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COMPARING RISK MANAGEMENT PRACTICES AT THE LOCAL LEVELS OF GOVERNMENT WITH THOSE AT THE STATE AND FEDERAL LEVELS*

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Summary

This paper contrasts the current view of risk management held by local government officials with those views held by both state level and federal level government officials. While generalization is itself risky, all of our observations point towards the conclusion that relative to state and federal officials, local government officials have little understanding of, hence little concern for, the quantity of risk posed for citizens by various hazards. To the extent that it seems desirable to place risk-management type decisions in the hands of local government officials, then some capacity for risk quantification, hence comparison, must be developed.

The findings presented in this paper are drawn from both generalized surveys of local and state decision makers and analyses of specific cases studied. These case studies include the decision to: remove asbestos from schools; close down a copper smelting facility in Tacoma, WA; shut off contaminated drinking wells; site hazardous waste facilities; and store hazardous chemicals.

1. Introduction

Purpose

This paper describes risk management practices at the local level of government by contrasting how risks are managed at the state and federal level. In making this comparison, we offer several alternatives for managing risk and safety at the city and county level of government. While we do not identify a "best management approach" under all circumstances and across all risks, we do discuss the primary advantages and disadvantages of each alternative.

This paper begins by offering a brief history of how risk management practices have taken different paths at the local, state, and federal levels of government.

We then offer a simple taxonomy for classifying risks at the local level of government.

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Finally, in Section I we describe how risks might be managed throughout the evolution of the risk. For example, the risks associated with an earthquake may be reduced prior to the earthquake by reinforcing concrete facades on buildings and by developing evacuation procedures. Risks may be reduced during the earthquake by increasing the number of fire engines, paramedics, and response vehicles on the scene. The risks following an earthquake may be reduced by providing for a more rapid and more complete clean up and relocation procedure.

In Section II we offer two examples of how specific risks are actually managed across the three levels of government – local, state, and federal

In Section III, we more generally describe and then assess how risks are managed at the city and county level of governments by discussing a limited survey we did. We then contrast this with surveys we did of risks managers at the state level of government. We also compare these surveys with a model of risk management at the federal level of government.

While the survey conducted at the local level was less structured than that which we did at the state level and less formal than the model we developed for the federal level, we can still draw some relevant findings.

In Section IV we offer several alternative ways for managing risk at the local level. And, finally, in Section V, we present a few conclusions.

Historical background

Historically, risk management, at the three levels of government – local, state, and federal – have taken rather different paths. At the federal level, numerous agencies and commissions, have continually assured a relatively formal approach for managing risks. Risks at the federal level are typically managed specifically by the technology or the natural event. For example, the Nuclear Regulatory Commission manages nuclear reactors, the Environmental Protection Agency manages pollutants emerging from various technologies, and the Food and Drug Administration manages both food additives and new drugs introduced into the market place. NOAA manages facts about the weather.

At the state level, there are typically a lesser number of risk management agencies and commissions, and these agencies and commissions are generally responsible for a broader spectrum of technologies and natural events than their counterpart agencies at the federal level.

At the local level of government, there are generally no formal risk management agencies and commissions.

Historically, local government in the United states have had no quantitative conception of risk, and hence no compelling need to devise strategies of risk management. Issues of public health and public safety have in the past been limited to hazards that are reasonably well understood and for which standards and codes specifying best practices have been developed by the engineering and public health professions, or, local governments have merely accepted and implemented federal or state policies or guidelines, or have been preempted by federal decisions in their risk management activities.

Classifying local risks

Before describing how risky technologies are managed or offer how risky technologies should be managed, we discuss an approach for classifying risks*. While this classifiction taxonomy is not unique – there are clearly a number of ways of classifying risks – this taxonomy does offer a comprehesnive approach to classifying essentially all risks facing a local decision maker.

The risks enumerated fall into four main categories: natural events, accidents, wars⇄disorders, and a final group labeled "potential".

It is common to see overlapping jurisdictions for dealing with a given risk, espeially within the category of natural events, where, for example, both state and local governments have the responsibility for dealing with floods.

Risk initiation often comes from multiple sources; the "primary party" and "others". Note that it is especially true within the category of natural event risks that more than one initiator can exist; although Nature is generally the primary one, many human agents also can contribute to this kind of risk. For example, humans can contribute to a natural hazard risk in the following manner. Mud slides are natural hazards. Humans can contribute to the risk of life and property by insisting to construct dwellings on mountain sides which have a high potential for mudslides.

In reviewing Table 1, it is clear that some risks dominate in some local areas and not in others. For example, while earthquakes more likely pose a greater risk to a Los Angeles population than to a Miami Beach population, the hurricane risk is greater for Miami Beach.

By examining Table 1, we also observe that some technologies and natural events pose a less certain worst case consequence than others. For example, while the consequence of a worst case ship accident could be bounded**, the consequence of a worst case nuclear reactor accident may be more difficult to bound.

The probabilities of certain events or hazards may be quite different than for others. For example, storms and floods are far more frequent in Los Angeles than are tsunamis.

Stages of risk management

Figure 1 shows the five stages of risk management, progressing in time from mitigation through relief. The first stage, mitigation of risk, involves reducing,

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*Risk is defined as the product of the probability of a negative outcome event and its consequence and is summed over all negative outcome events. For example, the annual risk associated with the auto industry is 50,000 fatalities in the US.

**A ship disaster such as the Titanic sinking resulted in death of about two thirds of the passengers and crew members. The worst case could have resulted in total loss of life to all passengers and crew.

TABLE 1

A classification of local risks

Risk category	Example risk	Responsible risk manager	Who initiates risks?		Who is impacted by risk?	
			Primary party	Others	Primary party	Others
Natural	Avalanche	State, Local	Nature	Construction	Site Popul.	
	Drought	Water District	Nature	Water Planners	Region Popul.	
	Earthquake	State, Local	Nature	Site Owners	Region Popul.	
	Flood	State, Local	Nature	City Planners	Site Popul.	
	Landslides	State, Local	Nature	Owners/Planners	Site Popul.	
	Storm	Local, State	Nature	NOAA	Region Popul.	
	Subsidence	Local	Construct.	Nature	Local Site	
	Tornado	Local, State	Nature	NOAA	Region Popul.	
	Tsunami	Local	Nature	Coastal Planners	Coastal Popul.	
	Volcano	State, Federal	Nature	Planners	Site Popul.	
	Wildfire	Forest Managers	Nature	Population		
Accident	Chemical plant	State, Federal	Plant Owner/Operators		Local Popul.	
	Dam failure	State, Corp. of..	City/Private Nature		Local Popul.	
	Hazardous material					
	In transit	Highway Patrol	Trucker		Enroute Popul.	
	Stationary		Plant Owner		Local Popul.	
	Nuclear reactor	NRC + Local	Utility		Local Popul.	General Popul.
	Power failure	PUC + NRC + etc.	Utility		Local Popul.	
	Transportation					
	Air	FAA + Local	Aircraft		Passengers	Ground Popul.
	Land	Police	Driver		Passengers	Pedestrians
	Water	Harbor Patrol	Ship Captain		Passengers	
		Coast Guard				
	Urban fire	Fire Dept.			Local Popul.	

War/disorder	Civil disorder	Local Police	Popul.		Local Popul.
		Nat'l Guard	Popul.		Local Popul.
	Conventional attack	Army			
		Local Police	Foreign Gover.		General Popul.
		Nat'l Guard	Foreign Gover.		General Popul.
	Nuclear attack	Army	Foreign Gover.		
		Nat'l Guard	Foreign Gover.		
	Riot	Local Police	Selected Popul.		
		Nat'l Guard	Selected Popul.		
	Sabotage	FBI	Selec. Popul.	Foreign Gov.	
		Local Police	Selec. Popul.	Foreign Gov.	
		Nat'l Guard	Selec. Popul.	Foreign Gov.	
		Army	Selec. Popul.	Foreign Gov.	
	Strike	Local Police	Union	Management	
		Nat'l Guard	Union	Management	
		Army	Union	Management	
	Terrorist	FBI	Selec. Popul.	Foreign Gov.	
		Local Police	Selec. Popul.	Foreign Gov.	
		Nat'l Guard	Selec. Popul.	Foreign Gov.	
		Army	Selec. Popul.	Foreign Gov.	
Potential	Crowds	Local Police			
	Olympics	Local Police			
	Foreign Visitors	Highway Patrol			

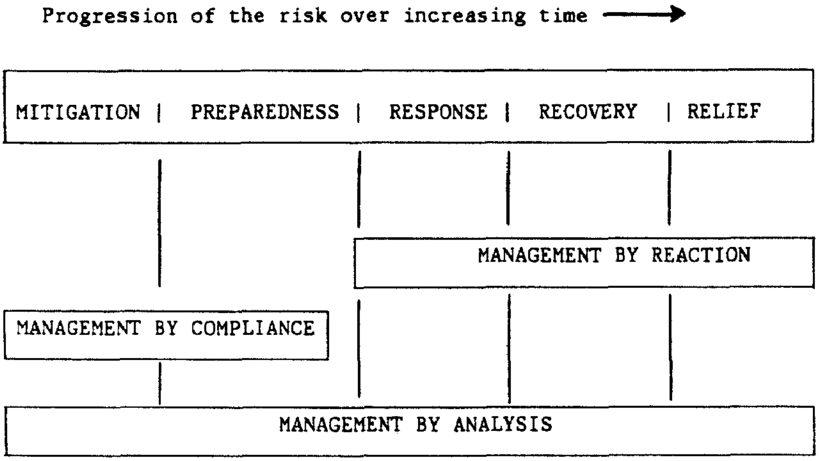

Fig. 1. Stages of managing a risk.

eliminating, or decreasing the number of hazards or their probability and consequences.

Preparedness, as the word suggests, entails dealing with hazards by preparing for them – for example, by applying in advance all possible corrective measures, such as: reinforcing unsafe buildings that might collapse during an earthquake; using stringent professional engineering standards in designing and constructing dams and bridges; and educating the public about such matters as evacuation, emergency communications, and food distribution, we prepare for hazards.

Response includes actions taken to prevent the recurrence of a hazardous event. An example is the enactment of ordinances requiring smoke detectors in apartments.

The last two stages – recovery and relief – encompass all the measures taken after a disaster: for example, cleaning up hazardous waste spills, demolishing damaged buildings, and offering low interest loans to those who need to rebuild homes or businesses.

Through our initial conversations with city and county officials, we learned of three strategies for dealing with risk. One we call management by reaction; the second we call management by compliance; and the third we specify as analytic. Management by reaction, as shown in Fig. 1, takes place after the fact – when a life-threatening situation or event has already caused damage or loss of life. Under this management strategy, measures intended to prevent their recurrence are implemented swiftly and in most cases without careful analysis of probable costs and benefits. Myriad instances of reactive risk management at the local level came to our attention in the course of this research, including the following:

- Liquified natural gas (LNG) was banned from a major harbor after fire and explosion of an empty oil tanker. Liquified propane gas (LPG), whose physical properties are almost identical to LNG, was not banned, and it continues to be transported through this harbor.
- Only after a disastrous apartment house fire was a local ordinance requiring fire doors enacted.
- Another apartment house fire triggered enactment of an ordinance requiring smoke detectors in all dwelling units.
- Discovery of trace amounts of commercial cleaning fluid in drinking water caused closure of water wells in a wide area.

Several elements are common to situations where reaction governs risk management. One is a highly publicized event. Normally, governments temporize. Speedy responses to any potential hazard generally occur only when substantial attention is given by the media. A second element is conversion of scientific questions concerning risk into political issues of public safety and protection. Generally, this requires that someone in a visible elected or appointed office adopt the issue as his or her own. The smoke detector ordinance is again illustrative. The public investigation of the high-rise fire that culminated in the ordinance was undertaken, in part, to draw attention to a municipal fire commission that had always been overshadowed by its counterpart local police commission. A third characteristic of reactive risk-management is its short time frame. Problems arise swiftly and vanish from public view once some action has been taken, regardless of the effectiveness of the measures enacted.

A somewhat different and less dramatic form of risk management by reaction occurs when last year's disaster triggers this year's emergency planning. Southern California, in particular, experiences a cycle of drought, brush fire, rain, flood, and mudslide. Only in the aftermath of the "fire season", which strips foliage (and dwellings) from hillsides, can the potential for floods and slides be ascertained and preventive measures taken, which comprise mainly the deployment of personnel and equipment. This type of risk management is reactive because it operates on a year-to-year basis without analysis of long-term risks.

Management by compliance occurs when rules, codes, standards, and statutes are established to govern decisions affecting life and health. Referring again to Fig. 1, we see that this management strategy works to mitigate and prepare for risk before the fact. Compliance is distinguished form reaction in that it is more routinized than ad hoc. The same standards, more or less, apply to all similar cases. Compliance is also distinguished from more analytical approaches in that the standards themselves rather than independent risk-assessment and risk-acceptance criteria inform choices. Several examples of risk management by compliance can be given:

- The amounts and types of waste discharged into public waterways, the disposal of hazardous wastes, and the levels of contaminants in public drinking water are limited by federal regulations promulgated by the EPA.
- Seismic design for buildings, transporting storage of hazardous materials, and highway safety are regulated by state and local building codes and statutes.
- The design of electrical generation and transmission networks, waterworks facilities, and dams and bridges as governed by professional engineering standards.

Risk management by compliance sometimes entails what psychologists often call "bootstrapping" whereby precedent and political and economic realities shape standards, and it sometimes entails"professional management", whereby judgments of experts are relied upon. However, risk management is by compliance so long as decisionmakers rely upon standards and codes set by others without attention to a guiding concept of risk or explicit risk-acceptance criteria.

The final risk management strategy – management by analysis – combines most of the elements of the formal risk management model. Specifically, there is an effort to confine overall risk within levels believed acceptable, regardless of how the latter are determined. The analytic approach is distinguished from reactive risk management in that it involves quantification and estimation of risk prior to decisions. Analysis is distinguished from compliance in that it does not automatically accept standards set elsewhere. Examples of the analytic approach to risk management in state and local government include the following:

- The final physical plan for major harbor facilities in a large port was made contingent upon detailed analysis of risk under alternative scenarios. Planning studies for a proposed LNG terminal at another port were also continent upon risk analysis.
- The design – but not the siting – of a regional hazardous waste disposal facility was based upon engineering criteria that included explicit estimation of risk.
- Analytic techniques were used by an air pollution agency to document that levels of airborne carcinogens were several orders of magnitude more risky than allowable levels of the same contaminants on water.

II. Examples of how two specific risks are managed across three levels of government

Most technologies and natural events are managed at multiple levels of government where the managing role may evolve down from the federal, through the state, to the local level. Consider that virtually all risk managment policy for toxic chemicals is currently set by the federal government; implementation of these policies is generally delegated to local authorities and, to a lesser extent, state authorities. In some instances, it might be desirable to allow localities a larger role in formulating risk management policies. Indeed, there have already been some attempts to give citizens at the local level a choice in the level of risk which they are willing to bear.

One example involves a copper smelter in Tacoma, Washington [1]. William Ruckelshaus, the former EPA administrator, has held public meetings to educate residents in the surrounding communities on the increased risk of lung and skin cancer they face from arsenic emissions by the plant's continued operation. The choice the citizens face is to keep the plant open and allow one additional case of cancer each year or to close the plant, putting some 500 people out of work. Many people in Tacoma resent having to choose between jobs and a lower rate of cancer; some feel that the decision should be made by "qualified experts", presumably the federal government. On the other hand, having the option to choose among alternatives gives the local people more responsibility for making trade-offs and greater control over their lives.

Another example where there is a larger local role involves asbestos in schools [1]. Prior to 1970, many public and private school buildings were built remodeled to include asbestos, a remarkably good fire-retardant and insulator. The federal government recently instituted a requirement that school districts have their buildings inspected and report the presence of asbestos to parent and teacher groups. Although there is no federal requirement to remove the asbestos, many school districts are paying to do so. This choice results from a consensus, reaching down from the federal, through the state, to the local level, that exposure to even small amounts of asbestos for a short time is not an acceptable risk. Many districts have diverted funds from the other less-urgent activities; even though the asbestos levels in the school building do not exceed the work-place standard, officials apparently believe that the risk of leaving it in place is too high.

There are both advantages and disadvantages in allowing localities more responsibility and/or leeway in risk management. One advantage is that high levels of toxic pollutants from a plant affect those people in the immediate vicinity. Since the local people, rather than the general public, are faced with the risks, they should be centrally involved in deciding the level of risk that is tolerable under local conditions. The copper smelter in Tacoma typifies this point. A second advantage is that local officials could make trade-offs in the choice of how to spend limited resources to reduce risks. Many localities, in allowing funds for asbestos abatement in schools, may have had to use money originally targeted for other risk-reducing activities. A third and less tangible advantage of local risk management is that, in general, people are more comfortable with an outcome if they themselves are able to make an informed choice. Although some people resent "government regulations", they readily choose to smoke in spite of a high risk of lung cancer.

There are also a number of disadvantages of increased local involvement in risk management. First, local decisions on risk may have a negative impact on neighboring communities. One town, for instance, may decide to allow high levels of toxic substances in a river near a plant; the contaminants will therefore be present near other towns at downstream locations. Second, local risk management would be costly, and might result in significant duplication of effort. It would be extremely wasteful, for instance, if each community across the country determined drinking water standards from the scientific data on all toxic chemicals. Third, and most important, local governments are extremely susceptible to local political pressures, and there could be highly unexpected on sequences from risk management decisions. For example, a community might be so anxious to lure new industry that it may not fully consider the potential health effects. This would occur most frequently in allowing high emissions of carcinogens or mutagens where the current economic benefits will inevitably be chosen since the cancer of birth defects may not manifest themselves until 40 years later. A fourth disadvantage of local control is that local officials would no longer be able to blame the federal government for unpopular actions.

The decision to allow greater local participation in quantitate risk management should not be taken lightly, especially in matters involving known carcinogens. The many inefficiencies in the current centralized system illustrate, however, that alternative methods should be examined. Increasing local authority and responsibility in certain instances will increase community knowledge and participation, and will give people more of a sense that they are shaping their own lives. We do not suggest that risk models as complex as those used by federal agencies should be developed or used by local governments. Many are beyond their means and expertise. We do argue, however, that a quantitative conception of risks and a rudimentary capacity to make risk comparisons may enhance the operations of local government.

III. Can we generalize; how are risks managed now?

We can contrast how risks are managed at the local level of government with how they are managed at the state level and the federal level. To learn how risks are managed at the local level we conducted a limited, in person survey and based on that survey, in Section IV we offer five models of risk management. At the state level, we conducted both in person interviews and a more formal, written survey. At the federal level, we did not conduct any survey; rather, we assert a simplified model of risk management.

In person interviews – local and state

To document somewhat systematically the impression formed in the initial interviews, a limited in person survey of local risk managers was conducted. Since concepts of risk analysis and management are at best poorly understood by local officials and encompass potentially all local government activities, the survey was limited to managers responsible for risks associated with drinking water and disposal of hazardous wastes. These areas were chosen in preference to others for several reasons. First, aside from bacteriological contaminants of water, the risks associated with drinking water and hazardous waste disposal are largely carcinogenic. Some risk is always present, and risks are distributed widely among exposed populations. (By contrast, risk due to floods and earthquakes are highly concentrated for persons living in substandard buildings and in flood plains, respectively.) Quantification of risks, inother words, is a reasonable alternative to controlling hazards with fixed standards. Second, risks associated with many, although not all, of the contaminants carried in drinking water supplied as well as with hazardous chemicals requiring disposal have been estimated quantitatively by various federal agencies, especially the Environmental Protection Agency (EPA) [2]. One might anticipate among local officials some familiarity with these estimates and the methods used to derive them. Finally, managers charged with managing drinking water and hazardous waste disposal risks are found throughout the United States.

A procedure similar to that followed in our initial inquires was used to locate respondents at the state level: a knowledgeable informant in the Governors office was asked to identify the persons principally responsible for management of risks arising due to contamination of drinking water as well as disposal of hazardous chemical wastes. These persons, or in some instances their immediate subordinates, were interviewed. During the interviews informants were asked for the titles of persons at the county (or regional) and municipal levels who had similar risk management responsibilities. In each of two counties as well as of two cities in a state, interviews were then conducted with the persons designated by their state-level counterparts. In each state, then, it was intended to interview two officials at the state level and two officials in each of two counties and two cities.

The two states chosen for this limited survey were Oregon and California. The localities were Multnomah and Lane Counties as well as the cities of Portland and Eugene, Oregon, and Los Angeles and Riverside Counties as well as the cities of Los Angeles and Riverside, California. Four officials at the state level, eight from counties or regional authorities, and eight from cities, then, were to have been interviewed. Not all could be reached, however, so that a total of nineteen interviews were completed. Overall, five state officials, seven at the county or regional level, and seven in cities cooperated in the survey. (An extra interview was obtained at the state level because the California Water Resources Board shares with the Department of Health responsibility for drinking water contamination.) No claim is made for the representativeness of this small sample of risk management officials. Indeed, it is unlikely that the representativeness of any sample could be determined as there is no clearly-defined population of risk managers who are potentially the subjects of study.

However, the survey does provide direct information on the beliefs and perceptions of selected risk managers and thereby complements some of the observations made above.

Given that risk is associated with almost all activities of government, a compilation of local risk management activities would not be feasible even if it were desirable. We can, however, observe how local officials think of risk, which elements of the overall risk management process outlined above tend to be present in local administration and which tend not to be, and the relative importance of analytical as opposed to other means of making decisions concerning risk.

The first and perhaps most important observation to be drawn from the interviews is that local risk managers tend not to think of risk quantitatively, although this is somewhat less the case for state as opposed to city, county, or regional officials. The interviews did not ask directly how risk is conceived of, as this would have yielded only perfunctory answers. We did inquire, however, which hazards receive the most attention. Almost all informants said that priorities had been established, but few indicated that they were based upon quantitative assesssment of risk. Some of the local officials' responses to the probe concerning how priorities were established include the following:

- "Things on a complaint basis. . ."
- "(Everything gets) about the same priority. We're a three man department."
- ". . .based on loss experience."
- ". . .past history."
- "Primarily subjective based on injuries."
- "state is responsible. Don't have analytic capabilities."

One local official denied that her agency set any priorities – "We believe in state and county preemption" – and five were unable to respond to the probe about how priorities were set. By contrast, one official stated that his agency's priorities were determined by an assessment of the impact of various hazards upon public health, while another stated that priorities were the result of "determination of the difference between ambient standards and maximum concentration and the relative ability to achieve the standards". In short, only two of fourteen local respondents suggested that their efforts were directed toward mitigating hazards that either posed the greatest risks or were most easily controlled.

Respondents in state agencies generally gave much richer responses to in-person questions concerning priorities for hazards recieving the most attention. One (of five) could not indicate what priorities were set, but the other four indicated the following as determining which activities take precedence over others:

- "Priorities have been shifted from acute to carcinogenic and toxic-concern at the federal level has prompted this."

- "Generally respond to toxics. In most cases, priorities are site, not hazard relative."
- "Public health is first major priority, environmental damage second."
- "Ignitability, corrosivity, radioactivity, and toxicity (above specified levels)."

The last two state officials had at least an implicit if not explicit quantitative conception of risk.

A similar pattern of responses emerged when officials were asked directly about their role in formulating and executing risk-management policies. Informants were asked whether their agencies were responsible for identification of new hazards. Three of fourteen local officials claimed that their agencies did do this, but they were unable to elaborate further. Four others gave highly qualified positive responses:

- "Yes, but it is not sophisticated."
- "Not consistently."
- "Bacteriological only – other [organics] are done by the EPA."
- "On an incidental basis."

The remaining seven local officials indicated that they did not direct effort toward identification of new hazards or that they did not understand the question. A typical reply indicating noncomprehension was, "We identify pollutants exceeding established limits".

Responses of state officials to the item concerning identification of new hazards did not differ greatly from those of their local counterparts. One gave an unqualified "Yes", which was not elaborated, and another indicated that unique conditions in his state compelled his agency to search for new hazards. One state informant gave a flat negative response – "We do not define new dangers" – while two indicated incomprehension as noncomprehensive as follows:

- "Yes, we do routine inspections."
- "Monitoring and enforcing pollution laws."

Informants were also asked whether "estimating risks associated with hazards" was undertaken by their agencies. Four of the fourteen local officials responded affirmatively, but without elaboration or comment. (Three of these four had also responded affirmatively to the question concerning identification of new hazards, also without elaboration, suggesting a predisposition toward positive responses or what survey practitioners call "yes effect".) Two more local officials gave qualified affirmative responses as follows:

- "Embryonic."
- "Very partially, i.e., aluminum in water."

Six local respondents gave outright negative responses to the question concerning estimation of risk associated with hazards, and the answers of two others indicated noncomprehension:

- "We certify contaminants by EPA or regional standards."
- "Review 1977 regulations under the Clean Water Act."

Responses of state-level informants as to whether they attempt quantitative estimation of risk differed somewhat from those of local informants. One stated "yes" without elaboration, the same respondent who gave an unqualified affirmative response to the earlier item about risk identification. Two responded affirmatively, stating that their toxicology laboratories made risk assessments. A fourth informant stated that risk estimates were not made for the following reason:

- "They are not worth the safety savings."

The fifth respondent responded incomprehensibly:

- "Monitoring water quality."

A generalization that might be drawn from these responses is that quantification of risk occurs only when technical expertise is available within an agency.

All five state officials and all but two local officials ranked the incremental option first. (The two local officials indicating preferences for formal methods gave very terse responses throughout the interview, which provided little indication as to whether or not they understood the meaining of formalization.) One state official commented on the "incremental" option as follows: "This is where we are". With regard to formal methods, he stated, "This is where we would like to be". Another state official indicated bluntly that, "I don't have time and resources" for formal risk analysis. Local officials, by contrast, had remarkably few comments when probed about general risk management decisionmaking procedures. Two perceived a trend in the direction of increased formalization, even though they retained incremental practices. And one official stated most graphically his agency's policy, which was classified as incremental: "If it's in the sewer, we're there".

The interviews also included items concerning the adequacy of fiscal, scientific, and technical resources available to local risk managers. None of these questions, save for one, indicated any important unmet need of risk managers. Some of the comments given in response to probes accompanying the forced-choice questions indicated why this is so.

Informants were asked whether they strongly agreed, disagreed, or strongly disagreed with the statement, "There is adequate coordination between local, state, and federal agencies to manage the hazards under my jurisdiction". Among state officials, two agreed, two disagreed, and one disagreed strongly. A similar pattern characterized local officials' responses: two agreed strongly, five agreed, four disagreed, and three disagreed strongly. The following open-ended probe elicited relatively few comments, but those that addressed the substance of the resource issue suggested why the closed-ended responses were so scattered:

- "Do not have adequate resources for water programs, other just barely adequate. Not keeping up with technical improvement."
- "(Agree) for major hazards such as heavy metals. . .enough for mundane hazards."

- "We have a six-person office for monitoring 20,000 hazards waste generators." ". . .to the extent that some hazards, though identified, may not be highly prioritized."

Informants were also asked for their agreement or disagreement with a statement that scientific and technical information about risk "is easily accessible to decisionmakers". As before, no clear pattern emerged from the closed-ended responses. Two state officials agreed, and three disagreed. Of the twelve local risk managers who answered the question, seven agreed, four disagreed, and one disagreed strongly. Few discursive comments were elicited from those who agreed with the statement, but some of those who disagreed observed the following:

- "Little staff time is available to locate technical information. "
- "Lots of loopholes in research."
- "Very little meaningful and particularly accessible information."
- "It is not. It takes money to get and must be updated along the way, which takes more money."

Again, these scattered comments do not form the basis for any strong inferences, but the near absence of elaboration from those agreeing that scientific and technical information is available together with the problems noted by those disagreeing suggest that at least some officials feel the need for more, and more readily available, risk information.

This impression is suggested by responses to a third open-ended item, "There is a need for additional quantification of hazards to assist decionmaking". *Four of five state officials strongly agreed with this statement, and one disagreed. Four of thirteen local officials responding to this time expressed strong agreement, and seven more agreed.* Two local officials disagreed. There was greater consensus on this item than on any other opinion question in the survey, and the comments elicited by our open-ended probes were among the most forceful encountered:

- "Lack of resources for us to do (quantification). I would like to know what part per million chlorine kills giardia (a protozoan)."
- "Toxicity of many existing chemicals not well defined."
- "Feds have to do it. State doesn't have the research resources."
- "Toxics are a new field." "We based most decisions on experience. Having quantitative analysis would be helpful."
- "Always a need and very expensive to obtain materials in print."

There is, of course, the possibility that the near-unanimous support for additional quantification reflects on more "yes effect", but this seems unlikely in light of the discursive responses elicited in open-ended probes. Furthermore, as shown above, local risk managers do not themselves engage in quantification of risk, and they tend not to think of the risks presently managed in quantitative terms. It may be that the thinking of risk managers is, in fact, little different from ours. They perceive, correctly, that there has been little quantification of hazards and that a quantitative conception of risk is absent from current practices. They may perceive also, again correclty, that they have little capacity to undertake quantification of risks with present resources and prob-

TABLE 2

Summary of survey of hazardous chemicals

I. General statistical information

1. Number of states responding to the interview	37
2. The number of agencies responding within a state	
Number of states with only one agency responding	25
Number of states with two agencies responding	7
Number of states with three or more agencies responding	5
3. Of the responding official personnel	
Number of states where the Governor or Governor's office responded	11
Number of states where a state health department responded	12
Number of states where a state environmental department responded	8
Number of states where a state safety officer responded	6
Number of states where response was from none of the above	20
4. The number of specific questions or portions of questions answered:	
None	4
One	1
Two	5
Three	5
Four	22
5. The number of states that sent supplementary information	19

II. Specific answers

1. The number of states responding to Question no. 1:	
How many states identified	
(i) Zero hazardous chemical facilities	4
(ii) One hazardous chemical facility	1
(iii) Two to five hazardous chemical facilities	2
(iv) Five to twenty-five hazardous chemical facilities	2
(v) More than twenty-five chemical facilities	5
(vi) "Some, many, a few, or numerous"	17

How many hazardous facilities were identified for

(i) Acrylonitrile	3	(viii) Hydrogen cyanide	3
(ii) Anhydrous ammonia	5	(ix) Hydrofluoric acid	6
(iii) Ammonium nitrate	2	(x) Liquified natural gas	15
(iv) Chlorine	6	(xi) Parathion	2
(v) Ethylene oxide	3	(xii) Tetraethyl lead	2
(vi) Fluorine	2	(xiii) Vinyl chloride	1
(vii) Gasoline	33	(xiv) Other	68

Out of a possible of 31 complete or partial responses to question no. 1.

2. Of the states responding to Question no. 2, how many
   - (a) Regulate the amount of potentially hazardous material at a single site or within a single tank? 15
     How many do not? 10
   - (b) Establish safety related design criteria 8
     How many do not? 5
   - (c) Regulate transportation of potentially hazardous chemicals 8
     How many do not? 4
   - (d) Identify acceptable levels of risk? 9

   Out of a possible of 32 complete or partial responses to Question no. 2.

3. Of the 25 states responding to Question no. 3, how many require an environmental impact statement? 11
   How many do not? 14
4. Of the 26 states responding to Question no. 4, how many compile information on abnormal release or accidents at large chemical facilities? 14
   How many do not? 12

III. *General responses not discussed above*

1. Some states indicated that their answers to questions nos. 1 and 2 were based on a reasonable guess or value judgment rather than on an actual survey.
2. A few states were willing to indicate the size of the largest chemical tank in the state. The sizes range from 10,000 gallons for gasoline to 25,200,000 gallons for liquified natural gas.
3. A few states gave qualitative, rather than quantitative, responses to Questions nos. 1 and 2.
4. Several states indicated that they follow Federal, rather than State, regulations regarding the chemical industry.
5. The information contained in the supplementary attachments usually answered each of the four questions.
6. Several states made a considerable effort to answer all questions.
7. Several states requested a copy of this study at completion.
8. Some information was obtained from telephone contacts.

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ably will not have sufficient resources in the future to do this. Nonetheless, they may still believe strongly that augmented quantitative data are needed for them to function as effectively as they might as risk managers.

In sum, while we find that there is no clear consensus among local risk managers concerning the adequacy of fiscal resources available to their agencies or the adequacy of scientific and technical information that is available to decisionmakers, we do find that there is strong consensus that additional quantification of hazards is needed to aid decisionmaking. Some of the comments made in response to probes concerning the need for additional quantification as well as other statements indicating inexperience, if not unwillingness, to quantify risks locally suggest, however, that quantitative estimation of riskiness should be developed by federal rather than state and local agencies.

Several items aimed at assessing the adequacy of current organizational forms for managing risk were also incorporated into our interviews. One question asked local managers to agree or disagree as to whether, "The legal authority I have in managing risks is adequate". There was near consensus on this issue: four state officials agreed and one disagreed; of the nine local officials who responded, three agreed strongly and six expressed agreement. Much less consensus was exhibited as to whether "adequate coordination" exists among local, state, and federal agencies charged with managing hazards. Four state officials agreed and one disagreed – the latter observing, however, that, "It's beginning to happen". Local officials, however, were of more mixed views concerning the adequacy of coordination. One agreed strongly that coordinations was adequate and six expressed agreement, while five disagreed, and one expressed strong disagreement. (One official did not respond.) Their comments are instructive, as they indicate even less satisfaction with existing arrangements than the closed-ended question would suggest:

- "Locals must respond directly to the feds, and feds don't keep on top of things."
- "Direct link betweeen locals and feds – everyone is floating around."
- "Disputes over Hazardous Waste Control Law over local authority.
- "(Agree) overall – not for radioactive and other exotic wastes."
- "Very little coordination."
- "Agencies still fighting for authority."
- "Regulatory agencies are understaffed – poor coordination."

There is no sure explanation for the discrepant views concerning the adequacy of coordination help by state and local officials, but in all likelihood this reflects their different functions. The states make policy by accepting different functions. The states make policy by accepting federal standards or exercising primacy, wheras local entities implement federal or state policies posing numerous questions of intent and jurisdiction. Because the latitude of localities is more constrained than states', localities may be more sensitive to difficulties of coordination.

Overall, the interview responses suggest that local officials although not their state-level counterparts, feel somewhat put upon by an intergovernmental system that holds them responsible for executing risk management policies without defining authorities and jurisdictions of the various state and federal agencies that participate in the policymaking process. There is no perceived lack of legal authority with which to manage risk, nor is there overwhelming sentiment favoring centralization of risk management. Rather there is a perceived absence of coordination, which is probably the result of a system that separates policy formation from its implementation, and in which there are multiple policymaking bodies at both the state and federal levels of government who are sometimes in disagreement as to procedures as well as the substance of what they are doing.

By mail interviews - state

We also conducted a more formal, written state survey.

In the state survey, we concentrated our concern with the storage of hazardous chemicals. We sent a survey questionnaire to fifty state Governors. The survey questionnaire is shown in Table 2. Of the fifty state Governors, a total of 37 states responded to the survey. In 11 states, the Governor or his/her office responded directly. In 12 states more than one agency responded. These were: 12 health agencies, 8 environmental agencies, 6 safety agencies, and 20 other, mostly industrial and labor, agencies.

The recipients of the survey letters were asked to answer four specific questions. These were:

1. To identify those chemical facilities that could present a potential high-consequence risk in their state.
2. Are the chemical facilities state controlled?
3. Does the state require an Environmental Impact statement for existing or planned large chemical facilities?
4. Is there any information compiled in the state on abnormal releases or accidents at large chemical facilities?

Most states responded to all four questions; only four failed to answer any questions. Question nos. 1 and 2 were the most commonly answered ones. Nineteen states had also sent supplementary information.

Most states responding to Question no. 1, gave a qualitative answer for the number of potentially hazardous facilities. Five states indicated that they had more than 25 such facilities; four states replied that there were no such facilities under their jurisdiction.

The single, most common chemical stored at a "hazardous facility" was gasoline. Liquified natural gas (LNG) was identified as the second most common chemical. The largest storage tank used is 10,000 gallons for gasoline and 25,200,000 gallons for LNG; most states did not respond to the question concerning the size of their largest storage tank.

Fifteen states regulate the maximum size of a single tank, 10 states do not.

Eight states regulate the facility design criteria, five states do not. Eight states regulate the transportation of hazardous chemicals, four states obey the federal Government's transportation regulation.

Of the 25 states responding to Question no. 3, eleven do, and fourteen do not require an Environment Impact statement for existing or planned facilities.

Of the 26 states responding to question no. 4, only 14 compiled information on abnormal releases or acidents at chemical facilities.

For this report, it was decided not to identify the responses on a state-by-state basis; rather the cumulative overall results are displayed. The reasons for this choice are:

1. Some states are qualitative or "value judgment" quantitative responses, rather than quantitative responses.

2. Some states gave answers, or sent supplementary information, that required interpretation or value judgment on the part of the reader.

Models of risk regulation – federal

At the federal level we observe that specific agencies of the government manage risk by implicitly, if not explicitly, defining a risk management goal and then taking actions to achieve that goal. Table 3 arrays ten typical risk reduction goals.

A risk reduction policy may have any of a number of possible goals. For example risk levels can be minimized

- by reducing the *average* societal risk
- by attempting to reduce risks for *each* individual
- by reducing the *high-level* risks for those exposed
- by trying to reduce the *total* risk to some acceptable level, versus reducing *individual* risks

Each of these has its own shortcomings. Reducing the average public risk may completely ignore segments of the society. Reducing risks for any specific individuals is impossibly complex. Reducing the highest level risks may overlook combinations of lower risks which are, in toto, more important. Finally, trying to reduce the total risk may overlook the benefits which may make some of the risks more acceptable than others, but concentrating on the individual risks may ignore the effect of the total risk to the public.

Risk regulation goals

Choosing a specific type of goal is an important first step in the development of a risk regulation policy, since different goals can favor different technologies. For illustration we present in Table 3 ten representative risk-reduction goals, symbolized by G_1 to G_{10}. We also characterize features of technologies affected by each goal, and in the discussion which follows, give examples of government agencies and groups which appear to implicitly or explicitly use particular goals. It should be pointed out that Table 3 is only a first approximation of the task of developing risk-reduction goals. A full implementation would involve sophisticated decision analytic techniques such as those developed by Keeney and Raiffa [3], which would, by iterations through the list of goals, sort out the major differences and eliminate the redundancies among the goals. The ten goals we consider are discussed below.

Goal G_1*: minimizing the magnitude of the maximum accident consequences*

This goal concentrates on the consequences (C) factor of the risk equation*

*The risk equation is defined as the product of the consequence of an undesirable event and the probability of that event, integrated over all undesirable events. The risk of the automobile in the U.S. is 50,000 fatalities per year for all types of auto accidents.

TABLE 3

An array of risk-reduction goals

Notation	Risk reduction goal	Description of goal and features of technology which goal favors
G_1	Minimization of maximum accident consequence	Minimizes consequences (C) of maximum consequence accident. G_1 favors energy technologies inherently incapable of producing catastrophic (i.e., very large) consequence accidents.
G_2	Minimization of probability of most probable accident	Minimizes probability (P) of most likely (highest probability) accident. Favors technologies having relatively low accident probabilities. Assumes that some minimum threshold accident consequence, C_{min}, is acceptable.
G_3	Minimization of both total accident and normal operational risk	Minimizes total probability times consequence of all risks for both accident and normal operational conditions, for all phases of the fuel cycle. Favors technologies having a minimum combined accident and routine operational risk.
G_4	Minimization of only accident risk	Minimizes those risks ($P \times C$) resulting from accidents only – a subset of goal G_3. Favors those technologies with minimum accident risks, regardless of routine operational risks.
G_5	Zero total risk	Requires reduction of all accident and normal operational risks to "zero" or some minimal "threshold" level either as perceived by the public or measurable with current technology. Favors technologies that can both minimize the probabilities of high-consequence accidents and minimize the consequences of high-probability events.
G_6	As low as reasonably achievable risk (ALARA)	Suggests that the marginal cost of reducing a risk be weighted against the marginal benefit that results from reducing the risk, down to the point where the cost and benefit are equal. An ALARA goal would favor technologies that would obtain the greatest risk reduction per dollar down to the lowest level of risks; i.e., those which, for a favorable cost/benefit ratio, would lead to minimum risks.
G_7	Equitable share of risks and benefits	Prescribes that to as great a degree as possible those receiving the benefit from the technology should share equitably in its risk. This goal would favor decentralized technologies and technologies that do not have extended impact on future generations without providing equivalent benefits to those future generation.
G_8	Minimization of socially perceived risk	Minimizes those risks that society as a whole or by segment perceives as most objectionable (e.g., cancer).
G_9	Minimization of peak risk	Concentrates on reducing the risks to those individuals or groups, whether occupational or general population, who are exposed to the largest risks, by reducing or spreading these risks over a larger population. Favors technologies that have a highly uniform (i.e., low uncertainty) level of safety across a range of risks, and for both general population and occupational hazards. This goal minimizes the integrated product of probability and consequence, for those risks affected.
G_{10}	All people (both general population and occupational population) share equally in risk	Asserts that all people exposed to the risk should share equally in the risk, independent of the benefit that they may receive from the technology.

by aiming to reduce the magnitude of the maximum consequence accident (C_{max}). If we consider only "credible" high-consequence accidents – those whose probability exceeds some minimum threshold level ($P > P_{min}$) – then this goal is consistent with regulations requiring that the consequences of such accidents be minimized by incorporating systems and structures which will withstand and mitigate the consequences of these accidents. For example, both the Nuclear Regulatory Commission (NRC)* and Department of Energy (DOE) utilize related goals, the latter as part of its four "lines of Assurance" (LOA) for nuclear safety.**

Goal G_2: *minimizing probabilities of the highest probability accidents*
For all accidents with consequences greater than some minimum threshold level ($C > C_{min}$), this goal seeks to reduce the probability of the most likely (highest probability, P_{max}) accidents, thus concentrating on the probability factors of the risk equation. Recent NRC-sponsored studies in probabilistic risk assessment have indicated increased interest in the probability aspect of risk equation. The minimization of accident probabilities (or reduction to zero probability) is also reflected in DOE's first line of assurance – "Prevention of Accidents."

Goal G_3: *minimizing total risk from accidents and normal operations*
This goal seeks to reduce the total risk (R), as defined by the risk equation integrated over all risks for both normal operational risks and accidents, and covering the entire fuel cycle, from drilling or mining of fuel to atmospheric or effluent releases to waste disposal (if any). Thus goals G_1 and G_2 are essentially subsets of G_3; G_1 and G_2 seek to reduce single aspects – consequences and probability, respectively – of the total risk equation. There has been much recent interest in one such approach, which has met with considerable controversy on technical and computational grounds, but according to at least one source, appears to be conceptually sound.

Goal G_4: *minimizing accident risks*
This goal, in essence, considers the risk equation, integrated only over acci-

*In 10 CFR 50, Appendix A, "General Design Criteria for Nuclear Plants," many of the criteria require systems to withstand postulated maximum consequence accidents, that is, to function to minimize the consequences of such accidents. For example, Criterion 50, Containment Design Basis, states, "The reactor's containment structure ... shall be designed ... (to) accommodate ... the calculated pressure and temperature conditions resulting from any loss-of-coolant acident". Such a loss-of-coolant accident is considered a high consequence accident.

**The four "LOAs" are prevention of accidents, limitation of nuclear reactor core damage, containment within primary system, and attenuation of radiological products. The latter three all relate to minimizing the consequences of the maximum consequence accidents, while the first relates to minimizing accident probability (G_2).

dent risks; that is, it ignores normal operational risks and health hazards (those with $P=1$) and is thus also a subset of goal G_3. Such a goal can be illustrated by considering many types of occupational regulations.

Goal G_5: *reducing to zero risk*

This goal seeks to reduce risks to "zero" or to some minimum threshold below which the effects are not perceived as undesirable by the public, or cannot be measured. This goal concentrates on both the *P* and *C* of the risk equation – requiring the minimization of probabilities of high consequence events, and the minization of the consequences of high probability events (e.g., normal or routine operations, where $P=1$). As such, this is the extreme limit of goal G_3. We see an example of this goal in the Delaney Clause of the Food and Drug Act, which automatically bans food additives suspected of posing a cancer risk. Another example is the interest of some intervenors in reducing radiation emissions from nuclear power plants to "zero".

Goal G_6: *reducing risks to a level as low as reasonably achievable (ALARA)*

This goal would reduce each risk (and thus the entire integral of the risk equation) as long as the benefits outweigh the costs. As expressed in Title 10 of the Code of federal Reglations the ALARA goal, applied to reducing the radiological hazards of effluents from nuclear power plants, means:

> As low as is reasonably achievable, taking into account state of technology, and the economics of improvements in relation to benefits to the public health and safety and other societal and socioeconomic considerations. . .*

This goal is a risk–benefit approach. That this approach considers the marginal benefits of each increment of risk reducing is further clarified** by requiring that a power plant include:

> All items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost–benefit return, can for a favorable cost–benefit ratio effect reductions in dose:

Furthermore, the ultimate cost–benefit trade-off point is specified by the criterion of $1000 per total body man-rem and per man-thyroid-rem. Other agencies have related risk benefit goals, for example, EPA's regulations "require the evaluation of risks and benefits as the basis of regulatory decisions".

Goal G_7: *regulating so that those who share the risks are those who also share the benefits*

This favors not only decentralized technologies, where the centers of risk (the energy generation facilities themselves) are geographically located near the population receiving the benefits, but also technologies that do not prop-

*10 CFR 50, Paragraphs 34a.
**Ibid., Appendix I.

agate risks to future generations without commensurate benefits. In this regard, such "obvious" future risks as irreversible atmospheric changes and nuclear plant wastes must be balanced against less obvious "risks" such as might result form the early depletion of cheap coal, oil, and gas reserves, leaving less acceptable energy sources for the future. Various intervenor or public interest groups appear to have such a goal, especially with regard to the long-term storage of nuclear wastes.

Goal G_8: *minimizing socially perceived risks*

This goal considers the subset of the total risks that the public perceives as the most hazardous or most objectionable. This could include such widely discussed risks as mining accidents and nuclear power plant accidents (occupational and general public risks from accidents), black lung disease and air pollution (occupational and general population risks form normal operation). The current inclusion of intervenor groups, speaking from various "public interests", in the licensing process of power plants indicates that regulatory agencies do consider such a goal.

Goal G_9: *minimizing peak risk*

This goal would reduce the risks of those occupational or population groups exposed to the highest level of risks. That is, this goal seeks to reduce those risks (that set of $P_i \times C_i$) which exceed some maximum levels of $(P \times C)_{max}$. Thus, this is a subset of total risk, and of goal G_3. This could mean reducing the major accident risks (large C, moderate P) of some technologies, and reducing the routine operational risks (large P, moderate C) for others depending on which dominate. Such a goal appears to underlie the NRC's interest in considering a proposal to lower the maximum allowable occupational radiation dose from 5.0 to 0.5 rem/year. Since the average dose is already below the lower level, only the peak exposures would be significantly reduced.

Goal G_{10}: *sharing risks among all persons*

This goal would attempt to assure that, as much as possible, all persons exposed to a risk share equally in that risk, independent of the benefit they may receive from technology. This is related to goal G_7 (sharing risks and benefits), except that in this case all persons would share the same risks. One difference is that under goal G_7 occupational workers could be compensated for bearing increased risks; for goal G_{10}, however, occupational and population risks would be equal.

Interaction of goals and agencies

As we have indicated, current regulatory policies appear to be based, at least implicitly, on some of these goals. Furthermore, a number of variations in the existing regulatory standards of different agencies, can be traced to differences in goals. For example:

- Many standards concentrate on either short term or long term effects of hazardous substances without considering the total combined risk of the two effects. This leads to inconsistencies in standards, and to a total risk higher than anticipated. As mentioned, until recently coal mine safety regulations concentrated on accidents and ignored such long term risks as black-lung disease.
- The risk regulation policies of various agencies are not only different, but sometimes contradictory. Thus, while the Delaney Clause mandates that the FDA have a "zero tolerance limit for carcinogenic food additives", the EPA's regulations "require the evalution of risks and benefits as the basis of regulatory decisions". The Occupational Safety and Health Administration lies in between, banning carcinogens only where less hazardous materials can be used.

It is clear as well that various groups and individuals within any one agency may employ different goals, just as the overall regulatory strategy of an agency may be based on a combination of goals. Thus, we have seen indications of NRC's interest in, or actual reliance on such goals as minimizing accident consequences (G_1), probabilities (G_2), the ALARA goal (G_6), and reducing socially perceived risks (G_8), the latter as part of the licensing process in responding to public interests groups and intervenors.

IV. Models of local risk management

Five models of local risk management are proposed (see Fig. 2). they are presented in a two dimensional figure which contrasts the relative strength of the risk manager (weak versus strong) with the extent of centralization of the risk management (less central versus more central). One model is the present system, largely dominated by the federal government. The second model buttresses the present system by strengthening local capacities to utilize competent professional judgment in managing diverse risks. This model is called the "weak" risk manager, or "weak" office of risk management. The third alternative links risk managers, who occupy relatively weak offices at local, state, and federal levels, into a network that facilitates sharing of data on hazards, risks associated with them, and risk acceptance criteria as well as policy. The fourth alternative is the "strong" risk manager who is charged with the full spectrum of risk management activities, from risk identification to policy and implementation. This "strong" risk manager, importantly, is a local rather than a federal official. The fifth model is one of radical decentralization of risk management, whereby prima facie evidence of riskiness above a low threshold compels the soure of risk, whether an agency of local government, or owner of

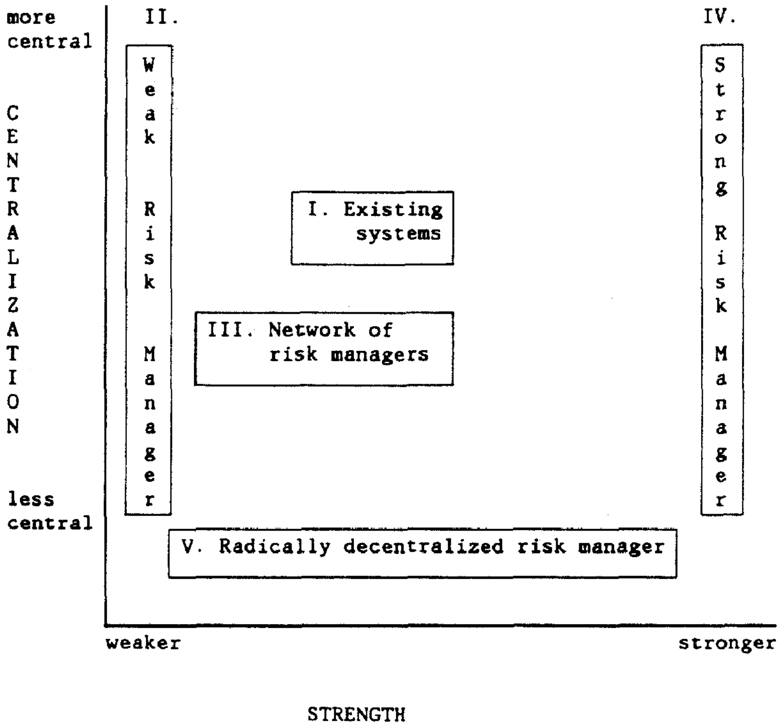

Fig. 2. Comparing the current risk management approach with alternative concepts.

property or of means of transport, to obtain appropriate risk studies showing the safety of proposed activities before proceeding with them.

The existing system

The present system of local risk management combines a number of disadvantages but some advantages. The greatest advantage is equity. Costs are distributed more or less evenly across localities, and substantially similar levels of hazard mitigation result, say for instances where states or localities apply standards more stringent than those of the federal government. Legitimacy is fairly high as standards are authoritative if accepted grudgingly. Quantification of risk is undertaken in the formulation of risk management criteria, but not in their implementation. There is no provision for trading hazards and their attendant risks against one another. While standards might be of concern to authorities, revision and updating of standards occur somewhat haphazardly, as there is no systematic means of cumulating the experience of diverse localities. Not only is there little coordination between local and state agencies, but various federal offices' charged with enforcement of environmental and safety laws often do not communicate with one another. Finally little allowance is made for variation in risk management policies across localities, whether due to physical conditions or citizen preferences, as uniform standards are applied in most instances.

The "weak" risk manager

A modification of the existing system buttresses capabilities of local and state governments by introducing an office specifically charged with managing risks, but with limited powers. A distinctive feature of this office would be expertise: its incumbent would understand the scientific basis, or lack of same, for regulations and professional standards governing local practices. The incumbent would seek, in selected instances, flexibility in the application of regulations and professional standards because of unique local circumstances. Additionally, under the "weak" risk management model, the reactive style of risk management would give way to a more anticipatory mode. Questions concerning the likelihood of flood, fire, tornado, and the like would be raised, and local responses would be keyed to probabilities rather than perceived certainties induced by panic. The "weak" risk manager would not be charged with identification of new hazards, quantification of risks, or formulation of risk acceptance criteria, as he or she would not have resources with which to accomplish these. He or she would hold, however, general authority over implementation of various policies directed at reducing risk. The role of the "weak" risk manager, then, is a means of augmenting professional competence among local officials whose basic job is to administer federal and, to a lesser extent, state regulations governing hazardous activities.

The model of the "weak" risk manager has many of the equity advantages of the present system. The legitimacy of risk judgments would probably be somewhat greater under this alternative than the extant system. Risk comparisons and quantification might be slightly augmented by the "weak" model of the risk manager, but lacking the wherewithal for original investigation, these advantages would be slight. The "weak" risk manager might also provide slight advantages in the revision and updating of standards, but his or her effect would be minimal as no formal means are provided whereby his or her judgments can serve to inform the federal policymaking apparatus. The "weak" risk manager might also be able to take slight cognizance of local preferences in his or her judgments, but, as before, his or her latitude is limited as he or she has at best an advisory role in the formation of policy.

The "weak" risk manager may be among the least costly and controversial of alternatives to the present system for it requires only training or upgrading of present local emloyees or, possibly, creation of a small number of additional positions in the largest jurisdictions. It is a matter of imparting competence, and not of constructing new bureaus with broad responsibilities.

Perhaps the most notable shortcoming of the "weak" risk manager is the difficulty with which managers could be coordinated.

The "network" of risk managers

Network approaches to adminsitration are only widely understood in some frameworks. In other frameworks they are not well understood because they are at odds with a conception of command hierarchy that permeates most thinking about organizations, especially governmental agencies. Structurally, networks consist of totally, or nearly totally, interconnected nodes such that any person has access to any other. There is no hierarchy of intermediate offices. Operationally, coordination of action in networks is secondary to the capacity of individuals to draw information and expertise from other members of the system. Network approaches to administration become feasible only where reliable and cheap technologies for storing and transferring information are available. Such is the case with large commercial data banks that are accessible by telephone from anywhere in the United states.

There are a number of alternative designs for a network approach to local risk management, but the basic elements in any network approach might be as follows. First, information about risks is stored centrally. Any risk management information system presupposes at least one and probably several schemes for ordering and classifying hazards that satisfy criteria of overall inclusivity as well as exclusivity of categories. Estimates of riskiness both for the general population as well as for high-exposure groups are provided for each hazard, but these estimates are subject to change as experience is accumulated. Second, information about localities is also maintained. Not only are risk profiles prepared and continually updated for a number of representative localities, but so are geographic, demographic, climatological, and economic data describing them. Of particular importance is information describing the type and location of industrial, transportation, and waste disposal facilities. Third, information entering the system, which originates from a variety of sources including local community, state, and federal agencies, as well as universities and research laboratories, is filtered through a national (although not necessarily federal government) body responsible for maintaining the risk-management system. Fourth, local representatives, perhaps called "risk managers," would be trained in utilization of the system so that they can determine for local policymakers: (1) the riskiness of specific hazards, (2) the overall level of risk due to known technological and natural hazards affecting their citizens, and (3) hazards likely to be present based on the experience of other cities, counties, and states but not yet detected locally.

The network approach to local risk management appears, on the surface, to offer the possibility of equitable distribution of costs. Presumably, federal dollars would cover the cost of the risk management information system, while utilization of the system would be funded locally. Externalities in information costs are largely avoided. The legitimacy of risk judgments arising from this approach would, in all likelihood, be high since the estimates of risk associated with particular hazards would be based upon the best available evidence and expertise while, at the same time, risk acceptance and policy would be left to local determination. Quantiification of risks at the local level, which allows for comparative risk assessment, is enhanced substantially compared to the existing system and the "weak" model of risk management discussed above. The network approach also provides explicitly for revision and updating of risk information, which is not possible under the previous models. Finally, the network model also accommodates variations in risk judgments across localities. It is to be anticipated, however, that divergences in risk acceptance standards across localities might not be dramatic since quantitative comparisons would force explicit policy judgments which, if substantially different from the norm, could prove to be political liabilities.

The feasibility of the network approach to risk management can be determined at present in part from the operation of local police and fire departments. Otherwise, there is little experience in nonhierarchical forms of administration, especially in the public sector, at present, and additionally, it is not now clear how objective risk data can be organized so that they are maximally useful to local officials. Both of these considerations need further exploration and will be discussed in the concluding section of this report.

The "strong" risk manager

The "strong" risk manager is charged with a full range of responsibilities, from risk identification to risk acceptance and implementation of policy. His is a self-contained unit of local government that does not rely heavily upon the scientific capabilities or expertise of other governmental units, although it may make use of scientific and engineering expertise drawn from a variety of sources.

The consequences of the "strong" risk management model for the constraints outlined above are fairly obvious. To being, substantial inequities are created. Localities either duplicate one another's risk management activities, incurring substantial costs, or behave opportunistically by relying upon analyses done by others, thereby creating substantial externalities in information in that a small number of localities bear the brunt of expenditures without compensation. The legitimacy of risk management judgments would also be problematic, as adjacent localities could, in principle, arrive at widely varying risk estimates for the same hazards. Quantification and comparative risk judgments would be undertaken under the "strong" risk management model, but the capacity of the local officials to draw effectively upon experiences of other localities and to revise and update risk estimates would be limited. Variations in risk acceptance and policy across localities would, of course, be substantial.

Radically decentralized risk management

It is possible to imagine, if not implement, a scheme that moves the locus of much of the risk management process to units even smaller and less aggregated than local governments, namely to the sources of risk themselves. Under radically decentralized risk management, officials would determine activities that are presumptively risky – for example, certain types of construction, transportation, storage and disposal of hazardous materials, and the like. In order to be licensed for any presumptively risky activity, a formal risk analysis, i.e., quantitative estimation of risks, would have to be undertaken or commissioned by the person, company, or agency planning the activity and the results of the analysis would have to fit within an overall risk acceptance framework developed locally. Radical decentralization then, removes the public sector from risk identification and quantificaiton, save for projects that are initiated by public bodies themselves.

The radically decentralized model has heuristic value, because it compels sources of potential risk to bear the costs of determining actual risk, allows for comparative risk judgments based on quantification, and allows for variation in risk acceptance due to local preferences. However, radical decentralization, to even a greater extent than the "strong" model of risk management, either is extremely costly and inequitable due to duplication of effort, or is fraught with externalities and the "free-rider" problem so that risk analyses done for one individual or agency are appropriated by others without compensation. Neither is a satisfactory state of affairs, hence radically decentralized risk management would, under most circumstances, be even less stable than the "strong" risk management model discussed above.

V. Conclusions and findings

This paper describes the current view of risk management held by local government officials and contrasts this with views of risk management held by state level government officials and federal level government officials.

Recognizing that the current paper eminates from the integrated findings of three prior efforts – risk management at the local level [2]; risk management at the state level [5]; and risk management at the federal level [6] – conducted at three different times and under distinctly different assumptions, we are still able to arive at a number of findings:

(1) There appears to be no formal, consistently accepted, and unique risk management approach at the local level of government.

(2) While there is truly no formal management procedure even at the state and federal levels; at these levels we do observe far more systematic management styles.*

*We find the same relative formality at the Federal level as compared to the local level in a number of "non risk related" issues. For example, In the Committee on Natural Security Telecommunication Policy Planning Final Report (July 1986, National Academy Press) the committee observes far more formality in communication operations at the Federal level than at the state level.

(3) We can contrast the present system for managing risk at the local level with a number of alternatives management styles. In assessing each of these styles, we find that the "network" style appears the most attractive.

(4) At the local level of government, risks are more likely to be managed by "reaction", as compared to how they are managed at higher levels of government.

(5) When the local governments manage by compliance, they most often comply with existing federal standards rather than rely upon locallaly generated ordinances.

(6) While there appears to be no unique taxonomy for classifying risks, all risks are likely to fall into at least one of the following four general groupings:

- natural events
- accidents
- wars/disorders
- potential hazards.

(7) It is common to see overlapping jurisdiction for dealing with a given risk, especially within the category of natural events where, for example, both state and local governments have the responsibility for dealing with floods.

(8) Risk initiation often comes from multiple sources. Again, this is especially evident for natural disasters. This also accounts for overlapping jurisdiction in managing risks.

(9) Locally regulated risks are often quite specific. For example, while earthquakes are far more prominent in California, hurricanes are far more likely along the Florida coast. Hence, not all localities need to manage all risks.

(10) There are both advantages and disadvantages in allowing localities more responsibility and/or leeway in risk management. One advantage is that high levels of toxic pollutants from a plant affect those people in the immediate vicinity. Since the local people, rather than the general public, are faced with the risks, they should be centrally involved in deciding the level of risk that is tolerable under local conditions. The copper smelter in Tacoma typifies this point. A second advantage is that local officials could make trade-offs in the choice of how to spend limited resources to reduce risks. many localities, in allowing funds for asbestos abatement in schools, may have had to use money originally targeted for other risk-reducing activities. A third and less tangible advantage of local risk management is that, in general, people are more comfortable with the outcome if they themselves are able to make an informed choice. Although some people resent "government regulations," they readily choose to smoke in spite of a high risk of lung cancer.

There are also a number of disadvantages of increased local involvement in risk management. First, local decisions on risk may have a negative impact on neighboring communities. One town, for instance, may decide to allow high levels of toxic substances in a river near a plant; the contaminants will, therefore, be present near other towns at downstream locations. Second, local risk management would be costly and might result in significant duplication of effort. It would be extremely wasteful, for instance, if each community across the country determined drinking water standards from the scientific data on all toxic chemicals. Third, and most important, local governments are extremely susceptible to local political pressures, and there could be highly unexpected consequences from risk management decisions. For example, a community might be so anxious to lure new industry that it may not fully consider the potential health effects. This would occur most frequently in allowing high emissions of carcinogens or mutagens where the current economic benefits will inevitably be chosen since the cancer of birth defects may not manifest themselves until 40 years later. A fourth disadvantage of local control is that local officials would no longer be able to blame federal government for unpopular actions.

(11) Quantification of risks seems to occur only when technical expertise is available wihtin an agency. Local governments have far less technical expertise than state, and state less than federal. Hence, local levels of government demonstrate far less risk quantification.

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