to develop a complete chronology of large earthquakes on major active faults in the San Francisco Bay area during the last 2000 years. The Bay Area Paleoearthquake Experiment (BAYPEX) involves digging trenches across active faults and detailed geological analyses of the trench walls to determine the history of earthquake occurrences for each fault. Charcoal samples taken from trench walls are collected for radiocarbon dating to help determine the absolute age of previous earthquakes. Some 23 sites are being excavated along the surface traces of active faults to estimate the time and size of past earthquakes. New results from this work indicate that an earthquake in 1836 previously thought to have occurred on the Hayward fault in the Oakland (California) hills occurred on another, nearby fault. This increases the lapsed-time from the last large earthquake on the Hayward fault and the current hazard from that feature. These and similar results are being used by the USGS to prepare a comprehensive statement on earthquake probabilities in the Bay area.

6. USGS RESOURCES IN NEHRP

The FY 1999 appropriation to the USGS Earthquake Hazards Program is $48,560,000. Approximately $12 million of this amount (about 25%) is directed toward external activities including: $6 million in research grants to universities, state agencies, and private concerns, $1.1 million under a cooperative agreement to the Southern California Earthquake Center, $3.1 million in cooperative agreements to 16 universities for the operation of regional seismic networks and related work, and the remainder in smaller projects and operational expenses.

In FY 2000 the President's Budget requests $44,115,000 for the USGS Earthquake Hazards Program. Although this figure appears to show a decrease, it actually contains an increase for

program purposes. In FY 2000 the USGS is restructuring its budget by removing appropriations for facilities and bureau-level administrative costs from program budgets and consolidating these costs elsewhere in the budget. This restructuring will more clearly reflect the funds that are being committed to our scientific efforts. The FY 2000 USGS earthquake program budget request is being justified as follows: $48,560,000 as the FY 1999 base; plus $1,075,000 for uncontrollable costs, plus $1,600,000 "real-time" earthquake assessments, and minus $7,120,000 for facilities and administrative costs covered elsewhere in the budget.

If Congress approves this request, the program will receive a net increase and the portion of our program directed toward support of external activities will remain constant.

7. GLOBAL SEISMOGRAPH NETWORK

Congress authorized $3,800,000 to the USGS for support of the Global Seismograph Network (GSN) in the last authorization of NEHRP (PL 105-47). Sums of $3,800,000 and $3,831,000 were appropriated for this purpose in FY1998 and in FY1999 respectively. In FY2000 the President's budget request for the USGS for the GSN is $3,481,000 based on the FY1999 appropriation, plus $42,000 for uncontrollable expenses and minus $392,000 for facilities and administrative costs covered elsewhere in the USGS budget.

With these funds the USGS maintains 71 stations of the current total of 107 stations in the GSN from a base at our Albuquerque Seismological Laboratory where we also operate a GSN data collection and quality control center. Literally, the sun never sets on these GSN stations. They range in latitude from the South Pole to Greenland, and circle the globe from Petropavlvosk, Kamchatka to Pitinga, Brazil. Data are used in routine earthquake reporting by the NEIC, for basic research into the structure, composition, and dynamics of the Earth, and in International Monitoring System being developed for the proposed Comprehensive Test Ban Treaty. The GSN is a joint effort involving the USGS, the Incorporated Research Institutions for Seismology supported by NSF, and the Institute for Geophysics and Planetary Physics at the University of California.

8. ISSUES

Seismic Monitoring. PL 105-47 authorized appropriations to the USGS of $3,000,000 in FY1998 and FY1999 for the development of a "Real-time Seismic Warning System". Funding for this purpose was not appropriated. This legislation also directed the USGS to prepare an Implementation Plan for such a system. This plan was submitted to Congress in March 1998 and it indicated that the costs of such a system in the San Francisco Bay region, for example, would be approximately $41 million to be spent over five years. The costs for operations were estimated to be approximately $5 million per year. These funding requirements far exceed our resources.

As indicated above, we are making progress in the Los Angeles region with Project TriNet as a pilot real-time hazards warning system and an additional $1.6 million has been requested to start additional pilot efforts in FY2000.

It is our assessment that the entire infrastructure of seismic monitoring in this country, most of which is based on 1960's technology, needs attention. In response to PL 105-47, we have recently delivered a report on this assessment to the Committee.

Modernization and stable support for seismic monitoring will improve the earthquake response of disaster information networks, which can only be as effective as the data and information they receive.

Scientific Advice. Because of the complexity of the scientific and technical issues we face in fulfilling our roles in NEHRP, the USGS would, in our view, benefit from the sustained perspectives, advice, and guidance of a standing panel or committee of external experts. This panel would be presented with our NEHRP roles, goals, and objectives and give us advice on how best to gain these ends. A standing panel, instead of an *ad hoc* body, would be more effective because it could develop a sense of our capabilities, give interim guidance toward major objectives, and assist in measuring our progress. It would be beneficial if reauthorization specifically established a USGS Scientific Earthquake Studies Panel of external (non-USGS) experts drawn from appropriate fields.

9. CONCLUSION

In conclusion, I hope, through this brief overview of our NEHRP work, to have conveyed a sense of accomplishment based on past results and experience. I also hope that I have conveyed a sense of enthusiasm and optimism for the future of NEHRP and the USGS role within this critical national program. I want to emphasize that one reason for my optimism is the growing number of partnerships in addressing earthquake problems we have developed with other federal and state agencies and the private sector. My testimony two years ago had a separate section where we listed these cooperative efforts. Today, that model would have made this testimony repetitious because practically everything we do involves working with another agency, group, or institution. The concept of joint efforts working toward common goals is being woven into the fabric of all our undertakings. The present offers many challenges to earthquake hazard mitigation, but I believe that the USGS, its sister NEHRP agencies, and our non-federal partners are working boldly and effectively to meet these challenges and to assure a safer future for our country.

Mr. Chairman, this concludes my remarks. I would be happy to answer any questions.