Government Liability for the External Costs of Earthquake Prediction

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The implementation of earthquake prediction technology will raise several policy questions which have important legal implications. Central among these legal issues is that of the liability of government for the external costs of an actual earthquake prediction. Among these costs may be those resulting from physical dislocation, depressed property values, increased insurance permiums, more rigid building and safety standards and personal mental stress. When an earthquake prediction is accurate, those costs are likely to be outweighed by the benefits of acting in response to the prediction. However, when a prediction is inaccurate, individuals and organizations are likely to seek redress for those costs, particularly if action resulting in significant costs was mandated by government. Even if people do not actively seek redress, any government seeking to maximize the net benefits of an earthquake prediction programme should carefully examine how the external costs of that programme are to be distributed.

This paper examines a broad range of alternative approaches to the distribution of costs, from total government assumption of liability to allowing the costs to be borne where they fall. An economic efficiency model is employed to assess the policy implications of the cost distribution alternatives. Central to this assessment is an analysis of the historical doctrine of sovereign immunity and of the behaviour of different forms of government in response to varying cost distribution schemes. It is hypothesized that theories of liability based upon private conduct are not directly applicable to government behaviour.

The fundamental objective of the paper is to develop a theory of government liability which will improve our ability to evaluate alternative systems for distributing the external costs of a government-sponsored earthquake prediction programme. The foundation will then be laid for empirical testing of the theory, and ultimately for the formulation of an optimal earthquake prediction policy.

1. Introduction

Recent advances in the geological sciences have made earthquake prediction a realistic possibility in the foreseeable future. Because of the magnitude and catastrophic nature of some earthquakes, and because of the anticipated high costs of earthquake prediction technology, it is a virtual certainty that governments will be intimately involved in earthquake prediction. Whether government involvement takes the form of sponsoring prediction or regulating private predictions, there are several legal issues which will be critical to the formulation of an optimal earthquake prediction policy. Most

important among these legal issues is the liability of government for the external costs of an actual earthquake prediction. This paper examines various government liability policies, from a total government assumption of liability to allowing the costs to be borne by those upon whom they fall. In examining these alternative policies, the objective is to develop an analytical framework which will inform government earthquake policy development.

2. *Definition of the Problem*

From a legal point of view, it is important to distinguish prediction activity from any warning activities which may follow upon a prediction. Prediction activities are those which involve information generation, interpretation and dissemination. The following types of activities fall into the category of prediction: 1) data collection and interpretation; 2) equipment construction and maintenance; and 3) prediction dissemination.

Warning activities, as distinguished for the purposes of this paper, are those which in some way require or recommend that an action be taken in response to a prediction. The distinction will be particularly important to the issue of the nature and extent of government liability. The focus in this paper is on the liability issue as it relates to government earthquake prediction activity.

The analysis of this problem begins from the assumption that any government involvement in earthquake prediction has as its purpose the improvement of the general social welfare—the reduction in net costs which result from the threat and occurence of earthquakes. It follows from this assumption that governments will not knowingly adopt earthquake prediction policies which result in more net social costs than would occur in the absence of any government action. The only exception might be a policy designed to achieve income distribution objectives. The analytical framework developed in this paper allows for the consideration of distributional policy objectives.

The external costs of earthquake prediction, as distinguished from the direct costs of government prediction activities, would include costs such as those resulting from physical dislocation, depressed property values, increased insurance premiums, more stringent building and safety standards and personal mental stress. When an earthquake prediction is followed by an earthquake of a magnitude comparable to that predicted, these costs are likely to be outweighed by the costs avoided through action taken in response to the prediction. However, when a prediction is inaccurate, individuals and organizations are likely to seek redress for those costs, particularly if action resulting in significant costs was mandated by government. Even if people do not actively seek redress, any government seeking to maximize the net benefits of an earthquake prediction programme should assess carefully what external costs are being generated and how the justifiable costs are being distributed.

3. *Optimizing Social Welfare and Assigning Liability*

Central to a government's decision to become involved in some way with earthquake prediction, including the regulation of private prediction activities, must be the determination that the welfare of the government's citizens will be improved by the government's prediction-related actions. As indicated above, it is assumed in this paper

that a government will continually seek assurances that its prediction policies lead to a net gain in social welfare. These assurances will depend upon a full accounting of the costs and benefits of alternative liability assignments.

Although it is true, as a matter of private tort theory, that liability assignments, assuming zero transaction costs, do not affect resource allocation decisions (Demsetz, 1972), it is equally clear that the reality of transaction costs makes initial liability assignments important (Posner, 1977). In addition, the fact that the government is both a rights holder and the rights definor introduces a variable which private tort theory has not had to contemplate. Not only may the government transact with others with respect to its liability, but it may appeal to the historical concept of sovereign immunity or unilaterally alter the rights of private parties, subject to constitutional restraints. Because under these circumstances some rules of liability will be more efficient than others—that is, they will produce a particular social gain at less cost—the justifiability of state involvement in earthquake prediction will be affected by the liability system in existence.

A simple example will illustrate the possible effect of liability assignment. Assume that a state determines that the issuance of an accurate earthquake prediction which leads to the evacuation of a high-risk area will result in avoiding 150 million dollars in losses at a cost of 100 million dollars, of which 90 million dollars result from the economic dislocation caused by the evacuation. Further, assume that the prediction has a fifty percent reliability factor, so that for every earthquake which occurs there will have been two earthquakes predicted.* Assuming the cost of each prediction to be the same, the prediction programme will have resulted in the mitigation of 150 million dollars in losses at a total social cost of 200 million dollars. If the government is liable for the injuries resulting from an incorrect prediction, the government will pay the full 100 million dollars in costs resulting from the inaccurate prediction. Thus, there is no risk to private parties who cooperate in the evacuation. Either they avoid 150 million dollars in losses at a cost of 90 million dollars (economic dislocation costs), or they are compensated 90 million dollars in damages from the government if no earthquake occurs. The society as a whole, however, has avoided 150 million dollars in earthquake costs at an expense of 200 million dollars. It is the taxpayers who bear this cost and the liability assignment therefore results in a significant redistribution of wealth (from the general taxpayer to the parties who experienced the costs of the earthquake prediction).

If liability for the economic dislocation costs of an inaccurate prediction rests with private individuals, they may seek to mitigate or eliminate those costs by permanent relocation or building modification. Although there would be costs associated with such relocation or structure reinforcement, they would be incurred only once, unlike the dislocation costs associated with evacuation. Whether or not it would actually be more efficient to relocate or suffer periodic dislocation would depend upon many factors, but they are factors which would probably be recognized in a situation of private liability and may not be recognized when the state is liable.**

*Of course no two predictions will have exactly the same reliability factor, but although the mathematics becomes more complicated, the analysis remains the same.

**The analysis of response to liability rules will be influenced by the reliability of past earthquake predictions, a variable which is ignored in this paper.

4. *Impact of Liability on Government Behaviour*

The discussion of the preceding hypothetical example left unaddressed the obvious issue of what impact the assignment of liability to the government has on government behaviour. Will the government seek to identify less costly mitigation alternatives? Will the government become more conservative and, under the cost conditions assumed, issue only predictions with a minimum reliability factor of 67 percent, to insure that, at worst, costs will be equal to benefits? (Six predictions at a cost of 100 million dollars each and four earthquakes with mitigated losses at 150 million dollars each.)

The answer to this question depends upon the nature of government behaviour in the face of liability for harm resulting from that behaviour. It is impossible to generalize about government behaviour in view of the diverse forms of modern governmental organization. Behaviour in similar governmental systems is also likely to differ significantly, due to the many variables which may conceivably influence government response to various rules of liability. These empirical uncertainties of government behaviour notwithstanding, it is essential to theorize about possible behavioural models, and eventually to test the accuracy of the theories. Once reliable models of government behaviour are developed, they must be related to existing or new theories of tort law in a way which will inform lawmakers of the effects of the liability rules they choose.

The remaining sections of this paper will: 1) suggest some alternative theories of government behaviour; 2) examine traditional Anglo-American liability theory in the context of those theories of government behaviour; and 3) set forth a framework for analyzing the impact of alternative policies with respect to government liability for the external costs of earthquake prediction.

5. *Some Theories of Government Behaviour*

5.1 *The Welfare-Maximizing Model*

Variations of the Welfare-Maximizing Model have been the most common in traditional political and social theory (Weber, 1947). The model assumes that all government actions are taken with the intention of maximizing net social welfare. Under this model, the government decision-maker will assess the costs and benefits to society of its earthquake prediction activities, and will therefore be directly influenced by the prospect of liability, assuming that the overall governmental process accounts for the opportunity costs of incoming liability.

5.2 *Specific-Goal-Maximization Model*

This model assumes that government decision-makers seek to maximize something other than the general social welfare. The goal might be to perform a pre-defined task at the least possible cost (Spitzer, 1977). If the task is earthquake damage mitigation, the possibility of liability for harm resulting from the mitigation activity of prediction will have a direct influence on the selected mix of mitigation activities which are actually undertaken. Other specific goals of government decision-makers might include empire maximization (Spitzer, 1977), profit and product maximizations (Niskanen, 1971). In each of these models, as in all rational actor models (Allison, 1971), all internalized costs will directly influence government behaviour. Because the assignment of liability can

result in the internalization of all, some or none of the indirect costs of earthquake prediction, it is a critical aspect of earthquake damage mitigation policy.

5.3 Non-Maximizing Models

These models of government behaviour are based on observation, and generally lack a solid theoretical foundation. Variations include decision-makers who seek to consume their budget while producing a fixed product (Niskanen, 1971), those who seek a fixed product at any cost (Allison, 1971), and those who seek to consume their budget without any fixed product (Spitzer, 1977). Although these models may describe actual government behaviour, it is difficult to conceive that they represent forms of government behaviour which would be considered desirable. Since it would be illogical to conform liability assignments to irrational patterns of government behaviour, these models are ignored in the remainder of this paper.

It is assumed in what follows that government behaviour is rational—that it conforms to some type of maximization model. With this assumption, it is of secondary concern what the object to be maximized is. In any case, the internalization or externalization of costs will have a direct impact on the actions taken by government to achieve its purposes. The government objective might be optimum earthquake damage mitigation in the context of all government activities, in the context of all natural hazard activities, or in the context of all earthquake prediction activities. Although the maximizing action may vary, the analysis of the problem of maximization will remain the same.

6. Traditional Liability Theory

Traditional Anglo-American liability theory is based upon an individualistic model in which individuals respond to liability rules in accordance with their self-interest. The objective of tort liability is to minimize the external costs which result from one person's behaviour impacting upon another person's welfare. Stated differently, the purpose is to internalize as many costs as possible to the person whose behaviour generates the costs. The standard rule for liability assignment, given this objective, was stated in the American case of *United States v. Carroll Towing Co.** Judge-Learned Hand argued that a defendant should be guilty of negligence if the loss caused by the accident, discounted by the likelihood of the accident's occurrence, is greater than the burden of the precautions that the defendant would have had to take to avert the accident. In other words, a defendant should not be liable if his avoidance costs exceed the costs avoided.

Applying this principle to the hypothetical example of an earthquake prediction with external costs of 90 million dollars, mitigated losses of 150million dollars, and a reliability factor of 50 percent, it is apparent that a rational government decision, assuming government liability, will be to *not* issue a prediction under the hypothesized circumstances. The issuance of earthquake predictions would require some combination of increased mitigation, decreased external costs, or improved prediction reliability.

This analysis assumes that the government's goal is to maximize the avoided losses per dollar spent on mitigation, including the external costs of an earthquake prediction. In

*159 F.2d 169 (2nd. Cir. 1947).

no case would it be justifiable for the costs of mitigation to exceed the avoided losses. Two general factors, in addition to the costs and benefits of mitigation, are important for the analysis of the issue of government liability. First, it is essential that the accounting not neglect all types of transaction costs. This is particularly important in the case of government, where such costs tend to be obscured by the intricacy of the bureaucracy. Second, it is likely that most governments will have some policy concerns for wealth distribution as well as for optimum allocation of scarce societal resources.

7. *A Framework for Analyzing Government Liability*

The term liability has been employed in this paper to mean responsibility for compensating the harm to others which results from government earthquake prediction. The following framework expands the concept of liability to include costs which are voluntarily assumed by government. Although an injured party may have no legal cause of action against a government, the government may choose to compensate for some or all of the damage suffered by the party in question. Because the concern of this analysis is with the ultimate distribution of the costs of earthquake prediction and the influence which the distribution of these costs has on the various actors, it is important to anticipate both legally imposed and voluntarily assumed costs which government incurs as a result of its earthquake prediction activities.

Table I summarizes the impact of alternative postures of government liability on several factors which are likely to be of concern to government policy-makers. The categorization of government liability options is based upon an assumption that sovereign immunity is the appropriate point of departure. Although absolute sovereign immunity may exist nowhere today, it is generally true that existing government liabilities have resulted from express or implied waivers of sovereign immunity. Hence, the first column of the table summarizes the policy implications of a renewed assertion of sovereign immunity from liability for harm resulting from government earthquake prediction activities.

The second, third and fourth columns of the table identify levels of diminished immunity or possible increased liability. A selective waiver of sovereign immunity might be addressed to government internalization of particular types of costs. A general waiver of immunity would place the earthquake prediction liability issue into the general government tort liability doctrine of the particular legal system in question. An affirmative declaration of government liability for harm resulting from earthquake prediction would extract the earthquake prediction issue from the general government tort liability doctrine and would probably lead to the development of a specific doctrine applicable to the particular problem of government earthquake prediction.

As distinct from the options which are modelled on the processes of judicially administered relief, the final three columns of the table examine the policy implications of voluntary liability based upon legislative authorization and administrative implementation. The three options discussed here do not exhaust the possibilities, but they do represent distinct approaches to the voluntary assumption of liability. Post-injury compensation would result from legislative appropriation after the social costs of an earthquake prediction have been incurred by the injured parties. A second option, examined in the sixth column of the table, contemplates pre-injury legislative authori-

zation for administrative compensation after injuries are incurred. The final option would involve the development of a schedule of benefits based upon anticipated categories of injuries. After an earthquake prediction which resulted in external costs, people would be compensated according to how their injuries were determined to conform to the schedule of benefits.

If a government takes these seven liability options into consideration, it will be interested in the likely impact of each option upon the government's policy concerns. Those policy concerns are classified in eight categories:

1) The magnitude of government liability is of obvious concern to any government which conforms to a maximizing model of behaviour. The opportunity costs of liability are very real.

2) The magnitude of private losses will be affected by the extent to which liability assignments require that the external costs of earthquake prediction be borne by those who initially experience them. This policy concern is limited to aggregate private losses. Individual losses are considered below under number 8.

3) The importance of government transaction costs was mentioned above. These costs include all government activities involved in administering whatever compensation the liability rule requires, including identification and valuation of injuries, organization of government agencies, administration of actual compensation to injured parties, and litigation over entitlement to and amount of compensation.

4) Private transaction costs will include all activities associated with the acquisition of insurance, and negotiation and litigation with both private insurers and public agencies over issues of liability and compensation.

5) Whatever the government's liability position, it will probably have an influence on government activity generally and earthquake prediction activity specifically. As was indicated above, government liability may lead to a more restrained approach to government involvement in, or issuance of, predictions.

6) Private conduct is also likely to be influenced by the assignment of liability for government earthquake prediction. The incentives for private parties to undertake mitigation actions will be directly influenced by their anticipated liability.

7) A less direct impact of liability assignment, but a potentially important one, will be on the behaviour of other governments. This is of particular concern in a federal system or where both national and local government may have some interest in mitigating earthquake damage.

8) Finally, all governments will have policy concerns about the wealth distribution impact of the operation of, and liability for, earthquake prediction. As with virtually all kinds of external costs, the social costs of earthquake prediction will not be equally distributed among the population. Liability assignments will have a significant impact on these loss distribution patterns.

Table I creates a matrix which allows systematic analysis of the seven liability assignment options upon the eight policy concerns. Because of its simplicity, this two-dimensional matrix cannot accommodate a comprehensive analysis of the relevant issues, nor will the length of this paper allow a verbal exploration of these issues. However, it is important to recognize that, although the liability options and the policy concerns appear to be quite independent, they are in fact very interdependent. For example a direct compensation system does not necessarily preclude judicially granted relief. Similarly, the

Table I. The policy implications of alternative approaches to government liability for injury resulting

	Judicially administered relief		
Policy concerns which influence liability assignment / Alternative approaches to government liability	Claim of total sovereign immunity	Selective waiver of sovereign immunity	General waiver of sovereign immunity
Magnitude of government liability	There could be no government liability.	Government liability could be high, depending upon the nature of the waiver and the judicial application of existing immunity and liability doctrine (causation, negligence, etc.),	Government liability could be high, depending upon the judicial application of existing rules of liability where immunity is waived.
Magnitude of private losses	All private losses will fall upon those injured or upon those participating in insuring against such losses.	Private losses could be low, depending upon the nature of the waiver, the judicial application of existing immunity and liability doctrine, and the opportunities for collateral source recovery.	Private losses could be low, depending upon the judicial interpretation of existing rules of liability where immunity is waived. Collateral source recovery will also have an impact.
Magnitude of government transaction costs	Litigation and administrative courts will be minimal or nonexistent. Some litigation of the validity of the immunity claim may be expected.	Transaction costs may be high due to litigation or issues of liability and damages and will be magnified to extent courts must interpret the scope of the waiver.	Government costs associated with private litigation are potentially high. Administrative costs will be limited to administration of judicially awarded relief.
Magnitude of private transaction costs	Private costs resulting from transactions with government will be minimal, except for those challenging the immunity claim.	Private transaction costs will be high because of the need to prove injury resulting from government action for which immunity has been waived.	Private litigation costs will be high, although the absence of the issue of the extent of the waiver of immunity will simplify litigation.
Impact of liability on government conduct	Government earthquake prediction activities will be unrestrained because of no prospect of liability for harm resulting from these activities	Government earthquake prediction activities will be restrained to the extent that the waiver of immunity increases the magnitude of government liability.	The extent of the restraint on prediction activities will depend upon judicial determinations of causation and negligence and upon the magnitude of damages awarded.
Impacst of liability on private comduct	Private parties will be certain of their liability and will have incentives to take private action to mitigate prospective losses.	Private incentives to engage in mitigation activities will depend upon the clarity and the extent of the government waiver of immunity.	Private mitigation incentives will depend upon judicial application of liability doctrine and upon the magnitude of damages awarded.
Impact of liability on conduct of other governments	Depending on their own liability, other governments will have less incentive to pursue earthquake prediction to the extent that their policies are promoted by the actions of the immune government.	Other governments will have incentives to pursue prediction to the extent that liable government is deterred and will have incentives to provide relief to uncompensated victims.	Due to disincentives liability, other governments may engage in prediction depending upon their own liability. Other governmental compensation will depend upon adequacy of awarded damages.
Distributional impacts of liability assignment	Losses will impact upon those in the affected area and will be relatively more serious to low income individuals living near a subsistence level.	The waiver might be manipulated to influence distributional outcomes. Low income people will be disadvantaged to extent that they bear litigation costs.	A general waiver is likely to magnify distributional inequities. This impact will be minimized by the provision of legal assistance to the poor.

from earthquake prediction.

	Direct legislative or administrative relief		
Affirmative declaration of goverment liability	Legislative compensation for existing injury	Authorization for administrative relief of prospective injury	Statutory schedule of relief for prosspective injury
Government liability could be high, depending upon the nature of the statutory assumption of liability and its judicial application.	The magnitude of government liability is dependent upon the losses compensated and the size of the legislative appropriation.	Government liability could be high, depending upon tghe extent of administrative discretion and the level of appropriation.	Government liability could be high, depending upon the injuries for which compensation is provided and the lavel of compensation prescribed.
Privater losses could be low, depending upon the nature of the statutory assumption of liability and its judicial appilcation. Collateral source recovery would further reduce losses	The magnitude of private loss is dependent upon the losses compensated and the level of the legislative appropriation.	Private losses may be low, depending upon the extent of administrative discretion and the level of appropriation. Collateral recovery could result in a net gain.	Private losses may be low, depending upon the injuries for which compensation is provided, the prescribed level of compensation, and the availability of collateral recovery.
Judicial costs will be high due to extensive litigation. Administrative costs will be limited to administration of awarded relief.	High transaction costs will result from the legislative process and associated political activities. Administrave costs will result from determining eligibility and administering relief.	High transaction costs could result from the need to determine eligibility for relief and from relief administration.	Assuming administrative efficiency, transaction costs should be moderate in comparison to more discretionary administrative schemes.
Private litigation costs will be high due to an incentive to litigate under an affirmative declaration of liability.	Private costs will reflect level of involvement in political process and burden of proof placed upon applicants for relief.	Private costs associated with relief administration will depend upon private burdens of proving eligibility and damages. Political costs may result depending upon administrative process.	Private costs should be relatively low depending upon the burden placed upon the applicant for relief.
Earthquake prediction will be severely restrained due to high compensation, likely to be awarded under a voluntary assumption of liability.	If post-injury legislative relief is anticipated, it will constrain prediction activity, particularly if past relief has been large.	Government earthquake prediction activity will be influenced by the extent of administrative discretion and the past or expected level of legislative appropriation.	Government will be able to anticipate compensation costs of earthquake prediction and will therefore be less restrained than in a situation of uncertainty.
Private mitigation actions will be discouraged by the prospect of significant recovery. The level of damages actually awarded is a central factor in private action in the long run.	Private scosts from uncertainty will be high due to political nature of relief. Incentives will exist for private investment in political influence	Private conduct will be influenced by the constancy of administrative action over time. incentives to mitigate will reflect past levels of relief.	Private individuals will have a high degree of certainty and will accordingly mitigate based upon personal costs and benefits.
Other governments will have incentives to undertake prediction They will be disinclined to provide compensation unless awarded damages are not compensatory	Because of overlapping constituencies other gtovernments will be influenced by both prediction and compensation policies of the government legislating relief.	Other governments will have incentives to engage in relief and prediction to the extent that citizen needs are not satisfied.	Other governments will be able to anticipate needs for additional compensation and will be less inclined to engage in prediction.
Distributional inequities will be exacerbated due to high costs of litigation, unless legal assistance to poor is subsidized.	Legislative relief could have a distributional objective, although the poor will be least able to influence the political process.	Legislative distributional objectives may be realized if the costs of seeking administrative relief are low and the process is not subject to political influence	Distributional impacts will depend upon the injuries for which compensation is provided. It is likely that subsistences losses will have a high priority.

magnitude of private transaction costs will clearly have a direct impact on the private decision whether or not to seek judicial or administrative relief, and thus on the magnitude of private losses and of government liability. A careful examination of the table will reveal many of these interrelationships, but the in complexity cannot be adequately demonstrated in a two-dimensional matrix. The analysis does, however, identify the basic issues and the primary interrelationships, a useful beginning so long as the true complexity of the problem is recognized.

8. *Application of the Analytical Framework*

Although a careful reading of the table is essential to an understanding of the analytical framework it provides, a few general conclusions will illustrate the use of this framework. The need to formulate an earthquake prediction liability policy may arise in the following context. A government first decides that the science of earthquake prediction is sufficiently advanced to justify the creation of an official agency whose tas it will be to review scientific evidence and issue earthquake predictions when appropriate. That agency will be faced with many questions about when predictions should be issued, how they should be issued, whether or not the prediction should be followed by a warning, and who should be notified of the prediction and/or warning. Decisions on all these questions will be influenced by the government's liability and its policy objectives. A few broad generalizations emerge from the proposed analysis:

1) The magnitude of government and private liability will have a direct impact on the mitigation actions of both parties. Because the objective of earthquake prediction is to mitigate earthquake damage, that liability assignment should be chosen which mitigates the most losses at the least cost. Mitigation incentives, or liability, should therefore be assigned to the party best able to mitigate costs.

2) The usefulness of liability assignment as an incentive for loss mitigation is in part a function of the certainty of the liability. To the extent that liability rules are unclear or are applied arbitrarily, loss mitigation incentives will be reduced.

3) Transaction costs will tend to be high in liability systems which lack certainty or which require the exercise of significant discretion in their administration. A liability system which minimizes transaction costs is particularly important to government, where bureaucracy tends to obscure the connection between product and the transactions which relate to that product.

4) It is unlikely that a liability system which eliminated all external costs of earthquake prediction would be desirable. The costs of total loss mitigation will almost certainly exceed the losses avoided. Therefore, one must assume an optimum distribution of liabilities and an optimum level of certainty in the definition of those liabilities.

5) Because of the nature of injury which may result from an erroneous earthquake prediction, it is very likely that losses will not be equitably distributed. Thus some form of government action to offset loss distribution will probably be required. The action may justify deviation from the goal of optimum loss mitigation. Differently stated, the optimum earthquake prediction liability policy will need to concern itself with distributional impacts.

9. *Conclusion*

There are few policy conclusions to be drawn from the preceding discussion. However, the analytical framework here proposed is one which will lead to the asking of the important questions to which answers must be found if an intelligent earthquake prediction liability policy is to be formulated. The answers to many of the questions will require significant empirical research. The answers to others will require a weighing of conflicting values. Those are tasks yet to be completed, but as with all problems, the solution to the problem of the appropriate government liability for earthquake prediction is initially dependent upon the asking of the right questions.

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DISCUSSION

J.L. Roberts

Would liability arise when a private person issues a prediction; could the United States (or state) government extend immunity to such a person?

A: A private individual might be liable for harm resulting from a privately issued prediction, although damages could be minimal. I believe the government in the United States could constitutionally immunize a private individual against prospective liability.

J. Nigg

The last point of your presentation referred to "injuries that would result from an erroneously-issued prediction." What type of "injuries" do you assume would occur and why?

A: Examples of post-prediction injuries would include relocation costs, loss of income due to temporary closure of business, and diminished property values.

C.C. Thiel

As a point of clarification, both Driscoll and Huffman have referred to a 8 billion cost of upgrading hazardous buildings in Los Angeles. It should be noted that this is the cost of upgrading the approximately 14,000 buildings built before 1934, principally of unreinforced masonry. They are only part of the total building stock of Los Angeles.