Democratic Science

Enhancing the Role of Science in Stakeholder-Based Risk Management Decision-Making

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July 2000

FOREWORD

This report was prepared at the request of the American Industrial Health Council and the American Chemistry Council in response to their concern that the growing use of stakeholder processes in environmental risk management decision-making has the potential to compromise the integrity and importance of science as a guide to risk management. As stakeholders themselves, those organizations believe that all stakeholders should recognize that scientific information and science-based risk analysis are central elements of effective risk management. Their concern is that without the factual knowledge provided by science, risk management priorities will be misidentified and risk management resources will be misdirected.

This report seeks to draw lessons from case examples of stakeholder processes, both successful and unsuccessful. It focuses on the role of science in risk management decisions made by convening groups of stakeholders who met, debated, and either agreed or disagreed about appropriate actions. For example, it evaluates efforts by stakeholders convened to determine whether MTBE should be added to gasoline, to make decisions about cleaning up DOE weapons sites, and to preserve air quality in Alaska. This report does not focus on policy decisions made by regulators, debated in the media and in the courts, where different stakeholders disagreed about the nature of the scientific evidence related to the decisions. In other words, it does not evaluate EPA Administrator Browner's chloroform decision, the events that led to the high-production-volume-chemical testing initiative, or the politics of using disagreements about scientific uncertainty as a trade barrier.

There is a notable absence of literature on the combination of science, stakeholder processes, and decision-making. Yet there is considerable debate about how science gets used in stakeholder-based decision-making, suggesting that this is an area ripe for study and empirical research. It is the hope of this author that the contrast between the somewhat haphazard information on which this report is based and the importance of this topic will provide an incentive to others to study this subject with greater rigor.

Acknowledgments

In addition to the American Industrial Health Council and the American Chemistry Council, who supported this project, I would also like to acknowledge the generous contributions of time and expertise of those who were interviewed for this report and who reviewed an earlier draft and provided comments. The case studies were drawn in part from interviews with George Busenberg, Bernie Goldstein, Dan Greenbaum, and Hank Topper, who also provided comments on the draft. Valuable comments were also received from Tom Beierle, Bill Bishop, Caron Chess, Jamie Conrad, Don Elliott, and Granger Morgan. Juliana Birkhoff, Terry Davies, Ortwin Renn, and Terry Yosie also provided valuable insights. I appreciate everyone's willingness to share their time and abilities.

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Executive Summary

Involving stakeholders in making decisions about the best ways to characterize and manage risks to our health, safety, and environment has been recommended increasingly over the past decade. This trend reflects a move towards increased democratization of risk management decision-making. One concern about increasingly democratic risk management decision-making is whether stakeholders have the ability to respect and preserve the role that science can play in informing decisions. Some argue that greater stakeholder involvement will marginalize science; others argue that decision-making is already tyrannized by science and scientific experts and that involvement of non-scientific, non-expert stakeholders represents a needed swing of the pendulum back towards an emphasis on social values.

Risk assessment has emerged over the last two decades as the dominant paradigm in the US, and increasingly elsewhere, for including science in regulatory decision-making about the best ways to manage threats to health and the environment. But because both science and judgment play important roles in risk assessment, decisions about the nature, extent, and appropriate response to risks remain controversial. This controversy is exacerbated by the inherent uncertainty of science, and by the concern that those in control of the science can use this uncertainty to serve their own ends. The case examples in this report illustrate the problem of resolving technically intensive policy disputes, as well as the challenges and difficulties associated with using risk assessment as one input to decision-making by stakeholders when the credibility of the underlying science is either in doubt or inconsistent with stakeholder concerns.

The successful case studies examined in this report used stakeholder processes to establish at the outset what the role of science would be in the risk management decision; in effect, practicing Democratic Science. In each case where Democratic Science was practiced, science played an important role, but a role that was shaped by stakeholder values to address their concerns and that was able to inform an evolving understanding of the scope of the problem. The report concludes that scientific integrity is maintained and its credibility is assured

when stakeholders are involved in deciding how science is used to answer their questions and in obtaining the scientific information needed to answer those questions. In other words, the case studies demonstrate the effectiveness of implementing what the National Academy of Sciences report *Understanding Risk* called the "analytic-deliberative process" and what the Commission on Risk Assessment and Risk Management outlined with its framework for stakeholder-based risk management decision-making.

Making effective risk management decisions will continue to be a struggle as we seek to give fair consideration to both science and values and to find the right balance between analysis and deliberation. A Framework for Democratic Science is described here that uses stakeholder goals and concerns to guide the use of technical information in risk management decision-making as part of an iterative analytic-deliberative process. In the context of the Democratic Science Framework, stakeholder values help clarify concerns about potential risks and risk management goals. Questions that must be answered to address stakeholder concerns are articulated and the factual information needed to answer those questions is identified. Stakeholders then identify and agree on whom should be responsible for obtaining the needed factual information. After the needed scientific information is obtained, it is combined with other information and used either to re-frame the problem and risk management goals or to guide decision-making. In the case examples described here, a model that seemed to work well involved establishing a group of scientific experts that all stakeholders agreed to; by working closely together through collaborative analysis, the scientists were able to understand the basis for the stakeholders' concerns and the stakeholders were able to understand the role that science could play and to participate in generating data. When the adversarial groups involved in a decision can jointly oversee and participate in the research needed to resolve scientific and other technical issues underlying a policy debate, they have the means to assure themselves that other stakeholders are not manipulating the analysis.

This report draws its conclusions from a few readily available case studies primarily because virtually all of the research that has sought to identify the determinants of successful public participation in environmental decision-making focuses on process-oriented social goals and does not evaluate the role of science. Not surprisingly, risk assessors have tended to focus on risk controversies and social scientists have focused on social dimensions; research in this area would benefit from teams comprising both risk assessors and social scientists. Research is needed that includes determinants of how science has been included in stakeholder-based decision-making and how its role has had an impact on process outcomes. An analysis of the social factors that contribute to differing interpretations of scientific information and how science weighs as a factor in decision-making is also worthy of more focused research. Finally, more rigorous study is needed to determine whether, as some cynics suspect, most risk management decisions are made on the basis of political expediency. The extent to which good science or efforts at stakeholder collaboration have any real influence remains to be determined.

1. Introduction and Background

Managing risks to health, safety, and the environment is evolving beyond being the sole purview of regulatory agencies. More and more risk management decisions are developed and implemented using collaborative processes involving consultation and cooperation among stakeholders, including regulators, regulated parties, advocacy-based organizations, and the general public. This trend constitutes a move away from the unilateral, technocratic, regulatory model of risk management decision-making toward more inclusive, democratic, non-regulatory processes, reflecting the democratic ideal that people should be involved in their own governance (English 1996). Growing stakeholder-based decision-making is thought to be a response to a lack of public trust in risk management decisions made by government and industry; expanded public awareness of environmental, health, and safety issues; increased social expectations for improved environmental quality; changes in information technology; and the desire by business and government to demonstrate responsiveness to public concerns (Yosie and Herbst 1998s). At the same time, it is a natural outgrowth of the interest group pluralism model of administrative action in which regulatory agencies act as brokers for the many relevant interests and perspectives on problems within their jurisdictions (Stewart 1975).

A number of organizations have made recommendations concerning the need for increased stakeholder involvement in decision-making. In its 1997 final report, the Commission on Risk Assessment and Risk Management (Risk Commission) concluded that a good risk management decision emerges from a process that elicits the views of those affected by the decision, so that differing technical assessments, public values, knowledge, and perceptions are considered (Risk Commission 1997). The Risk Commission's report also stated:

> Stakeholders bring to the table important information, knowledge, expertise, and insights for crafting workable solutions. Stakeholders are more likely to accept and implement a risk management decision they have participated in shaping. Stakeholder collaboration is particularly important for risk management because there are many conflicting interpretations about the nature and significance of

risks. Collaboration provides opportunities to bridge gaps in understanding, language, values, and perceptions. It facilitates an exchange of information and ideas that is essential for enabling all parties to make informed decisions about reducing risks.

In its 1996 report, *Understanding Risk*, the National Academy of Sciences carefully avoided using the term "stakeholder" but noted that risk management processes must have an appropriately diverse participation or representation of the spectrum of interested and affected parties, of decision-makers, and of specialists in risk analysis, at each step (NRC/NAS 1996). The report defined "affected parties" as people, groups, or organizations that may experience benefit or harm as a result of a hazard, or of the process leading to risk characterization, or of a decision about risk, noting that such parties need not be aware of the possible harm to be considered affected. "Interested parties" were defined as people, groups, or organizations that decide to become informed about and involved in a risk characterization or decision-making process (and who may or may not be affected parties).

The Western Center for Environmental Decision-making asserts that public involvement can help gather information; create forums for the exchange of technical information and public opinion; help participants make better decisions about environmental problems; accelerate (but not guarantee) change; and begin to reclaim the legitimacy of government by demonstrating a recommitment to public debate (Western Center for Environmental Decision-making 1997). The US Environmental Protection Agency (EPA) recommends building stakeholder partnerships for environmental improvement because doing so promotes voluntary environmental management, shifting the responsibility for environmental quality from government to a partnership that includes industry. It also opens up the evaluation and assessment process to those parties—customers, workers, and local communities—affected by the choices that industry makes (US EPA 1995). Building on that theme, the American Chemistry Council requires as part of its Responsible Care® program that member companies seek and incorporate public inputs into their products and operations (American Chemistry Council 1999). In addition to EPA and industry, states, municipalities, the governments of other industrialized nations, and the US

Departments of Energy and Defense, among others, all rely increasingly on stakeholder processes to help make decisions about their activities that have potential environmental health impacts.

Despite the common-sense appeal of stakeholder-based processes, they have been criticized for several reasons. These include the substantial investment of time and resources required; the likelihood that they will heighten, not alleviate, conflict; the difficulty in identifying and facilitating the inclusion of truly representative stakeholders; the possibility that they are actually counter-democratic due to increased representation of special interest groups; and the concern that when nontechnical people are included in decision-making, the scientific or technical and factual basis of a problem or solution will be distorted, trivialized, or ignored. The latter concern arises partly because of the difficulty scientists have communicating technical information as part of stakeholder deliberations and partly because decision-makers often perceive nontechnical stakeholders as being more legitimate representatives of social values (US EPA 1995). It can also be attributed to nontechnical stakeholders' suspicion that science can be distorted to support different stakeholders' points of view.

Assessing the impacts of stakeholder processes to date requires clarification of the many different types of processes that have been conducted and evaluated. Stakeholder involvement can range from national and multinational decision-making, such as that associated with implementing the Clean Air Act or the North American Free Trade Agreement, to community-based decision-making, such as that associated with the cleanup of contaminated sites. It can mean negotiated rulemaking efforts ("reg-negs"), such as that which created the microbial disinfectant by-products rule for drinking water, or comparative risk projects such as those conducted by states to help set risk management priorities. They can be directed towards setting exposure limits for chemicals, as were a number of attempts by the US Occupational Safety and Health Administration to set workplace Permissible Exposure Limits, or towards identifying the sources of public health problems in a disadvantaged urban area, like South Baltimore. Some types of stakeholder processes convened by regulatory agencies require consensus and some do not; some are binding and some are not. That is, some result in recommendations from the majority of participants that regulatory agencies are not required to implement, but may take into account when making the ultimate risk management decision. Stakeholder processes inform regulatory decision-making, but do not constitute decision-making; regulatory agencies may benefit from the outcome of a process but must, in the end, take the final, legal responsibility for a decision. As a result, evaluating the “success” of a stakeholder process can be somewhat difficult. Of course, stakeholder-based risk management does not have to be initiated or conducted by regulatory agencies. Regulated parties, for example, may initiate risk management efforts on their own in collaboration with other stakeholders, as the electric utility industry did when it invited Environmental Defense to help them identify cleaner power production technologies.

Much of the concern about how science is used in risk management decision-making results from how science is used or abused when risk management policies are debated by stakeholders in the absence of a formal process. For example, the global controversy over the safety of genetically modified organisms and the reactions in the UK to bovine spongiform encephalitis (BSE), in Belgium to dioxin in chicken feed, and in the US and Europe to phthalates in toys are all situations where stakeholders—government regulators, the media, advocacy organizations, industry, and consumers—are debating appropriate risk management actions in the absence of an organized framework. Deciding what risk management actions are appropriate generally depends on some agreement about the nature and extent of the risks; in those cases, stakeholders disagree about the nature and extent of the risks mostly because they disagree about the underlying science. Some stakeholders argue that because the science is uncertain and the risks potentially severe, extreme risk management actions are warranted. Those stakeholders assert that it is up to the proponents of a potential risk (e.g., toy manufacturers) to demonstrate its safety; they also tend to mistrust any proponent-sponsored scientific research or claims of safety. Other stakeholders argue that the science is not uncertain, or at least not uncertain enough, to warrant extreme actions; these stakeholders also tends to argue that the consequences of extreme risk management actions are disproportionate to their benefits. In either case, Paul Slovic argues that whoever controls the definition of risk controls the rational solution to the problem at hand; defining risk thus becomes an exercise in power (Slovic 1999).

In general, many decisions that people make about risk management in our daily lives are not made on the basis of science or facts, but on the basis of perceived fairness. If people made decisions on the basis of scientific facts or quantitative risk estimates alone, they would not smoke cigarettes or eat doughnuts, and would drive only reluctantly. Science and concepts of risk are not irrelevant; many people have stopped smoking, many who continue to smoke know that they are at increased risk of lung cancer, and people know that doughnuts are not good for them. However, risk is also a social construct, with most people making decisions about risk based on a complex set of perceptions that include familiarity, harm, benefit, values, dread, voluntariness, and other factors (Slovic 1987), and on what they hear from a few people quoted in the newspapers or on television. Newspaper and television reporters cover risk on the basis of rarity, novelty, commercial viability, and drama, not on the basis of relative risk (Graham 1998). In the absence of formal stakeholder processes in which nontechnical stakeholders work together with technical stakeholders so that the former come to understand the technical issues and the latter come to understand the nontechnical issues, the self-interest of all parties—described as the Rashomon effect, in which different parties give differing accounts of the same situation, suiting that party's interests (Mazur 1998)—will dominate risk debates.

Much of the literature on stakeholder processes focuses more on providing guidance for establishing and conducting them and less on evaluating their successes, failures, and impacts. While the emphasis on the former is not misplaced, more research is needed on the latter. Resources for the Future has a project underway that is identifying the successes, failures, and impacts of public participation in environmental decision-making by evaluating about 250 case studies (RFF 1999) using an evaluation framework based on social goals (Beierle 1999). More typical (but also valuable) is a report from the Western Governors' Association assessing the value of local stakeholder involvement efforts at two sites (Belsten 1996). The 1998 report by Yosie and Herbst, based on case studies and extensive interviews, is probably the most recent and comprehensive analytic evaluation of the issues and challenges associated with managing stakeholder processes (Yosie and Herbst 1998b). In general, the literature indicates that stakeholder processes vary substantially in terms of process quality and influence on policy outcomes. Most studies also agree that stakeholder processes are not a transitory phenomenon but an important development that reflects a fundamental change in the way environmental risk management decisions are made.

This report relies primarily on case examples. Although there is a good literature on science and decision-making and on stakeholder processes and decision-making, there is very little that examines all three aspects together. The report uses information from the case examples to draw conclusions and make recommendations about ways to improve or enhance the role of science in stakeholder processes. By focusing on science as part of a decision-making process and not solely as an outcome of a process, the report attempts to avoid the difficulties inherent in identifying objective measures of scientific or technical quality. It relies instead on whether stakeholders can resolve scientific conflicts as the basis for evaluation.

2. The Problem: Uncertainty, Credibility, and Communication

The root of most debates about the role of science in risk management decision-making is the fundamentally uncertain nature of science. Most highly subjective, contradictory, or incorrect scientific claims occur in the areas of uncertain knowledge, or in the application of well-established knowledge to novel or ambiguous situations (Mazur 1998). Uncertainty allows the participants in a debate to generate competing technical analyses to support their conflicting policy arguments (Mazur 1975). Surprisingly often, disagreements on key technical points remain unresolved and scientific uncertainties remain unaddressed, undermining opportunities for resolving policy debates (Adler et al. 2000).

The essential problem with the “dueling scientists” approach is that the adversaries recognize that each group can manipulate or distort its analysis to support its policy position. The resulting suspicions make it difficult for any one participant to generate technical information that will be credible to the other participants (Busenberg 1999). When no common ground of technical knowledge is achieved, its role and importance in deliberation can be diminished or eliminated.

Poor communication about the role of science in a risk management decision-making process also leads to misunderstanding and suspicion. It is often the quality of the communication—not the technical information itself—that stands in the way of finding common ground (Hance et al. 1988). Problems arise when participants misunderstand the extent to which science can and cannot provide answers to their concerns. If nontechnical stakeholders do not understand the science or the role it can play in decision-making, it is unlikely to play a significant role. If the scientists or technically oriented stakeholders do not understand what the real concerns of the other stakeholders are, then science—no matter how well deployed—will not solve the problem.

This section uses two case examples to illustrate the problem of resolving technical policy disputes. The first involves competing scientific knowledge claims and the second, conflicting goals and communication failure among the participants.

Case #1: Valdez, Alaska (Busenberg 1999). Large volumes of crude oil are shipped in the Prince William Sound region of Alaska, with oil loaded onto tankers at the port of Valdez at a terminal operated by the Alyeska Pipeline Service Company (Alyeska). Alyeska had supported the establishment of a Regional Citizens' Advisory Council (RCAC) to help oversee environmental management of the marine oil trade there. The RCAC and Alyeska engaged in two major disputes involving technically based policy issues. In the first, a suspicion that science was being distorted to support the industry's desired outcome led to a stalemate, with the technical issues ultimately ignored in the risk management decision-making process. The participants in the second dispute, perhaps learning from the lessons of the first, resorted to a collaborative process instead (see Section 4).

The first dispute involved the impact of crude oil vapors emitted by the oil terminal on air quality in the city of Valdez. Alyeska had commissioned a series of air quality studies that examined the levels and sources of airborne volatile organic compounds in Valdez and the RCAC convened a panel of scientists to evaluate the results of the studies. The panel agreed with the findings regarding the levels of ambient airborne benzene but disagreed with the method used to identify the source of the benzene emissions. The two groups of scientists then generated contradictory knowledge claims regarding the sources of benzene, with the RCAC concluding that 90% of it originated at the oil terminal and Alyeska concluding that only 25% originated there. The RCAC asked Alyeska to install vapor control systems and Alyeska refused, unless a significant health risk could be attributed to the terminal. Interviews revealed that the Alyeska scientists questioned the validity of the RCAC models and that RCAC scientists believed the Alyeska results had been manipulated to support the industry's arguments. Mutual suspicions of distorted communication arising from claims of mistaken and manipulated analyses led to an impasse, with neither party accepting the other's interpretation. In the absence of a common foundation of knowledge, further discussion stalled and the Valdez air quality debate remained deadlocked for two years.[1]

Case #2: Baltimore Community Environmental Partnership (US EPA 1999a). Southern Baltimore is an industrialized area with a large concentration of industrial, commercial, and waste treatment and disposal facilities. Major facilities include chemical manufacturers, petroleum storage facilities, a medical waste incinerator, the city landfill, and a municipal wastewater treatment plant, 11 of which report air emissions to the EPA Toxics Release Inventory. Additional facilities, such as the city waste incinerator, a large steel mill, and two utility power plants, are located nearby. Altogether, more than 175 chemicals are emitted from facilities in the area, leading residents to rank air quality first on their list of concerns at a community priority-setting meeting. In particular, community residents were concerned about the possible public health consequences of exposure to the combined emissions from all the industrial, commercial, and waste treatment and disposal facilities located in and around their

[1]Eventually, the debate was superseded by implementation of the 1990 Clean Air Act Amendments and an EPA draft rule requiring a 95% reduction in the emissions of all hazardous air pollutants from the Valdez terminal. Alyeska responded by installing vapor controls. Thus the risk management action taken was in response to impending regulatory requirements, not a result of any determination of potential health effects by a stakeholder process.

neighborhoods. A Community Environmental Partnership[2] had been started in southern Baltimore as a community-based approach to environmental protection and economic development. A subcommittee of the partnership comprising representatives of different community sectors was formed to address air quality, while a separate subcommittee was formed to address community health. The goals of the air quality subcommittee, co-chaired by one resident and one industry representative, were to determine whether current levels of air toxics resulting from industrial emissions in partnership neighborhoods might affect community health and to recommend actions to improve air quality. All decisions were made by consensus.

The air quality subcommittee chose to use a risk-based screening method to help provide information on the potential health risks associated with airborne chemicals in partnership neighborhoods. The approach used standard methods to identify chemicals from air pollution sources that might pose the greatest health risks. Three successive screens of the original 175 chemicals of potential concern identified four chemicals as being of most concern to the partnership neighborhoods. Of those four, only benzene emissions were estimated to result in airborne concentrations above the subcommittee's screening level, suggesting that local industrial emissions do not pose a threat to public health in that area. Petrochemical storage facilities in one neighborhood were identified as the primary source of the modeled benzene, but contributed only 12% of the measured ambient benzene concentrations in the area. Mobile sources were thought to account for most of the ambient benzene concentrations but mobile sources were not considered in the screening exercise, which looked only at point-source emissions.

The limited scope of the subcommittee's investigation produced a dilemma. The subcommittee wanted to focus on facility-related point-source chemical emissions and to develop concrete recommendations to improve community health. As it turned out, the study

[2]The Community Environmental Partnership comprised community residents, businesses, organizations such as local schools and the Johns Hopkins School of Public Health, local governments (Baltimore City and Anne Arundel County), state government (Maryland Department of Environment), and federal government (US Environmental Protection Agency).

found that the point sources evaluated were not likely to be a significant contributing factor to community health concerns. By not including a potentially important source of air pollution—mobile sources—in the study, the subcommittee did not have enough information to develop the most effective recommendations. Thus it is possible that poor air quality does contribute to public health problems in South Baltimore, but by failing to look at the whole picture, the study could not answer the question. The relationship between the limited scope of the subcommittee's work and its ability to make recommendations for improving community air quality and health was not adequately discussed, understood, and agreed to at the beginning of the effort.

When the participants realized that the results of the study were not going to be able to show what some expected—that industrial air emissions posed risks to their health—the environmental advocacy group representatives resigned from the subcommittee. In a letter to EPA (timed to be released one day before the study results were made public), those who resigned (and others who had not been involved in the project at all) stated that they were "deeply committed to the Partnership's ultimate goal: the discovery of more effective ways to reduce pollution through the reinvention of traditional regulatory programs." That goal had not, in fact, been articulated and agreed to at the start of the effort. The letter authors went on to say that what they had sought by participating in the project was "a real opportunity [to develop] a new and deeper understanding of the environmental conditions *that threaten us* and [to debate] the best way to address those problems" [emphasis added]. Thus those who resigned had started with the assumption that the environmental conditions they were addressing posed risks to their health. When that assumption was not borne out by the results of a process they had agreed to and participated in from the start, they resigned in an attempt to discredit the process and findings and to maintain their adversarial position. In this way, the conflict became one less about what science was relevant and more about whether science was relevant. Scientific legitimacy was appealing when it suited the needs of the environmental advocacy participants; scientific information was sought as a means to buttress their beliefs, not to answer a question or solve a problem.

While the Baltimore Air Committee process did not exactly fail, its results did not have the support of all participating stakeholders. It was not able to use science to change views, solve a problem, or develop a consensus. One problem was that the environmental activists were the only community resident representatives involved. Broader community representation that did not rely on only one sector or viewpoint would have created better conditions for an effective deliberative process. The process should have clarified at the outset what the science would and would not allow the study to accomplish and how the science and the political agendas of some stakeholders conflicted. Involving participants in collecting actual data to verify the estimates of the air contaminant exposure models might have contributed to a shared understanding of the results of the study and improved its credibility. Finally, by taking a longer-term view of the deliberative process and an iterative approach to problem definition, the two subcommittees formed to address air quality and community health separately might have been combined. This study could have been one of several steps taken towards answering the larger question, What factors contribute to health problems in the community? By focusing on the narrow question it did, it could not answer the broader public health concerns of the community.

3. Science, Precaution, and Risk Analysis: The Challenge

The case examples in Section 2 illustrate some of the challenges and difficulties associated with using risk assessment as an input to decision-making by stakeholders when the credibility of the underlying science is either in doubt or inconsistent with stakeholder concerns. Despite such difficulties, risk assessment has emerged over the last two decades as the dominant paradigm in the US and elsewhere for including science in regulatory decision-making about the best ways to manage threats to health and the environment. Risk assessment is a way to organize scientific information in a form that is meant to provide a useful input—both qualitative and quantitative—to risk management decision-making. Risk assessment is not the only input to decision-making, of course; social, economic, feasibility, legal, equity, and political considerations also play important roles. The challenge is to maintain a role for risk assessment and to preserve the integrity of science when decision-making is influenced by many nontechnical factors. As the cases in the previous section show, doing so is particularly challenging when risk management decisions are conducted as collaborative efforts among stakeholders with differing technical knowledge levels, interests, goals, and world views.

3.1 Evolution of risk assessment as the scientific vehicle for informing risk management

Before risk assessment became a well-recognized and codified discipline, a precautionary approach often guided risk management decision-making in the US for many years. For example, in the 1950s the Delaney clause required the Food and Drug Administration to ban outright food and color additives that had been shown to produce tumors in humans or laboratory animals. In the 1970s, a legal basis for a precautionary approach was established when the Environmental Protection Agency was required by the *Ethyl* decision to proceed with its plans to ban leaded gasoline even if the science was not strong enough to be able to prove exactly what the benefits of removing lead would be (*Ethyl Corp. v. EPA*. 541 F.2d 1 (DC Cir.)(en banc), cert. denied, 426 US 941, 1976).

In 1980, however, the *Benzene* decision overturned the precautionary basis of the *Ethyl* decision and substituted a risk-based principle by establishing the need for some form of evaluation as a basis for deciding if a risk is “significant” enough to deserve regulation (*Industrial Union Dept., AFL-CIO v. American Petroleum Inst*., 448 US 607, 1980). A series of Executive Orders requiring cost-benefit analysis of proposed decisions also fueled the demand for risk assessment, because the benefit of environmental regulation is typically the risk reduction that it is predicted to achieve.

To a large extent, the body of US laws that seek to establish practices that will ensure safety—or at least mitigate risk—from chemical or other contaminant exposures were established before risk assessment emerged as a discipline. Most of the methodology of risk assessment was developed in reaction to the calls by these laws to define limits on exposure that will “protect the public health with an adequate margin of safety” or lead to “a reasonable certainty of no harm”. That is, in passing the laws, the US Congress called on the regulatory agencies to develop means to assess risks so as to define exposure levels that would achieve the stated qualitative goals of health protection (Rhomberg 1997).

Thus, in response to the Executive orders, the Supreme Court, and Congress, the US has moved away from a precaution-based approach to regulation and risk management and substituted a risk-based approach, albeit one that incorporates precautionary assumptions. Until recently, however, little attention has been given to the complications of reconciling the scientific process of risk assessment with the needs of democratic procedure (Kasperson et al. 1999).

3.2 Role of science in risk management decision-making

Because both science and judgment play important roles, risk assessment is controversial. Often, the controversy arises from what we do not know and from what risk assessments cannot tell us, because our knowledge of human vulnerability and of environmental impacts is incomplete (Risk Commission 1997). Nonetheless, because of its scientific underpinnings, risk assessment generally constitutes the vehicle for including science in risk management decision-making. Thus, risk assessment is based on science to the extent possible and on judgment when necessary.

The importance of assuring a strong technical basis for risk management is well recognized. In *Understanding Risk,* the National Academy of Sciences acknowledged that reliable technical and scientific input is essential to making sound decisions about risk (NRC/NAS 1996). The report recognized scientific analysis as the best source of reliable, replicable information about hazards and exposures and as being essential for good risk characterization. Relevant analysis, in quantitative or qualitative form, strengthens the knowledge base for deliberations; without good analysis, stakeholder processes can arrive at agreements that are unwise, not feasible, or simply a reflection of who possesses greater political power. The chief challenges are to follow in practice analytic principles that are widely accepted and to recognize the limitations of analysis.

The Western Center for Environmental Decision-making concurs, stating that a "better environmental decision" is one that is based on a better understanding of the relevant science. Public attitudes can change public policies, but they cannot change the laws of nature, e.g., the chemistry of ozone depletion, the physics of air pollution, or the neurotoxicity of lead. The normal political processes of reaching decisions by compromise will produce bad results if they assume that a natural system or physical law can "compromise" as well. Risk managers have a special obligation to ensure that the public understands the technical constraints imposed by the natural world (Western Center for Environmental Decision-making 1997).

Scientific and technical experts bring substantive knowledge, methodological skills, experience, and judgment to the task of understanding risk. In addition to their specialized knowledge, scientists bring a capacity to build systematic and reliable ways of analyzing and interpreting information about new situations (NRC/NAS 1996). At the same time, the nontechnical public can contribute valuable knowledge and information to the factual basis of a decision. It is important to elicit and facilitate the incorporation of such knowledge in a valid scientific framework.

Although, to a great extent, science provides the factual basis for decision-making, it may not always be neutral and objective as a decision-making tool, even when it meets all the tests of scientific peer review. According to the National Academy of Sciences (NRC/NAS 1996):

> Good scientific analysis is neutral in the sense that it does not seek to support or refute the claims of any party in a dispute, and it is objective in the sense that any scientist who knows the rules of observation of the particular field of study can in principle obtain the same results. But science is not necessarily neutral and objective in its ways of framing problems [or] in its choice of assumptions . . . Evidence that science has been censored or distorted to favor particular interested parties has long been a source of conflict over risk characterizations.

Nonetheless, scientific data and knowledge form the building blocks necessary to ground consensus-seeking deliberations and to promote confidence in the process and its outcome (Adler et al. 2000). Objectivity and subjectivity are relative, not absolute, and scientific knowledge is considered more objective than other systems of belief about the natural world. And while science has its subjective elements, modern science does discover real features of nature—viruses, ions, planets, gravitational attraction, electromagnetic radiation, supernovas—in a way that other methods of knowing cannot (Mazur 1998).

Integrating science into a multifactorial decision-making process is challenging because science alone is not an adequate basis for a risk decision. Risk decisions are, ultimately, public policy choices. A specialist's role is to bring as much relevant knowledge as possible to participants in a decision, whose job it is to make the value-laden choices. Good science is a necessary—in fact, an indispensable—basis for good risk characterization, but it is not a sufficient basis (NRC/NAS 1996).

3.3 Science, judgment, and democracy

The role of experts and technical knowledge in a democracy is frequently debated, particularly in the context of environmental health and ecological risk management. The debate centers on conflicts between the "world of values, ethics, politics, and life philosophies" and the "world of information and technical expertise" (Yankelovich 1991). Scientists have been accused of failing to place their efforts in an adequate social context, believing that science is separate from social factors or that social factors play minimal roles (Brown and Mikkelsen 1990). Some describe the choice as one between "Almighty Science *versus* Nature" (Jackson 1999), where Nature represents all that is good and democratic and science is evil because it "subdues" nature, presumably through empiricism. Even Isaac Newton recognized that hypotheses about nature that are not based on empirical evidence "have no place" in science, however (Van Doren 1991). Others assert that "new frontiers of scientific knowledge developed not from a value-free forward march of science but from conscious decisions to examine data in a new light and to seek new sources of data" (Brown and Mikkelsen 1990); few, of course, would suggest that science is value-free and most would equate the re-examination of data and the search for more data with the scientific method itself.

Properly understood, the distinction is essentially one between information and judgment. As Daviel Yankelovich has somewhat tendentiously put it, “In its eagerness to exalt the truths of science, empiricism has, crudely and blindly, undermined other modes of knowing, including public judgment . . . American culture grossly overvalues the importance of information as a form of knowledge and undervalues the importance of cultivating good judgment. It assumes, falsely, that good information automatically leads to good judgment” (Yankelovich 1991).

There is a fallacy that people sometimes succumb to, which is to assume that if only the “right” science were known or generated, the “right” answer or course of action would become apparent. This belief arises in part due to misunderstanding science, in part due to attempts to mask needed judgment as science, and in part because of the legal tradition in the US that relies heavily on establishing a factual basis for decision-making. Regulatory decisions in the US have to be justified by an extensive factual record that is subject to judicial review. The factual basis for a risk management decision is highly valued because, in the absence of a complete factual basis or record, decisions are easily challengeable. As a consequence, the judgmental or less factually based component of risk management decision-making is perceived as being less highly valued, contributing to Yankelovich’s assertion that “In present-day America, a serious gap exists between the point of view of the experts and that of the general public” (Yankelovich 1991).

Nonetheless, both information and judgment are recognized as being essential components of decision-making (Yankelovich 1991):

> Although the struggle between experts and public has become adversarial, there can be no such thing as the “victory” of one side over the other. If the experts overreach themselves and further usurp the public’s legitimate role, we will have the formal trappings of democracy without the substance, and everyone will

> suffer. If the public dominates and pushes the experts out of the picture altogether, we will have demagoguery or disaster or both. A better balance of power and influence is needed, with each side performing its function in sympathy and support of the other.

The movement over the last several years towards more inclusive and democratic environmental health risk management decision-making processes reflects an attempt to develop better ways to integrate social, political, economic, and technical issues into fair risk management decisions; in effect, to balance the scientists' facts and the public's judgment. As Yankelovich put it, "When the proper balance exists between the public and the nation's elites, our democracy works beautifully. When that balance is badly skewed, the system malfunctions. The chief symptom of imbalance is the nation's inability to arrive at consensus on how to cope with its most urgent problems" (Yankelovich 1991). It is certainly the case that consensus on how best to manage risks to health and the environment is seldom achieved. It is also not surprising that, as we struggle to seek the right balance in order to achieve consensus, decisions often will be skewed, with scientific and factual knowledge playing roles of varying importance and influence.

Robert F. Kennedy, Jr. contends that the issues of environment and democracy are intertwined and inseparable, and that the environmental movement and the laws it spawned gave us "true democracy in this country for the first time" (Kennedy 1998). He argues that the body of 19 major federal environmental statutes passed since 1970 essentially re-enacts the ancient doctrines of nuisance and public trust and acknowledges that while we need industry, we also have a right to a clean environment. Risk assessment can play a role in helping us decide how much risk society will tolerate if it justifies the destruction of an absolute right.

Some argue against the wisdom of delegating environmental risk management decisions to either public stakeholders or experts, proposing market-based policies instead. Markets are considered truly democratizing means of decision-making due to the broad extent of public participation. However, few of us are willing to rely on "democratic participation" stakeholder processes to manage the financial risks associated with our savings and pensions, for example; we should be unwilling to do the same with regard to health and environmental risks (Shogren 1998).

4. Striking the Right Balance: Approaches to Solving the Problem

This section uses case examples to illustrate how different approaches to collaborative analysis have been used to overcome the problems of distorted analysis, credibility conflicts, and poor communication as stakeholders strive to give due consideration to both science and values. In each case, the disputing parties collaborated to generate a knowledge base that all stakeholders understood and trusted and that directly addressed their concerns.

Case #3: Prince William Sound. Following the dispute described in Case #1 (Section 2) between the oil industry and the residents of Valdez, Alaska over air quality, a second dispute took place (Busenberg 1999). The second dispute involved a debate over the capabilities of the tug vessels used to escort oil tankers in the Sound. The tug vessels' primary purpose was to help correct course errors that might otherwise lead to collisions and oil spills. The RCAC (citizens' group) proposed that the oil industry deploy highly maneuverable tractor tug vessels in one region of the Sound and an ocean rescue tug vessel with an enhanced propulsion system in another region of the Sound, on the basis that doing so would reduce the risk of oil spills. The oil industry opposed the proposal as an unnecessary expense given that existing studies did not demonstrate that those tug vessels would improve safety. The oil industry then proposed to resolve the dispute by performing a comprehensive risk assessment of the oil trade in the Sound. The risk assessment was to be jointly funded and managed through a steering committee comprising RCAC members, oil industry managers, and representatives of the two government regulatory agencies with the appropriate jurisdictions. To avoid "dueling scientists," the steering committee combined the industry's scientific experts with the RCAC's scientific experts to form a single research team. Later interviews found all parties agreeing that if the oil industry had conducted the risk assessment on its own, no one else would have believed the results. By having the participants in the dispute structure and perform the risk assessment jointly, collaborative analysis was used to resolve potentially adversarial technical disagreements.

There were several benefits to using the collaborative model. One benefit was mutual learning among the participants. Frequent meetings led the steering committee to gain a better understanding of the technical dimensions of maritime risk assessment and the research team to better understand the problem at issue and to gather data it would not have otherwise. Steering committee members actually participated in data gathering with the research team. Another benefit resulted from combining resources, making more money available to conduct the work. The results of the risk assessment were accepted as credible by all parties involved in the issue, who agreed that hidden agendas or conspiracies could not influence the collaborative process.

In response to the results of the assessment, the oil industry deployed an ocean rescue tug vessel in the Sound. The risk assessment was not able to determine whether tractor tug vessels would improve the safety provided by the conventional tug vessels already active, however. The governor of Alaska decided the issue by declaring that tractor tug vessels constituted the "best available technology" as required under state law and the oil industry responded with two such vessels on the basis of the policy decision. Thus both science and politics played roles in the outcome.

Case #4: MTBE and HEI. The 1990 amendments to the Clean Air Act established the Federal Reformulated Gasoline Program to make recommendations about reformulating gasoline in ways that reduce emissions of air pollutants from motor vehicles. One of the ways the program has tried to reduce carbon monoxide emissions is through the addition of chemicals that increase the oxygen content of gasoline, or "oxygenates." Methyl tertiary butyl ether (MTBE) is an oxygenate that has caused some controversy because of disagreements about its effectiveness, its potential to cause human health effects, and its ability to contaminate ground and surface waters.

The introduction of reformulated gasoline containing MTBE had elicited a number of complaints from workers and the general public in some areas of the United States, including reports of unpleasant odor, headaches, burning of the eyes and throat, and other symptoms of discomfort. In response to those concerns, the Health Effects Institute (HEI) was asked by EPA and the Centers for Disease Control and Prevention to convene an expert panel to review the available scientific information on MTBE and other oxygenates and assess potential risks to health resulting from their use. HEI is an independent, nonprofit corporation supported jointly by EPA and industry to "provide high-quality, impartial, and relevant science on the health effects of pollutants from motor vehicles and from other sources in the environment" (HEI 2000).

HEI convened a panel of scientists to evaluate oxygenates but recognized that the scientists did not represent the stakeholders. Appreciating that credibility in a broader context was needed, HEI identified an advisory board comprising stakeholders to work with the scientists and to help formulate the questions of concern. The advisory board members were representatives of environmental advocacy organizations, industry, state health departments, other government agencies, unions, other scientists, and citizens. The first meeting included both the scientific panel and the advisory board so that the initial problem formulation was conducted by both scientists and stakeholders. Together, scientists and stakeholders clarified the scope of the evaluation and identified and interpreted the needed scientific information. A draft report describing the study's conduct and conclusions was reviewed by both groups. Although the substance of the draft and final reports did not differ significantly, both groups considered the review valuable because it improved the way in which the report's message was communicated. The report concluded that risks from gasoline containing MTBE were essentially the same as risks from gasoline alone because any potential risks from MTBE were offset by its benefits (HEI 1996). Involving stakeholders in the process that was used to reach that conclusion added time and expense but, according to HEI president Daniel Greenbaum, the effort was considered worthwhile by EPA and HEI because credibility was maintained and stakeholders were satisfied with the outcome (D. Greenbaum, personal communication).

A second inquiry into the impacts of oxygenates in gasoline benefitted from the lessons learned during the first review. The first review had flagged ground water contamination by MTBE as a potential issue of concern deserving further study. The second review was able to focus on that issue, putting the potential health risks issue aside. The second review was conducted by a “blue ribbon panel” convened by EPA and comprising representatives of all stakeholders (US EPA 1996). The challenge for that panel was separating the credible science from the science influenced by stakeholder interests. Because the panel was an effective blend of stakeholders and technically competent non-stakeholders, the technical people were able to keep the stakeholders honest, thereby maintaining the credibility of the process and its outcome. The panel concluded that while current levels of MTBE in ground water pose no health risk, they recommended dramatically curtailing its use due to potentially widespread water pollution problems.[3]

Thus both reviews of oxygenates in gasoline demonstrated the effectiveness of combining scientists and stakeholders in a manner that was able to maintain the integrity of the science while addressing stakeholder concerns and assuring stakeholder “buy-in.” The scope of the second review was guided by the outcome of the first, demonstrating how an iterative approach to problem definition can help focus stakeholder efforts.

Case #5: Savannah River and CRESP. The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) began operation in 1995 in response to a conclusion by a National Academy of Sciences committee (NRC/NAS 1994):

> The Environmental Management Office of DOE [US Department of Energy] needs an independent institutional mechanism to develop data and methodology to make risk a key part of its decision making.

CRESP’s mission is to improve the scientific and technical basis of DOE’s environmental management decisions, leading to protective and cost-effective cleanup of the nation’s nuclear weapons while enhancing stakeholder understanding of nuclear weapons production facility

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[3]EPA is currently exploring whether MTBE can be regulated, and possibly banned, under

waste sites (CRESP 2000). CRESP is organized to provide both guidance to and peer review of the evolving effort to use risk-based methods and evaluations to shape cleanup decisions at DOE sites.

One of the site cleanups that has involved CRESP is underway at DOE's Savannah River Site. The Savannah River Site was constructed during the early 1950s to produce the basic materials used in the fabrication of nuclear weapons, primarily tritium and plutonium-239. Today, the site both stores and is contaminated by high-level, low-level, and liquid radioactive wastes as well as by radioactive wastes, mixed with hazardous chemical wastes. Before CRESP was involved at Savannah River, DOE, EPA, and the states had performed different risk assessments, obtaining conflicting risk estimates due primarily to differences in assumptions about exposure to contaminants through fish consumption. When CRESP became involved, its researchers concluded that the many conflicting assumptions about fish consumption could be overcome by obtaining actual data to replace the assumptions, and proceeded to work with local residents to collect the data. Another risk assessment was performed, monitored closely by stakeholders, and a new risk estimate was obtained that was higher than previous estimates. Nonetheless, risks from the approximately 3-millirem radiation exposure occurring through contaminated fish were still considerably lower than risks from background radiation levels of 200-400 millirem. The new risk estimate appears to have been credible and accepted by the stakeholders who participated because it directly addressed their concerns and because they had been involved in both research planning and in its actual performance.

5. Conclusions and Recommendations

The limited case studies considered here suggest that a key to successful use of scientific information in collaborative decision-making is Democratic Science—using a broadly based deliberative process to help shape the technical analysis. Collaborative, Democratic Science-

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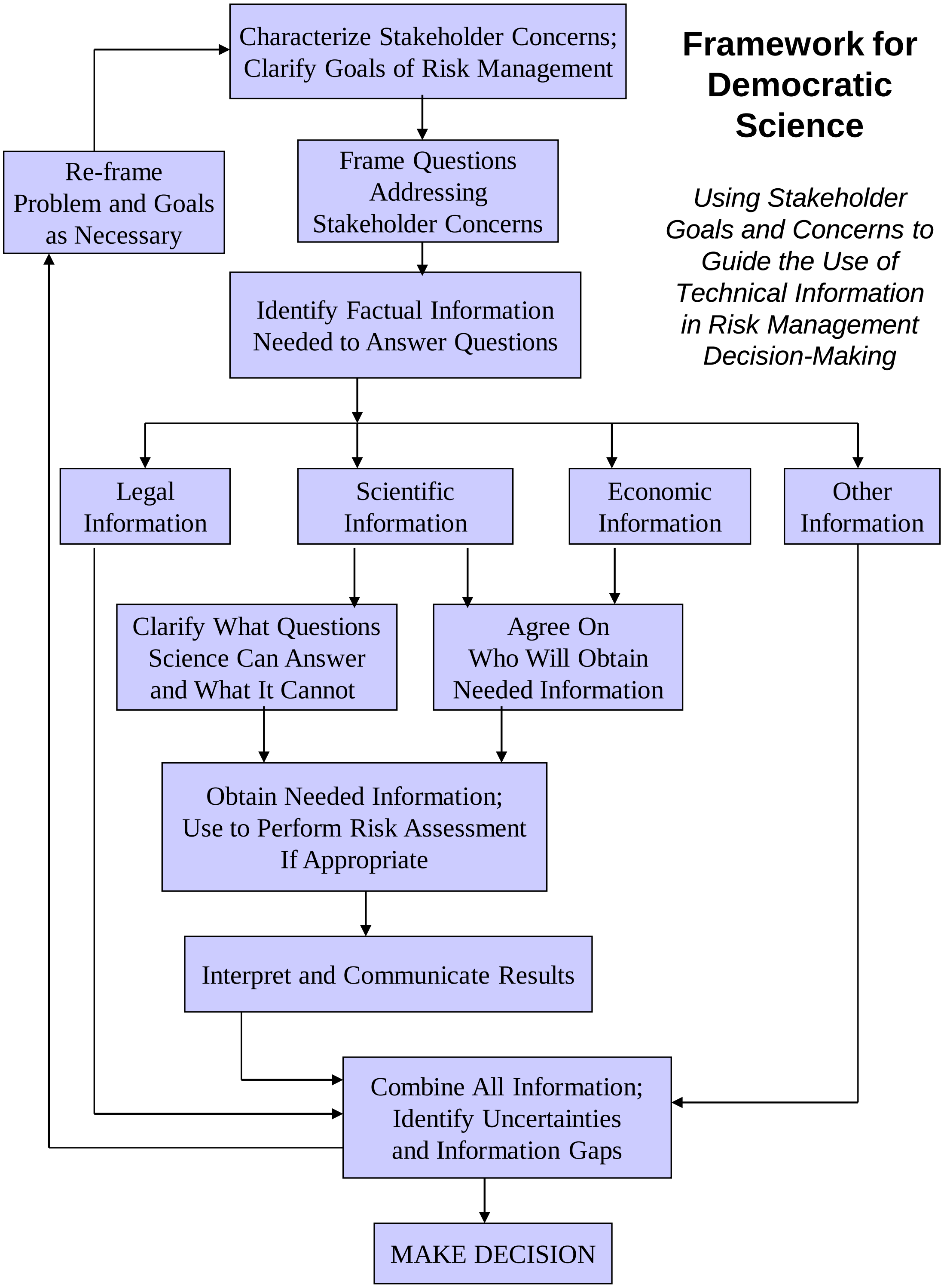
the Toxic Substances Control Act.

based decision-making can determine which analytic techniques and information are used, interpret analytic results, and use those results to guide decision-making or re-frame the risk management problem and goals, as necessary. What each of the successful case examples in Section 4 have in common is that stakeholders agreed to use one jointly overseen group of scientists and agreed on what that group of scientists would consider. In that way, stakeholders' choices were used to establish what the role of science would be in the risk management decision-making process. In each case, science played an important role, but a role that was shaped—through Democratic Science—by stakeholder values to address their concerns. Through Democratic Science, science was also able to inform an evolving understanding of the scope of the problem. The integrity of the science was maintained and its credibility assured because stakeholders were involved in deciding how science would be used to answer their questions and in obtaining the scientific information needed to answer those questions. In other words, the Democratic Science-based case studies described here demonstrate the effectiveness of implementing what the National Academy of Sciences report *Understanding Risk* called the "analytic-deliberative process" (NRC/NAS 1996) and what the Risk Commission outlined with its framework for stakeholder-based risk management decision-making (Risk Commission 1997).

5.1 Framework for Democratic Science: Combining science and values in decision-making

Page 27 depicts a Framework for Democratic Science, or a guide for using stakeholder goals and concerns to guide the use of technical information in risk management decision-making as part of an iterative analytic-deliberative process. In the first step, stakeholder concerns guide the identification of potential risks and clarify risk management goals. In the second step, the questions that must be answered to address stakeholder concerns are articulated. These two steps are critical to clearly understanding the problem *before* attempts to solve it are made. Next, the factual information needed to answer those questions is identified. Such information need not be solely scientific and might include information about economic impacts,


Framework for Democratic Science
Using Stakeholder Goals and Concerns to Guide the Use of Technical Information in Risk Management Decision-Making
Characterize Stakeholder Concerns; Clarify Goals of Risk Management
Frame Questions Addressing Stakeholder Concerns
Re-frame Problem and Goals as Necessary
Identify Factual Information Needed to Answer Questions
Legal Information
Scientific Information
Economic Information
Other Information
Clarify What Questions Science Can Answer and What It Cannot
Agree On Who Will Obtain Needed Information
Obtain Needed Information; Use to Perform Risk Assessment If Appropriate
Interpret and Communicate Results
Combine All Information; Identify Uncertainties and Information Gaps
MAKE DECISION

statutory issues, and demographics, for example. Stakeholders then identify and agree on whom should be responsible for obtaining the needed factual information. In several of the case examples described here, a model that seemed to work well involved establishing a group of scientific experts that all stakeholders agreed to; by working closely together through collaborative analysis, the scientists were able to understand the basis for the stakeholders' concerns and the stakeholders were able to understand the role that science could play and to participate in generating data. After the needed scientific information is obtained, it is combined with other information and used either to re-frame the problem and risk management goals or to guide decision-making.

A similar model to the Framework for Democratic Science that is recommended here is the model of cooperative discourse, or three-step participation model (Renn et al. 1993, Schneider et al. 1998). In the first step of that model, values and criteria for judging different risk management options are elicited from stakeholders, which in turn are used by a group of technical experts in the second step to guide the development of indicators or measures for evaluating the performance of each option as compared to the evaluative criteria. For the second step, a group Delphi process is used to reconcile conflicts about factual evidence and reach an expert consensus via direct confrontation among experts representing diverse views (Renn and Kotte 1984). In the final step, citizens deliberate to evaluate and design policy options based on knowledge of the likely consequences of each option and on their own values and preferences, with input from the first two steps. The model of cooperative discourse has been implemented in Germany to address energy policies and waste disposal issues and in the US to develop sludge-disposal strategies, with mixed results.

It is important to acknowledge that science may not always be the sole basis for a decision; in many cases, it will be one—but not the overriding—consideration. The goal is to maintain the integrity and credibility of the science and to define a useful role for scientific information in decision-making. That goal can be achieved through collaborative analysis that generates a single body of knowledge that will be accepted by all the groups in a policy debate as a valid basis for negotiations and agreements (Ozawa 1991, Busenberg, 1999). When the adversarial groups involved in a policy debate jointly oversee the research needed to resolve the underlying scientific and other technical issues, they have the means to assure themselves that other stakeholders are not manipulating the analysis. This observation is consistent with the general principal established by other studies of decision-making processes, which have found that when people have an opportunity to participate in a process, they are more likely to view its results as fair and credible (Thibault and Walker 1975).[4]

The following guidelines will help implement Democratic Science in order to maintain a useful role for science in stakeholder-based decision-making.

1. Research and analysis should respond directly to stakeholders' concerns.
2. All stakeholders should be involved at the research planning stage.
3. Stakeholders should collaborate with scientists to obtain data and other information.
4. Decision-making should be iterative, with technical information used to guide either decision-making or problem re-evaluation, as necessary.

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[4] Interestingly, the thesis that participation increases credibility is also consistent with other cases, not discussed here, where community participation in scientific investigations improved the credibility of the results within an affected community, but not necessarily within the broader scientific community. For example, during the contentious debate that characterized the investigation and litigation associated with the Woburn, Massachusetts community's belief that trichloroethylene-contaminated drinking water was the cause of their leukemia cluster, the only scientific study that was credible to the community was "The Harvard Study". That study, performed by Harvard School of Public Health scientists, began with a cooperative agreement regarding the extent and nature of community involvement in the investigation itself (Brown and Mikkelsen 1990). It is possible, however, that if the Harvard Study had not supported the community's belief regarding a causal association between exposure and outcome, that it would not have retained its credibility with the community.

5.2 Suggestions for further research

Research teams comprising both risk assessors and social scientists are needed. By operating independently, risk assessors have tended to focus on science and decision-making while social scientists have focused on the social determinants of decision-making. More rigorous study of science in stakeholder-based decision-making would be facilitated by both types of scientists working together.

1. *The role of science in stakeholder processes*. Virtually all of the research that has sought to identify the determinants of successful public participation in environmental decision-making focuses on process-oriented social goals. While some perceive that science suffers in the hands of stakeholders, it is difficult to evaluate that perception objectively using the currently available data base because of the emphasis on social goals as evaluation metrics. Little work has been devoted to evaluating the role of science. Research is needed that includes determinants of how science has been included in stakeholder-based decision-making and how its role has had an impact on process outcomes.
2. *Policy disputes resulting from differing scientific interpretations*. This report has focused on the role of science in formal, convened, stakeholder decision-making processes. Much of the genesis of the concern over that role results from situations that do not involve formal stakeholder processes. Such disputes involve general disagreements among stakeholders that arise partly due to differences in interpretations of the science that underlies particular actions and partly due to differences in how science is weighed against the many other factors that contribute to decisions about managing risks. A rigorous analysis of the social factors that contribute to differing interpretations of scientific information and how science weighs as a factor in decision-making is beyond the scope of this analysis and worthy of more focused research.
3. *Politics versus science*. Some cynics argue that most risk management decisions are

made on the basis of political expediency and that neither good science nor efforts at stakeholder collaboration have any real influence. More rigorous study is needed to determine whether and to what extent that is indeed the case.

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