WYOMING STATE GEOLOGICAL SURVEY
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SEISMIC NETWORK RECOMMENDATIONS FOR THE WYOMING TRONA MINING AREA AND THE STATE OF WYOMING

by

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PRELIMINARY HAZARDS REPORT
95-2

This report has not been reviewed for conformity with the editorial standards of the Wyoming State Geological Survey.

Laramie, Wyoming
1995

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March, 1995

Introduction

Seismic networks are composed of a series of seismometers that are strategically placed to provide data that can be used to determine the magnitudes, locations, durations, and depths of earthquakes in an area of interest. There are many seismic networks in the United States. Most are local in extent, and are designed to provide detailed information on small to moderate earthquakes. The seismic networks in place in Yellowstone National Park and in the Jackson Lake region are considered to be local networks. Local networks are usually composed of a dense array of short-period, vertical, high-gain seismometers. The short-period seismometers generally are operated at high magnifications to detect very small local events, but the waveform signals are clipped or truncated on larger events, resulting in lost data. The instruments, however, provide very accurate timing of first motions to locate an earthquake, and the duration of the signals can be used to estimate the magnitude of an event. A well-distributed local network of short-period instruments can provide data to locate rather precisely all magnitude 1.0 or larger events in the vicinity of the network, and can provide data to locate smaller events with less precision.

The U.S. Geological Survey has created and is expanding a National Seismograph Network(NSN). The national network is currently composed of 38 standard and cooperating digital stations scattered throughout the United States. The standard stations are composed of highly reliable, real-time, three-component, well calibrated, broadband seismometers. Cooperating stations, most of which are operated by universities, provide similar data using instrumentation from other manufacturers. The 24-bit dynamic range of the digital seismographs records earthquakes, with unclipped signals, at local, regional, and continental distances. They also supply more detail than do short-period seismometers for earthquakes with magnitudes larger than 2.5. The data supplied by these broadband instruments can be used to generate rather precise waveform models, which are useful when trying to distinguish unusual events from tectonic earthquakes. In many cases, an underground explosion, rock burst, or a mine collapse may be distinguished from a tectonic event by using data from a few NSN stations. As with a local network, greater locational accuracy of earthquakes can be achieved by increasing the number of stations in the network. Existing NSN broadband stations that are in or near Wyoming are located at Boulder, Wyoming; Rapid City, South Dakota; Dugway, Utah; and Golden, Colorado. A NSN station has been proposed for Yellowstone National Park.

The U.S. Geological Survey/National Earthquake Information Center in Golden, Colorado, currently utilizes data from more than 100 broadband and short-period seismic stations throughout the country in order to determine earthquake locations and magnitudes. Many of the short-period stations operate antiquated equipment. Upgrades or modifications are needed at these stations to increase their versatility.

The accuracy of earthquake locations (computed hypocenters) is generally a function of the density of seismic network stations. The velocity models that are used to analyze seismic data can also affect the accuracy of the hypocenters. In general, existing local networks have a locational accuracy of +/- 1.0 miles (U.S. Bureau of Reclamation personal communication). In many cases, especially when portable instruments are deployed, much greater accuracy can be obtained from local networks. The U.S. Geological Survey's existing network of broadband and short-period stations provides a locational accuracy that generally is better than +/- 6 miles. As more NSN stations are installed, the locational accuracy of the U.S. Geological Survey network should improve significantly. For example, if a NSN station is placed in southwestern Wyoming, regional hypocenter accuracies there should be better than +/- 3 miles (U.S. Geological Survey personal communication).

Seismic Network Costs

There can be significant short-term and long-term cost differences between a local network and a National Seismic Network station. As would be expected, the size of the local network dictates the cost of the network. The Jackson Lake Network, operated by the

U.S. Bureau of Reclamation, is composed of twenty short-period stations. The present day cost for a network of that size would be approximately $250,000 for equipment purchase, installation, and testing. Approximate yearly costs for data analysis and equipment maintenance for a network of that size would be in the $80,000-$100,000 range, depending upon personnel, transportation, and repair costs. Using the size of the Jackson Lake Network as a model, it would cost approximately $12,500 to purchase, install, and test each short-band seismometer station, and approximately $5,000 per year per station to analyze data and maintain the station. There will be additional costs for data transmission, with costs dependent upon access to microwave transmitters and telephone lines. These cost estimates are based upon data supplied by the U.S. Geological Survey, the U.S. Bureau of Mines, and the University of Utah.

A National Seismic Network broadband station costs considerably more than a typical short-band station. Based upon cost estimates provided by the U. S. Geological Survey, it appears that the cost of equipment and installation of a NSN station is approximately $60,000. Installation costs will increase approximately $2500 for each 1000-foot increment over which a power line has to be installed. Due to recent federal budget cuts, the U.S. Geological Survey requires $50,000 in outside funds to install a NSN station. The U.S Geological Survey will absorb the station maintenance, data transfer, and data analysis costs for the station. A summary of approximate costs for both short-band local stations and networks and broadband NSN stations is presented below.

<u>Approximate Cost: Short-Band Seismic Station</u>

Equipment/Installation:	$12,500/station
Yearly Personnel/Maintenance:	$ 5,000/station

<u>Approximate Cost: 16-Station Short-Band Local Network</u>

Equipment/Installation:	$200,000
Yearly Personnel/Maintenance:	$ 80,000

<u>Approximate Cost: NSN Broadband Station</u>

Equipment/Installation:	$60,000(no cost share)/ $50,000(with cost share)
Yearly Analysis/Maintenance	$ 0

Early Warning Systems

Seismic networks provide information on the magnitudes, locations, depths, and durations of earthquakes. Depending on the accuracy and sensitivity of a network, small earthquakes that may be precursors to a larger event can be detected, although not all small earthquakes are precursors. If either an area or a specific fault system, such as the Teton fault, have been seismically inactive, and small scale earthquakes suddenly initiate, a high quality seismic network can ensure that such events are detected. While the significance of such events may not be known, any abrupt and/or prolonged increase in seismic activity could be brought to the attention of local, state, and federal officials, as well as to private industry. Seismic networks, however, are not true early warning systems.

Recent events in the trona mines have raised the question of whether or not a dense local seismic network can serve as an early warning system for future incidents. If there was a small magnitude seismic trigger to the collapse at the Solvay mine, a local network probably would have detected it. In fact, a National Seismic Network station in the vicinity of the mines most likely would have detected a small magnitude seismic trigger. No seismic network could have given an indication that a small magnitude earthquake would lead to a mine collapse, however.

Increased monitoring of extraction rates, pillar loads, deformation within the mines, and subsidence on the surface above the mines may lead to the development of a true early warning system. In fact, such data may be used to determine what effects earthquakes of various magnitudes may have on mine stability.

Recommendations for Trona Mining Area-Southwestern Wyoming

It is recommended that a National Seismic Network station be placed in the vicinity of the trona mines. As stated previously, a NSN station will provide the type of waveform data that can be used to distinguish unusual seismic events. In conjunction with other NSN stations and existing local networks, a NSN station will also serve to provide more accurate locations for local and regional earthquakes in the magnitude 2.0-2.5 range, as well as for larger events that may be associated with regional active faults capable of generating magnitude 7.0-7.5 earthquakes. The NSN station will not provide data that can distinguish events in one mine from those in another mine, but that information can be provided by the mines themselves. The addition of a NSN station will provide for better locational accuracy of small to moderate magnitude earthquakes, but not the degree of accuracy provided by a dense local network. A NSN station may be used to determine if small-magnitude events are occurring in the trona mining region. If numerous such events are recorded, then a dense local network may be justified. The total cost of a NSN station is $60,000 without cost-sharing. A partial cost-share with the U.S. Geological Survey is possible, although recent federal budget cuts have limited the amount of federal funds available for this purpose to $10,000. Again, the U.S. Geological Survey advises that they will absorb the costs for the station's maintenance, data transfer, and data analysis.

At this time, a local seismic network is not recommended for the trona mining area. The primary reason for this recommendation is that it appears that the majority of the February 3, 1995, energy release in the vicinity of the Solvay Minerals Corp. trona mine, was due to a collapse in the mine. It is unknown at this time whether or not a small tectonic-earthquake triggered the mine collapse. If there was such a trigger, it was most likely of small magnitude, and below the detection limit of the existing, distant seismic stations. While a local network could accurately detect such a small event, probably less than magnitude 2.0, the low level of historic seismicity in the vicinity of the mines does not warrant such an expenditure at this time. The recommended NSN station would allow for the detection of earthquakes in the magnitude 2.0-2.5 range, although the NSN-derived location would not be as accurate as one derived from a local network. If the NSN station detects significant small-scale seismic activity, however, the need for a local seismic network should be reconsidered.

Expanded monitoring of the roofs, pillars, and floors in the trona mines may provide more immediate benefit to the mines and miners than would an extensive local seismic network. More frequent ground surveys for subsidence would also provide more benefit to the mines and miners. Deformation, strength, and load data can be analyzed and used to estimate what effect various sizes of earthquakes may have on mine stability.

Recommendations for Wyoming in General

Local seismic networks are usually deployed in areas where active faults are exposed at the surface, where damaging historic earthquakes have occurred, or where the earthquake potential is considered to be significant based upon other geologic evidence. Areas in Wyoming that meet those criteria are Yellowstone National Park, the Jackson Hole area, the Star Valley (Wyoming) to Draney Peak (Idaho) area, the Rock Creek area west of Fossil Butte National Monument, and south-central Uinta County. Areas of lesser concern are the Wind River Basin, the Casper to Esterbrook area, and the north-south trending Oyster Ridge area in southeastern Lincoln County. Local Networks are already in place in Yellowstone National Park and the Jackson Hole area, although there is a possibility that the Jackson Hole network may be reduced in size in future years.

As mentioned previously, the short-period seismometers that are usually used in local networks are often operated at high magnifications. This often results in the truncation of waveform signals for larger events. Because of this, it is often desirable to have a few broadband seismometers located in the same general vicinity as a short-period seismometer network. The short-period seismometers can be used to monitor small to moderate events, and the more expensive broadband seismometers can be used to provide useful data on moderate to large events. Considering the above discussions, the following are the recommendations for the State of Wyoming in general.

It is recommended that funding sources be sought for a National Seismograph Network station in the Star Valley area. The potential for large, damaging earthquakes in the area dictates that high quality instrumentation capable of accurately recording a moderate to large earthquake be installed. A NSN station in this locality would complement any local seismic networks in the region.

In order to provide for increased resolution in locating earthquakes in Wyoming, it is also recommended that funding sources be sought for a NSN station in the northern Laramie Range area. Locating a station in the Star Valley area is a higher priority than placing a station in the Laramie Range area, but a station in eastern Wyoming should be a long-range goal.

A NSN station has already been proposed for Yellowstone National Park. Political, if not monetary, support should be given to the U.S. Geological Survey for the proposed Yellowstone National Park station.

It is recommended that political, if not monetary, support be given to the U.S. Bureau of Reclamation for the continued operation of their Jackson Lake seismic network. It is important that the network not be downsized.

It is recommended that funding sources be sought for expanding existing local seismic networks by adding short-period seismograph stations in the Star Valley-Draney Peak area, the Rock Creek area, and south-central Uinta County. After networks are expanded in those areas, it is recommended that funding sources be sought for establishing local seismic networks in the Wind River Basin, the Casper to Esterbrook area, and the Oyster Ridge area in Lincoln County.