

The Impact of Earthquake Prediction

by J. EUGENE HAAS

With an early scientifically credible prediction, it may be possible to have a large earthquake and only a small disaster

THOSE WHO ARE involved in the scientific side of earthquake prediction are sometimes accused of wearing blinders about the social impact of what they are doing. The charge is unjust to the extent that they have had little concrete evidence of what that impact may be, and also because earthquake prediction differs greatly in at least one major respect from the warnings that exist for other natural hazards. In earthquake prediction, lead times up to several years are possible, whereas they amount only to hours, or at most a day or so, in warnings of hurricanes, for example.

Since social scientists are sometimes regarded as being in the "soft" sciences, I want to be very careful in explaining what my group at the University of Colorado has been doing in this field. Our approach was to try to estimate, through very careful empirical research, what the consequences of a scientifically credible earthquake prediction would be. Our procedure involved interviewing individuals who would be directly involved in making decisions when faced with such a prediction. In the course of this study, we secured such a quantity of data that I can present only the highlights here — some of the findings, the major implications, and a few of the questions the study raised.

In terms of average annual loss figures in this country, earthquakes do not rate very high, either in loss of life or in direct property damage. But the potential catastrophe from earthquakes is very large, perhaps one of the largest we have to face. A single event could not only be a local disaster, but it could have statewide, regional, or even national impact. For example, suppose a great earthquake occurred in Santa Clara

County. If you know where the semiconductor industry in the United States is based, how it relates to the whole computer industry, and all the other things that are tied in with it, you'll see that though it might be a local disaster in terms of direct damage, it would also be a regional and to some extent a national catastrophe. It is in that context that we need to recognize earthquake hazards and the potential of earthquake prediction.

As a nation we try to cope with earthquake hazards not only by attempting to prevent or decrease losses but also by trying to share the losses and making an effort to pick up the pieces after the damage has occurred. Eventually, we will have scientifically based earthquake prediction, and it will be characterized by long lead times (ranging from months through years), specified location and magnitude, and some statement about probability. With this information, we almost surely will change our attitudes and activities. It was with this in mind that we made our study.

The work was done almost entirely in California (though we also checked some of our findings against the actual consequences of a quasi-prediction that was in effect for about seven months in the Kawasaki area of Japan in 1975). The data were taken from approximately 200 organizations, mostly in California — federal, state, and local government agencies (both legislative and executive branches) and businesses ranging in size from multinational corporations to local firms in two communities. One of these communities was in northern California and one in southern California; one had a population of about a million and the other about half a million. In one of those two communities we also

interviewed a stratified random sample of over 200 families to try to get an understanding of the response that could be expected from the general public in addition to that from business and government.

Unlike the usual survey, we attempted to move sequentially. First, we learned as much as we could from the seismologists about what the early predictions would probably be like, how the information might be released, and what problems they foresaw in the process. We then discussed those findings with California's large news media and tried to understand how they anticipated carrying such stories, particularly where there might be an extended lead time.

We then went to federal and state agencies, summarized what we had learned so far, and discussed with them what they saw as their major responsibilities for problems that might develop. From them we went to the large business firms, told them what we had learned, and asked what they would plan to do in this situation.

The source from which the prediction comes is the most critical factor of all

Moving to the local scene, we talked first with the local news organizations. By this time we could tell them in general what would be happening in the state and nation with respect to the prediction. After talking to people in local government, we went to local business firms, and finally to the families.

Our research approach differed in one other respect from many surveys. We were concerned that we might get off-the-cuff answers from those we interviewed, answers that might not relate very well to their later behavior if they were actually faced with such a prediction. To avoid that possibility we conducted extended informal discussions with people in each of these categories, using only a check list of potential issues as the basis of the discussion. We took extensive notes, then summarized what seemed to be the major trends and put them together in two short stories or scenarios that reflected what we thought we had been hearing from them.

We then sent those scenarios back to the people we had interviewed and asked them to review them. Were we overemphasizing certain things and omitting other things? About two weeks later we went back and had a more formal, structured interview and asked them to answer a series of standardized questions.

In that two-week interim period they had an opportunity to discuss the issues with other people. Some of them called up their friends in other organizations — banks or insurance companies, for example — and asked whether they had been talking to “the researchers from the University of Colorado.” This is precisely what we hoped would happen. It meant that they were giving careful thought to the whole process, and when we came back a second time, they could give us realistic estimates of what they thought their organizations would actually do.

When we finally were ready to interview the families, we realized that by this time the findings were so voluminous and so involved that we probably couldn't expect the average husband and wife to read them. We had to make selections. After a lot of pretesting, we decided to present the major findings on an audio tape, followed by a series of flip charts that would portray them graphically. We realized that most people have never thought what they would do in the face of an earthquake prediction, so again we went back and asked for a more considered opinion two weeks later. Altogether, we had more than 1,000 interviews.

One of the things we discovered early in the study was that the source from which the prediction comes is the most critical factor of all. A prediction from a place such as Caltech or Berkeley that has a long history of doing careful research in the field is going to have a different impact — regardless of the content of the prediction — from one from a different kind of source.

Roughly, then, this is how we got our data, and I would like to discuss some of the findings as summarized in one of our scenarios — Scenario B — which deals with a large expected earthquake. The dates were arbitrarily chosen for convenience. They are not real, or at least they are not intended to be.

In this scenario, we suggest that in July of 1977 the U.S. Geological Survey announces that there are some anomalous seismological data from a particular area (we changed the area depending on which of the two communities we were working in at a given time). These data suggest that the area ought to be intensively studied. It is made clear that it is not an official prediction. Asked by newsmen to evaluate the data from the Survey, a couple of seismologists say, “It's not clear, but if I have to make an estimate, I would say that in about three years there is going to be a damaging earthquake.” When pressed further, they give a 25 percent probability estimate.

Let me emphasize that we did not dream up this scenario. It came out of our discussions with seismologists. We asked them for their best estimates of

what the very first predictions are going to be like. What is likely to precede them? How are they likely to develop over time? No single seismologist wrote this plot; it is a compilation of ideas that we discussed at length with them. Notice the trends that the data indicate will start to develop — which are presented below in simplified scenario form.

In the 13-month period after July 1977 there is an increase in the purchase of earthquake insurance, or at least attempts to buy it. There will be evidence of a slowdown in construction, both public and private, because investors and public officials are beginning to think they had better play it cautious. There is some evidence of a slowdown in population growth and some indication of a decline in new business starts in the area.

In August 1978 we see the announcement of the first official prediction. The prediction is for an earthquake to occur two years hence during a two-month time window — September or October of 1980. The expected magnitude is 7.0 or larger, and a 50 percent probability is assigned. Now a second important event occurs. It deals with whether there is public evidence that the recognized experts in the field also see the prediction as scientifically valid.

In this scenario we say that the California Earthquake Prediction Evaluation Council certifies the U.S.G.S. prediction as a reasonable interpretation of the data. When they so inform the Governor, he asks relevant state agencies what they have done about it and what their responsibilities are. What, in addition, needs to be done? Local officials are a bit more dubious, and they hesitate to express their views for public consumption. Behind the scenes, however, they start planning and taking some action.

The State Insurance Commissioner makes a decision in what he considers the best overall interest of the public. He decides that new earthquake insurance policies will no longer be available for that particular area. His argument is straightforward: Those persons who have been paying premiums over the years for earthquake protection have a right to solvent companies after the earthquake occurs — if it does. If every Johnny-come-lately can now come in and buy earthquake insurance on an event that is relatively certain (whatever you mean by that term), some companies might not be solvent after it is over. So leaders in the insurance industry, real estate, and other interested sectors of the economy start calling for an alternate insurance program or something that is functionally comparable to it.

Within a few months damage-estimate maps begin to appear in the newspapers. The maps show projections

of major and moderate damage areas. (We shall see later that the maps have considerable impact on what happens to property values in the area.)

Buildings already under construction are completed because they will be less vulnerable that way, but within a few months new construction comes to a halt. As a result, unemployment in the building trades starts to skyrocket. There is a sharp reduction in mortgage availability. Some local lenders who have to live in the area will continue to offer mortgages, but on a highly selective basis. As the availability of mortgage money declines, real estate transactions also slow down.

As a spin-off of what happens to the construction industry and those parts of the economy that support it, there is a general decline — moderate at first and then accelerating — in the business activity level. Sales tax revenue starts to decline within about nine months, and so the long-term projected revenues for city and county government have to be revised downward. Long-term city planning is reconsidered. City officials begin to wonder which public services will need to be trimmed if revenues continue to decline. They begin making some tentative decisions. Parks and recreation, libraries, and eventually trash collection and street cleaning will be cut back if revenues continue the downward slide.

About a year after the first official prediction, Congress begins to hold hearings on possible alternatives to insurance. (If that seems dilatory, remember that we are talking about a possible disaster in a single community in one of 50 states.)

A number of homeowners have their houses inspected to find out how they are going to respond to the earthquake. They take steps to improve safety in the home — water heaters are bolted to the walls, bookcases fastened so they are less likely to topple, and the like. At this stage about a quarter of the families delay or cancel planned purchases of automobiles, TV sets, refrigerators, deep freezers, boats, and things of this kind. As a result, savings deposits begin to climb. Some of the sharper property owners realize that there is some indication that property values are falling. Many are owners of rental properties, and once they get some supporting data, they appeal to have their property reassessed for tax purposes. As others find out about the appeals, they follow suit. Within a year about a third of all homeowners have requested this kind of reappraisal.

Now imagine that it is about nine and a half months from the predicted earthquake time. The prediction is refined. The earthquake, it is now said, will occur during the month of September; the magnitude estimate is made considerably more specific (7.1-7.4); and the

probability is increased to 80 percent.

According to the data we have, a certain time has to pass before you have convincing statistics for significant economic impact on the community. Once you have those statistics, they can be used as the basis for the Governor asking for a Presidential declaration that a state of emergency exists. The law, by the way, is not very clear as to whether there can be such a declaration in advance of the actual disaster, and there is a long delay in this case before the President responds to the Governor's request.

The Governor, citing statistics that show a strong negative economic impact on the community, asks for a Presidential Emergency Declaration. Employers now start to talk about the possibility of having vacations for all of their employees during the month of September 1980 instead of the usual staggered vacations. There is a lot of activity at the government level, and there is no shortage of information, since a number of educational campaigns are under way in the local community.

A few firms move out of the area. They are large national firms with a considerable resource base, which gives them other options. With an extended lead time, they relocate simply to avoid whatever difficulties might arise. As an example: A national insurance firm has a two-million-dollar facility, which they operate every day of the year, doing a lot of computer work. Their top executives will not tolerate, if there are any reasonable options, the disruption of their business activities that would come with an earthquake — even if there were to be no serious damage. So, with two years lead time, they are willing to take as much as a 50 percent loss on their property and try to move elsewhere. They encourage their employees to go with them.

Local governments make an effort to maintain fire, water, and police protection, and other basic services, but some services are cut as both sales and property tax revenues continue to decline.

A number of employers announce in the early summer of 1980 that they will cease operations during the month of September. Most employers believe that their buildings and facilities are going to stand up adequately, but they have two main concerns. One concern is with legal liability. They are not sure what change, if any, there is in their legal liability as an employer in the face of a prediction that has broad scientific support. If they ask their employees to come to work as usual and the earthquake does occur roughly as predicted, what is their legal liability? Since they don't know, many of them don't want to take a chance.

The other side of that coin is a moral question. They

don't want to have to face the possibility that because they asked people to come to work some of them got killed or injured. They don't want that on their consciences when they could have just taken a financial loss. There is a kind of underlying caution running through much of the decision-making.

More than half of the families are continuing to delay large purchases, and so they are saving more. More than half have now asked for a reappraisal of their property for tax purposes. Some few are buying extra life, fire, and medical insurance. More than half the families and the businesses have made special plans for emergency responses and for stockpiling supplies such as food and water.

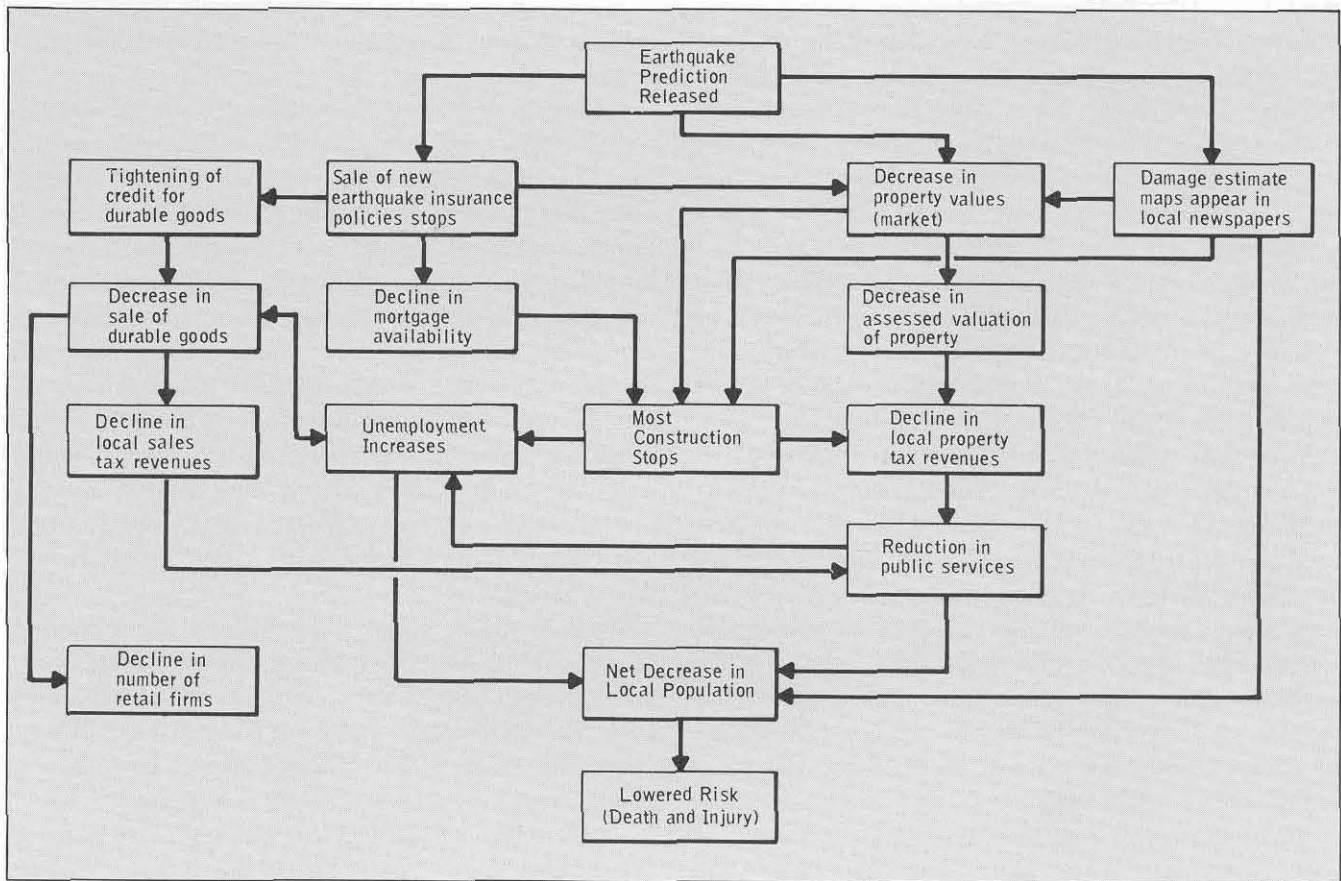
Some families move family heirlooms and other prized possessions out of the area entirely. During this time period something like 5 to 10 percent of the families in the area have moved out intending to stay away permanently. (Incidentally, we have no information on how many families who might ordinarily move into the community during this time period will not do so in the face of the earthquake prediction. The same thing goes for new business starts.)

Coming down to the final 60 days, the prediction is revised again and made more specific. It is now reported that the earthquake is supposed to occur during the first week in September 1980. The magnitude is narrowed to an estimated 7.3; the probability remains at 80 percent.

Now that the earthquake is expected during a specific week, planning can be much more specific. There is no serious discussion of forced evacuation. In certain high-risk areas — such as near dams or reservoirs, where landslides might be expected, and where there are numerous old hazardous buildings — people are urged to evacuate well ahead of the expected earthquake. Citizens ask local authorities whether they can provide protection against vandalism during the time when they are gone. Many people worry about what will happen if half of the houses in their neighborhoods are standing empty or if many businesses are closed in an area. Local officials can't provide guarantees against vandalism especially because revenues are down and they can't afford to augment the police force. This is a real source of tension between the local officials and the residents.

Hospitals and prisons transfer their charges. Unemployment is up sharply; property values continue to decline, and real estate sales are sporadic. Finally, a year after the Governor's request, the President grants a Declaration of Emergency.

Some retail stores, particularly supermarkets, lo-



Coming events cast their shadows before — as is evident from this chart of the consequences that slowly develop at the local level when a 7.3 earthquake has been predicted and is believed.

Planning and action before the actual event, however, could lessen some of the negative effects, including ruinous economic impacts and very serious social disruption.

cated in single-story buildings that their owners believe are solid remain open for business. Some post signs that say, "We don't run in the face of an earthquake prediction." Inventory that remains is given special protection, particularly fragile equipment such as computers. In addition, inventory generally in the community is sharply lower as managers try to preclude losses. Outside firms that normally provide goods on consignment no longer do so because they are unable to secure insurance to protect them in case of damage.

A large proportion of the families (roughly 75 percent) are staying home more than usual and away from what they consider to be the more dangerous areas, which they define as older areas of the city and tall buildings. Businesses in these areas suffer sharp declines in sales. Families who stay as well as those who leave the area turn off their utilities to avoid fire and water damage and other kinds of problems. The final safety measures are taken now by most families — covering furniture, taking breakables down off shelves, packing things away. With so many people leaving town, savings withdrawals are now up sharply.

As the time of the expected earthquake grows near,

surveys show that about one-tenth of the families have moved away permanently and another half have left temporarily. So while the community is not a ghost town, it is very sparsely populated as the end of August 1980 approaches.

All public buildings are vacated — not because they are expected to collapse, but because of the liability and moral questions. The majority of businesses also close temporarily. Critical services are continued, though some personnel are working out of mobile or temporary locations, where they presumably will be safe. The National Guard, located on the periphery, is on the alert.

Now let me try to summarize briefly some of these findings. There will be a lowered risk of death and injury, and the major reason is that there will be a net decrease in the local population. In the wake of the earthquake prediction, the sale of new earthquake insurance policies will be stopped, and that decision will have a series of impacts that link together, and finally come down to a reduction of public services and an outflow of the population.

As you might expect, the drop in the market value of

property and the damage-estimate maps also have some unfavorable consequences. Now, depending on your perspective, you can look at this and say, "Terrible. Terrible. It would be better if we had no earthquake prediction. Look at the negative economic impact; the community is going to be on its economic knees." On the other hand you can say, "But look, if you have a prediction that is generally believed and the earthquake occurs approximately as predicted, you can have a large earthquake and only a small disaster — at least so far as casualties are concerned. Property can be rebuilt, but lives can't be replaced." It depends on your emphasis and the values you have.

Moving companies will do pretty well, and so will a lot of engineering firms. Many companies and government agencies are going to want to know how their facilities will perform, so physical-vulnerability assessments are going to be widespread. There will also be a good deal of economic-vulnerability assessment largely applied to two questions: First, what will the earthquake do to the firm economically? Second, what will the prediction do? Those who are good at that kind of analysis will have a lot of work, especially for a period of time right after the prediction comes out.

Our data suggest that these trends and consequences will occur unless we take some prior action and change some policies. Many of these negative impacts do not need to be nearly so strong if we try to handle the problems in some reasonable way before the first prediction. Here are some of the issues to which we might address ourselves:

If you own a business in a high-risk area, how would you feel about having that area cordoned off a few months ahead of time? What will that do to the income from your business?

For every family that leaves the area and for every business that closes down for a time, the probability of casualties is reduced, but that very same act is also a sharp negative blow to the local economy. If you want to save lives, you will encourage some people to leave the area at some point. What that point is, is very difficult to determine on the first prediction. Do you recommend that they wait till the very last day, the last week, the last month? Or do you just say, "Use your own judgment, folks, as long as you're gone by twelve midnight on August 31, 1980."

After a year of unemployment, a number of people are not going to be able to make their mortgage payments. So, some of them will put their homes on the market and sell them for whatever they can get to get their equity out. That kind of panic selling is going to drive property values way down. One of the basic

questions, therefore, is whether there is some way to provide at least a minimum financial base for such persons.

Another problem is which damage-estimate map to believe. How good are the data? How competent are the people who put these maps together? What if several different maps appear in the local media? Much confusion and economic uncertainty can be avoided if local leaders agree in advance how they are going to proceed with respect to projected damage maps. If they agree to work with, say, the U.S.G.S. and announce soon after the prediction that within 90 days there will be an official map based on the best available data, the media might be persuaded not to print any other maps. Those maps are going to have a tremendous impact, and it's not fair for those who have responsibility to sit around and wait to see what happens when that first prediction comes along.

It would be nice to have some mechanism for pooling resources to make at least some mortgage money available. Even in heavily damaged areas not all buildings suffer serious damage. From the point of view of prospective damage there is no reason why all construction should stop, but in the absence of mortgages it is likely to do so. Is there some way that industry as a whole, or industry backed by governmental reinsurance of some kind, can provide some mortgage money so that the construction industry won't have to go clear to the bottom?

The California legislature passed a bill in August 1976 that attempts to release from liability all public officials who act in good faith and with good professional judgment in the face of a scientifically credible prediction. It does not change the liability of private employers. Unfortunately, a recent opinion of the Attorney General's office suggests that this piece of legislation may have muddied the water more than it clarified it. It may be that more attention needs to be paid to what the liability is, because clearly many problems will arise out of lack of knowledge.

Overall, it seems pretty clear that scientifically based earthquake prediction, generally believed — which it will be if it comes from a reputable source and has broad scientific support — will have three major types of consequences: First, there will be very few casualties; second, there will be considerable reduction in the property loss that would otherwise have occurred. Finally, there are going to be very serious negative economic impacts and social disruptions, some of which can be avoided or softened if we make some reasonable and meaningful decisions before the first predictions come along. □