FUTURESITE: An Environmental Remediation Game-Simulation

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FUTURESITE, a game simulation, was developed to stimulate and inform public participation in the highly controversial environmental cleanup decisions affecting a former nuclear weapons facility in the United States. Meaningful public participation demands an understanding of the technical, financial, and political constraints on the cleanup process. The primary purpose of the game simulation was to present information concerning the environmental contamination, health hazards, and potential future uses of the facility in a readily comprehensible format. An additional purpose of FUTURESITE was to encourage cooperation and consensus building in making actual remedial plans for the facility.

KEYWORDS: *community involvement; environment; FUTURESITE; pollution; public participation; risk communication; Superfund.*

This article reports a game-simulation that was developed to assist a citizens advisory board in making recommendations for the environmental cleanup of a former nuclear weapons production facility that had badly contaminated its surroundings. Involving the general public early in the environmental decision-making process is an important and welcome departure from the traditional "decide-announce-defend" paradigm of governmental action, and it is gaining ground. Even with the best intentions, however, it is difficult to obtain informed, useful public participation when the issues facing decision-makers are highly technical and complex. Recognizing this problem, some observers advocate a circumscribed role for the public in environmental decision-making (e.g., Breyer, 1993), but others recommend taking up the challenge to make the issues more manageable (Morans & Emrich, 1981; Straus, 1981). The game-simulation FUTURESITE addresses the need to communicate complex technical information to the general public and to achieve the cooperative working relationships among members of the public and government officials that form the basis for reaching consensus.

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Several pollution control games and simulations have been reported, but they do not focus on the cleanup problems that dominate environmental expenditures. Furthermore, these exercises are oriented to research and educational goals and are not designed to be an integral part of public involvement in actual decisions (e.g., Baba, Uchida, & Sawaragi, 1984; Exline & Larkin, 1979; Kirts, 1991; Maidment & Bronstein, 1973; Sharda, Willett, & Chiang, 1988; Susskind, 1994).[1] FUTURESITE was a practical solution to a practical problem. Although its influence on the decision-making process cannot be clearly disaggregated from other simultaneous public outreach activities, it demonstrates that a game-simulation will help citizens to deal realistically with conflicting goals and limited resources. A game-simulation also can be an effective tool for involving and empowering the public in critical health and safety decisions.

The Site and the SSAB Process

Between 1952 and 1989, the Fernald Environmental Management Project near Cincinnati produced high-purity uranium metal for the U.S. Department of Energy's Nuclear Weapons Complex and discharged an estimated 1,000,000 pounds of uranium into the environment, most of it in the form of airborne dust emissions that settled on the soil around the plant (Centers for Disease Control, 1993; U.S. Department of Energy, 1994). The uranium and other wastes generated by the production process also severely contaminated the large drinking water aquifer that flows under the plant. The contamination at Fernald is being cleaned up under the Superfund statute, which calls for remedies with very low residual (i.e., postcleanup) risk to human health and the environment.[2]

Citizens who live near Fernald have aggressively pressed for cleanup since 1984, and in recent years the site management has actively sought the input of the public in remedial decisions through a variety of outreach programs, including regular public meetings, educational programs, direct contacts with key stakeholders,[3] a liaison program, and an extensive public reading room. In 1993, the Department of Energy established a site-specific advisory board,[4] named the Fernald Citizens Task Force, to make consensus recommendations to it and its regulators—the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency—concerning the future use of the site, a location for waste disposal, residual risk levels, and remediation priorities.

To ensure a diverse task force membership, the Department of Energy hired a distinguished former federal official to act as an independent convener.

After several months of research and interviews, she recommended 16 individuals who represented the site's major stakeholders: citizen activists, labor leaders, local government officials, site neighbors, educators, health professionals, business people, and ex officio, senior site officials from the Department of Energy and its regulators. The Department of Energy accepted these recommendations, appointed the task force, and provided funding for an independent technical consultant. The authors of this article are, respectively, the chair and technical consultant of the task force.

The Technical Problem

At Fernald, large volumes of both soil and groundwater are contaminated with chemicals and radionuclides. Uranium makes up the bulk of the contamination, and, with few exceptions, removal of the uranium contamination will include all other contaminants. Unfortunately, existing technology does not provide much relief from uranium contamination because, being elemental, it cannot be broken down into less dangerous components by incineration or chemical reaction. Thus the remediation of uranium is a function of limiting exposure by rearranging it into a safer configuration.

At Fernald, the fundamental cleanup issue can therefore be simplified as the following: How much uranium-contaminated soil must be removed from the site to make it acceptably safe to persons on or near it?[5] The answer, in turn, depends on three variables.

First, the relationship of soil contamination to persons who use the surface of the land is direct: The more contact one has with the soil and the more contaminated the soil is, the greater the health risk. The difficulty lies in deciding on the acceptable risk level. Because naturally occurring uranium is ubiquitous in the environment and other risks of all kinds abound in our lives, the baseline risk to persons on or near the facility begins well above zero. Moreover, the law requires achievement of very low residual risk levels, between 1×10^{-4} and 1×10^{-6} excess individual risk of cancer death.[6] Because the background risk people face everyday from all sources is already several orders of magnitude higher than the highest risk in this range, the significance of risk levels in this range is not intuitively obvious.

Second, one cannot assign an acceptably safe level of residual contamination without asking, "Safe for what use?" The risk to a person on the surface varies considerably depending on the way the land is being used. A farmer who lives, works, and derives his food from the site would have a great deal of contact with the soil, but an occasional hiker through a wildlife preserve would have very little. Accordingly, less contamination needs to be removed from a site that will see minimal use.

Third, the greater the volume and concentration of soil contamination, the more uranium will reach and contaminate the aquifer (regardless of the use of the surface land). The contaminated aquifer threatens the health of persons who drink from it or (theoretically) who consume agricultural products irrigated with it, as well as the natural systems that depend on the aquifer's water.

In sum, to answer the fundamental question of how much uranium to remove, the public must be able to understand and work with these interrelationships of risk, land use, and hydrogeology.

The Decision-Making Problem

FUTURESITE was created to build common understandings of the conditions at Fernald among task force members with a wide range of knowledge concerning site conditions, risks, and remediation options. Large portions of the Fernald community believed that the site should be returned to its "pristine" condition before the plant was built (U.S. Department of Energy, 1994), and this view was clearly in tension with financial and technological constraints. Few members had a sufficient background to make broad recommendations or to appreciate the many interactions among different contamination problems and cleanup options. The range of residual risks used in Superfund cleanup is difficult to conceptualize, contextualize, communicate, and use; moreover, the acceptability of a risk level requires the added elements of values and perceptions.[7]

In addition, several very real constraints limit what can be done with the Fernald site. The most obvious is cost. Superfund cleanups can be enormously expensive (initial estimates for Fernald were upwards of $10 billion), and funding for Department of Energy facilities comes from an already strained federal budget. Next is acceptability. Disposition of large amounts of contaminated soil is sure to encounter substantial local opposition by residents surrounding the disposal facility. Last is damage to the environment. The excavation of large amounts of soil would destroy many trees and disrupt associated habitats. As a result, the choices before the task force required trade-offs among inconsistent goals, within narrow constraints.

The task force also faced the usual problems of group dynamics. Although members were originally selected with an eye to their willingness to work with others, the differences in background, experience, and views about the site were an obstacle to reaching consensus. Moreover, the task force was working under stringent deadlines because the legal timetable for deciding how to clean up the site was already well underway when the task force began work. By the time the task force had hired its technical consultant and developed a work plan, there was a lot of internal pressure to get down to business.

Against this backdrop, additional time spent on traditional team-building exercises seemed infeasible. A game or simulation in which members could become engaged in group decision dynamics based on the site suggested itself as a solution to both the decision-making problems just described and the need to create stronger coherence within the group. As the literature points out, simulations are ideally suited to conveying large amounts of detailed interrelated information (Greenblat & Duke, 1981; Straus, 1981). Gaming, likewise, is a proven way to display interrelationships and contextualize concepts, both of which are necessary to enable lay persons to participate effectively in cleanup decisions. Gaming is also a promising tool for illustrating tradeoffs (Inbar & Stoll, 1972; Starr, 1994; Wynn, Overall, Smith, Taylor, & Totterdill, 1982) and it provides a means of bringing together technical facts with values and perceptions (Klabbers, 1989; Klabbers, Swart, VanUlden, & Vellinga, 1995; Mautner-Markhof, 1995). Finally, the process of gaming is a good way to build teamwork among persons who must learn to cooperate in making "real-world" decisions (see Greenblat & Duke, 1981; Maidment & Bronstein, 1973, who emphasize the learning of facts as well as process). It provides a forum for cooperative work among technical experts, decision makers, and lay stakeholders (Klabbers et al., 1995). With these considerations in mind, FUTURESITE was developed for the use of the task force by the authors and two colleagues, Nolan Curtis and Sarah Snyder. It was our hope that a game-simulation would enhance communication among the groups at Fernald so that, as Klabbers (1989) puts it, they could eventually "converge on solutions through shared knowledge and a will to understand and act" (p. 4).

The Game-Simulation

Objective

As a game, the objective of FUTURESITE is to decide on a desirable future use or uses of the Fernald site while keeping the overall need for excavation and disposal of uranium contamination and their associated costs within environmentally, fiscally, and politically manageable limits.

Components and Setup

The "game board" is a map of the Fernald facility divided into a grid representing 1,000 by 1,000 foot squares. This size was selected to provide a reasonable number of segments for the game-simulation while allowing a fine enough grid to isolate waste areas and develop detailed future use scenarios. For each square, the volume of material (primarily soil) to be removed to achieve altern- ative future uses was calculated from sampling and hydrogeologic models and is represented by colored poker chips. Next to the board are bins representing disposal options for the chips. These are limited to either on-site disposal or off-site disposal. All chips removed must be placed into one of these disposal options; they cannot be transferred to other squares on the board.

The poker chips used to represent volumes of soil contaminated with uranium are colored to indicate the various concentrations of uranium. In keeping with the purpose of the game to enable a lay public to make practical decisions, the chips are not coded by uranium concentrations per se; rather, concentrations are translated into the land uses that they would permit at specific risk levels. For example, at 300 parts per million of uranium, only restricted access (an occasional trespasser) is permissible if the acceptable risk level is 1×10^{-6} excess cancer risk to an individual. However, if the acceptable risk is 1×10^{-5}, the same concentration allows for the exposures associated with commercial or industrial use, and if a 1×10^{-4} risk is deemed acceptable, virtually unlimited use (residential or agricultural) is permitted. To account for the variance in risk levels, different versions of the exercise were designed for the 10^{-6}, 10^{-5}, and 10^{-4} residual risk levels.

The chips are stacked on the appropriate grid square in ascending order of degree of contamination and restrictive land uses. These uses are color-coded within a given risk level as follows:

Restricted access	Red
Undeveloped green space	Yellow
Developed park	Green
Commercial/industrial	Blue
Residential/agricultural	White

The order of the colors is the same for each risk-level version, though the total number of chips decreases as the acceptable risk level rises because less soil must be removed. Indeed, simply comparing game boards that were set up for the various risk levels dramatically illustrated the different consequences of choosing different risk levels.

Removal of all chips in a stack returns the square to background levels of uranium in the soil. In addition, separate black chips represent extremely dangerous production wastes that must be removed under any circumstances and must be accounted for within the context of the exercise. An "aquifer card" is inserted into each stack to indicate the amount that must be removed to protect the aquifer from the leaching of uranium through the soil.

The configuration of chips was based on many assumptions, given the uncertainty that attends all environmental data. Subject to that qualification, the FUTURESITE data were objective. The assumptions and calculations were fully explained to participants, and they were free to express their own values and perceptions of acceptable risk in their choices of cleanup levels.

Running the Simulation

The simulation was run on numerous occasions by the task force and by other groups. In each case, teams of four to six persons worked together to develop a single scenario. Players worked cooperatively in their teams and were encouraged to keep an open mind in looking at the exercise. Deliberate role-playing was discouraged. This choice contrasts with other environmental games—for example, the DEAD RIVER water pollution game, which was based on role-playing and stressed winning by exerting influence on the final decision (Exline & Larkin, 1979)[8]—because we were concerned that role-playing might lead to a hardening of positions that would impede consensus in the actual decisions before us (see Dukes, 1990; Gamson, 1972).[9]

The use of teams permitted us to assemble different combinations of people and perspectives, working with different risk-level versions of the simulation in various iterations of the game. The differing outcomes provided the basis for options in later decision-making. For example, for the first session the task force members were purposely placed into roughly homogeneous groups so that quite different solutions would emerge, giving everyone a chance to see the different possibilities.[10] Likewise, the simulation was run with other homogeneous teams—Department of Energy managers, the general public at Fernald, persons familiar only with other weapons facilities—to obtain a spectrum of results. At later sessions, intentionally diverse teams were organized to encourage the development of consensus results.

To achieve a future land use on a given square, teams removed all chips representing contamination at concentrations above that required for the selected use. For example, to achieve commercial or industrial use for a given square, all chips above the blue on that square had to be removed. Teams could make a square "cleaner" than its desired future use to create a margin of safety. Teams were encouraged to consider a variety of land uses within the site because this permitted greater flexibility.

When a chip is removed, it must be placed in either the on-site or off-site disposal bin. A cost and impact are associated with each option. Material placed in off-site disposal is assumed to go to a long-term disposal facility in an arid part of the western United States, thus incurring substantial transportation and disposal costs as well as unquantified risk and disruption from a certain number of trains or trucks traveling though the area to remove it. Due to their high degree of hazard, the high-level production wastes (black chips) were automatically placed in the off-site category. The total permissible volume of off-site disposal was limited to 1,000,000 cubic yards to account for off-site capacity limitations and the realities of interstate politics.

Contaminated material placed in the on-site bin must be disposed of in an engineered facility to isolate it from the ambient environment. It was assumed that each 13,000 cubic yards of contaminated material requires one acre of land on the site itself for a disposal facility, and space on the site must be reserved for the placement of disposal facilities at the completion of the exercise. Because operation of a disposal facility is considered an industrial activity, the area selected for the on-site disposal cell must first be cleaned at least to that use level (i.e., down to the blue chips).

Teams were told to consider, in addition to the above requirements, issues such as risk perception, transportation risks, geography, natural resources (there are several wetlands on the property), infrastructure, community needs, and surrounding uses in configuring the site. These were not quantified, but the task force had previously been provided with detailed information on these topics.

Although the simulation concentrates on the questions arising from surface use, all three determinants (surface soil risk, future land use, and aquifer protection) must be considered. So, for example, if the players decided that groundwater protection was the first priority,[11] then they began by removing all chips above the aquifer card. Of course, those chips had to be treated or disposed of just like chips removed on account of surface use. On the other hand, players could ignore or modify groundwater protection (i.e., assuming abandonment of the aquifer as a drinking water supply) to explore other possible future scenarios.

Simulations involve simplification and assumptions (Greenblat & Duke, 1981; Raser, 1978), and the simplification and subdivision of a problem into more comprehensible units are essential to productive discussions (Klabbers, 1989; Mautner-Markhof, 1995; Straus, 1981). The budget constraints and off-site disposal limitation assumptions unquestionably reflected our best estimate of the likely situations at Fernald (Maidment & Bronstein, 1973). In all cases, participants were accordingly fully informed of the simplifications and assumptions and permitted to disagree with them.

Completing the Exercise

After the teams removed all chips necessary to achieve their cleanup and future use goals, they calculated the total volume of materials removed, the dollar cost, the transportation impact (numbers of trucks and trains), and the space needed (if any) for on-site disposal by adding the appropriate values from all chips in each disposal option. Tally sheets enabled players to make these calculations. The resulting plan of the site was drawn on a transparency for the final stage of the exercise, a debriefing[12] in which the different teams described their solutions, the costs and impacts, and their reasoning. This became the basis for a discussion of values, goals, and trade-offs that led to consensus on the actual decision.

Results and Conclusion

FUTURESITE should be considered a game-simulation (Brewer, 1978; Dukes, 1990; Raser, 1969). It is a simulation in that it realistically abstracts the key contamination and cleanup processes and allows players to manipulate them, and it is a game in the sense that there are objectives and constraints on players' choices. It does not impose a single-outcome structure characteristic of formal games (Jones, 1985). It was designed to simulate the reality of complex, multifaceted decision-making but not to make the actual decisions.

Curiously, participants had, in hindsight, differing views of the homogeneity of results.[13] One felt, "You get different results with different members. When you played with a member of the community or DOE [Department of Energy], it was always amazing how different of results you got." Others thought that the "general direction in every case was the same" or that "there were subtle differences . . . but the outcome was generally the same." Our observation was that the public tended to adopt configurations that emphasized the creation of a relatively uncontaminated buffer around the site, but those more familiar with it tended to tackle the highest levels of contamination, resulting in a more even distribution of contamination across the facility. This observation helped the public to understand better the perspectives different groups bring to the decision. In particular, site engineers and managers approached the site from the perspective of reducing the largest risks, which tend to be in the center of the site, and ignoring the lesser risks, which tend to be at the site borders. On the other hand, citizens were first concerned with the risks that were physically closer to them, preferring to start from the outside and move all waste to the center of the site.

FUTURESITE proved to be highly successful in achieving the purposes envisioned for it. Our overall objective was to develop a menu of future use scenarios—some representing particular viewpoints and some a compromise—and an inventory of values and goals that would form the basis for further discussion of the actual problems at the site. We also sought to facilitate the interpersonal cooperation on which the later real-world consensus decisions could be based. The use of several variations over the course of several months resulted in precisely this variety of options and rationales.

FUTURESITE also served several other functions. The first was educational: The exercise provided a tool for understanding and discussing the difficult interactions of diverse risks, future uses, levels of soil contamination, and surface and groundwater exposures. This information had previously been presented in tables and maps, and in this respect FUTURESITE was a kind of capstone to and synthesis of the task force's education about the site. A public decision-making process of this kind must both simplify information to manageable proportions, as was done in the earlier presentations, and enable the public to manage the complexity, which is a function that models often serve (Klabbers, 1989; Straus, 1981). At least as important, however, is that FUTURESITE demanded engagement with the information in a way that traditionally presented, passively received material could not (see Klabbers et al., 1995, for a description of the "interaction/participation model" of developing policy options that games and simulations can assist). In this way, game simulations like FUTURESITE respond directly to the recent call by the National Academy of Sciences for integrated scientific and technical information that facilitates public involvement in environmental decision-making.

Several of the participants in the FUTURESITE exercise were interviewed after the task force issued its recommendations and this educational aspect was most frequently recalled. For example, "It helped people get a handle on what we were talking about. . . . It helped with understanding risk and terms like *ten to the minus [six]* and *ten to the minus four*." Although this was particularly useful, as one member put it, "for people who don't grasp every issue," it also helped far more experienced and informed persons: "It helped me on all of those [i.e., soil and groundwater contamination, alternative remedies, differences among risk levels]. . . . It helped me think out things." FUTURESITE was also seen as enabling discussion, both as an icebreaker and in providing confidence to speak up: "It was a real good tool for people . . . so that they can talk about [risk] levels." Even a member with a strong technical background, who characterized the simulation as oversimplified, agreed that it "provided a vehicle for participation for task force people reluctant to do so. . . . However, enough discussion was generated that it helped the process—I'm glad it was done."

Second, the process of playing the game and the basic information it revealed about the issues (e.g., how many truckloads of contaminated dirt would have to roll through the area to return the site to background levels of uranium) were instrumental in reaching consensus on the actual recommendations. On some issues, the facts led to an obvious conclusion. On others, the process of working together in teams and sharing views with other teams increased confidence in members' own views and trust in other members' sincerity and good intentions.

Participants noted the importance that trade-offs and constraints assumed for them and, in particular, the need to abandon the lowest risk levels as unrealistic. "For the first time it helped people to understand the volume [of contaminants] and what could be shipped [off-site]." A long-time activist said, "Initially for me 12 years ago, I wanted everything off the site—it was really, really helpful [in evaluating off-site disposal]. . . . It's always interesting to see the light dawn on others." An experienced regulator said, "It crystallized what it took to remediate some of these things, to understand the trade-offs and balances." Another noted that FUTURESITE demonstrated that "the site was going to look like a moonscape if [contamination] went to background." Several participants, both experienced and new to the site, agreed that the simulation helped them to make up their own minds.

Third, the exercise brought the task force to some of its substantive conclusions. As noted, a key difference between FUTURESITE and other game-simulations was its role in facilitating real-world decision making. It was one part of a 2-year process of education, discussion, deliberation, and decision that was carefully designed to develop the necessary information and cooperation that would lead to a set of consensus recommendations. As a simulation, it addressed real and difficult issues, but it was also "safe" because there was no expectation that the results of any particular session would be conclusive.

Surprisingly, however, the task force did not rely much on FUTURESITE to identify future uses, even though that was the ultimate objective of the game. In the meetings following the exercise, discussion turned to the more abstract risk levels that the exercise had illustrated. In other words, FUTURESITE helped this lay group of citizens to become sufficiently comfortable with the risk issues and trade-offs so that they were prepared to confront them directly, without first focusing on specific future uses. The exercise also allowed the task force to settle on risk levels higher than they otherwise were likely to because the higher levels were demonstrably better suited to the available technologies and financial resources. A background level was ruled out by cost and waste volume quite early on. More dramatically, the 10^{-6} risk level, which is within the legal Superfund range, was abandoned for similar reasons. This marked a real departure from previous views and can only be characterized as a major shift in thinking.

The awareness of consequences and constraints, together with greater comfort in discussing the issues, made it easier to achieve consensus results. As one member put it, "There's not enough money in the government to clean this place up [to a pristine level]. FUTURESITE made it that much clearer, whereas I might have been stricter before." But, as another participant noted, "There was a great deal more going on than just the game." In hindsight, therefore, after consensus had been reached, those who participated in the exercise were inclined to credit it with assisting in the educational and consensus-building functions that we have emphasized.

One must be cautious, of course, in reaching global conclusions from this exercise. FUTURESITE should not be credited with revealing the precise approach ultimately taken by the task force, nor is it alone responsible for creating the relationships of openness and trust that enabled the group to reach consensus. Nevertheless, in its final recommendations, the task force identified a future use plan for the entire site, risk levels and concentrations for uranium cleanup, and on-site and off-site disposal volumes, all of which had their origins in the results of the FUTURESITE exercise. Moreover, FUTURESITE demonstrated great value in facilitating a process that brought some degree of consensus to a sharply divided community.

In an era when political discourse often degenerates into soundbites on nonissues, and voters are regularly encouraged to believe that patently contradictory goals can be simultaneously and fully achieved if only they elect the right person, simulations may be one of the best ways to get people to confront reality. There is irony in this conclusion, but the utility of FUTURESITE received some confirmation when the recommendations of the task force were adopted in their entirety by the Department of Energy and its regulators. Actual cleanup is proceeding apace.

Notes

1. An exception is the climate policy exercise developed by Klabbers et al. (1995), though its published description suggests less of a game or simulation than a carefully organized consensus process.

2. 42 U.S.C. § 9621. The formal name of the statute is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Fernald was listed on the Superfund National Priorities List in 1989, and a consent agreement between the Department of Energy and the U.S. Environmental Protection Agency established the schedule for cleanup.

3. The term *stakeholder* is widely used to describe a broad range of individuals and groups having an interest in the outcome of an environmental cleanup. In this context, the focus is on individuals living in communities surrounding the contaminated facility.

4. An interagency committee led by U.S. EPA, the Federal Facilities Environmental Restoration Dialogue Committee (1993), had recommended the formation of such groups

primarily to deal with expected funding shortfalls. The July 1995 report of the Fernald Citizens Task Force provides a detailed description of its origins, operations, and conclusions of the site-specific advisory board at Fernald (Fernald Citizens Task Force, 1995).

5. This made the inevitable simplification of the technical issues for the purposes of a simulation truer to reality than might otherwise be the case. The WQM water pollution game, for example, limited its scope to one of several equally important water pollutants (Sharda et al., 1988).

6. 40 C.F.R. § 300.430(e). Although cancer is by no means the only risk at a site such as Fernald, U.S. environmental laws focus on cancer risk as the most sensitive indicator of danger to human health.

7. A large body of literature has grown around the problems of providing comparisons and context without unduly prejudicing the issues (see, e.g., Kahneman & Tversky, 1982).

8. Having an apparent "winner" may have discouraged cooperation in the COMMONS game (Kirts, 1991).

9. It has been noted in other consensus-based processes that it is valuable to avoid solidifying opposing views (see Clark & Emrich, 1980). DEAD RIVER, by contrast, was not an adjunct to an actual decision process.

10. Klabbers's (1995) climate policy exercise also sought to develop options rather than a single solution.

11. EPA's use of the Safe Drinking Water Act as an "applicable or relevant and appropriate requirement" under CERCLA may well legally require this. 42 U.S.C. § 9621(d); 40 C.F.R. § 300.400(g).

12. The COMMONS game also used transparencies this way (Kirts, 1991). See generally Lederman (1992). The value of debriefing is exemplified by Susskind's (1994) Hawaii development simulation.

13. Several task force members were interviewed by a graduate student at the University of Cincinnati in February and March 1996 as part of a different research project nearly 2 years after FUTURESITE was used. Given the original purpose of the exercise, no contemporaneous interviews or surveys were conducted. The interviewer's transcripts of the interviews were made available to us. Other interviews are reported in a more contemporaneous newspaper article (Kaufman, 1994).

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