Kasperson, R. E., P. Derr, and R. W. Kates, 1983. "Confronting Equity in Radioactive Waste Management: Modest Proposals for a Socially Just and Acceptable Program", Roger E. Kasperson, ed., Equity Issues in Radioactive Waste Management, Cambridge, MA: Oelgeschlager, Gunn and Hain, pp. 331-368.

Chapter 15

Confronting Equity in Radioactive Waste Management: Modest Proposals for a Socially Just and Acceptable Program

*Roger E. Kasperson, Patrick Derr, and Robert W. Kates**

The United States has entered the 1980s with one of its major potential energy sources—nuclear power—immobilized by myriad institutional, economic, and social obstacles. Preeminent among these obstacles is the waste management problem, a concern which heads the list of public worries about the use of nuclear power to generate electricity.

Recognition that our lack of an effective and acceptable waste management program can be traced to past neglect of difficult social and institutional—rather than purely technical—problems has come very late. But it has come, and in its 1979 report to the President, the U.S. Inter-Agency Review Group on Nuclear Waste Management (1979, 87) forcefully pointed out that the resolution of these social and institutional issues was likely to be much more difficult than overcoming the remaining technical problems.

Unfortunately, federal radioactive waste management continues its preoccupation with technical problems and technical solutions. The Department of Energy has yet to initiate a broad-based research program on social and institutional problems, and gave scant attention to

*Clark University

them in its final environmental impact statement on commercial wastes (U.S. Department of Energy: 1981a), its *Statement of Position* (1980) on the nuclear waste confidence rulemaking procedure, and the latest draft of its *National Plan* (1981b). While the National Research Council's Committee on Radioactive Waste Management (1980) and others have lamented the past neglect, the social and institutional obstacles continue to make it difficult for the DOE even to gain access to the various states where it must seek prospective waste management sites.

This chapter will suggest one way in which these difficult social and institutional problems might be fruitfully addressed: namely, by way of an explicit consideration of the equity issues raised by nuclear waste management. In particular, this chapter will show how one might approach the waste management problem with the goal of defining an equitable and socially acceptable waste management system. Whether the resulting system will resemble the system dictated by a purely technical analysis remains to be seen. Because it gives explicit consideration to equity, the analysis that follows here will consider two different kinds of information:

1. a statement of the distribution of benefits and harms to some specified population which would result from a given decision or policy. This requires an empirical analysis that includes (a) a specification of those "things"–whether social goods, opportunities, harms, or experiences–whose distribution is being investigated; (b) an explicit delineation of the population and relevant subpopulations–possibly including past or future populations–to be considered in the analysis; and (c) a statement of the actual impact distributions–as defined by (a) and (b)–which would result from alternate proposed solutions to the radioactive waste problem.
2. a set of standards or principles by which the equity or "fairness" of particular distributions may be judged and by which the social preferability of one distribution over another may be judged.

The standards or principles included in (2) are, of course, principles of equity. We begin by surveying several such possible principles. Three are selected for actual application to the locus, legacy, and labor/laity aspects of the radioactive waste management problem, and it is this application–the actual equity analysis–which the rest of the chapter addresses.

It must be noted that, although we find the three selected principles to be plausible (and endorsed by substantial public opinion), the analytic approach we suggest does not depend on the inherent justice or social acceptability of precisely these three principles. What is to be demonstrated is how moral analysis using a set of equity principles can be apthis principle to nuclear waste from its application to the entire nuclear technology. For example, both the Nevada test grounds and the Hanford reservation in Washington are currently candidate sites for a high-level waste repository. It can be argued that these areas have already borne more than their fair share of the nuclear burden from weapons testing and military uses and that other peoples and places should absorb future additional risk.

Proportionality of benefits to need and burdens to ability. A very different equality principle is involved here. It is predicated on inequalities in existing distributions, and it allocates burdens and benefits to achieve more equal end states. The notion that burdens should be distributed in proportion to ability to bear them has been a central tenet in Marxist thought ("from each according to his abilities, to each according to his need") and also underlies, for example, progressive tax structures. Applying this principle, Hanford might logically become a preferred site for a high-level waste repository because its accumulated knowledge and experience would equip it to absorb nuclear risks better than communities lacking such experience. Similarly, experienced workers would more easily absorb risks than publics unfamiliar with radiation hazards.

Such a principle, it is apparent, threatens to concentrate risk, thereby enlarging the discrepancy between the enjoyment of benefits and the experience of burden. As with the equalization of burden principle, it may also lead to enlarging rather than reducing risk burdens. This concern has arisen in the controversy over the genetic screening of workers: the screening out of workers who are particularly vulnerable to certain hazards, it is argued, will encourage the perpetuation of higher exposure levels, will deny employment opportunities to some groups, and will encourage neglect of risk-reduction strategies.

In regard to the legacy issue, it could be argued that the future is more likely to be able to bear burdens than the present. With time, for example, it seems likely that more developed technology, increased scientific knowledge, and even greater societal wealth will be available. There may even be a cure for cancer, or at least an enhanced medical capability. Such a linear view of progress, however, particularly for distant future generations, would appear to be an imprudent assumption for this generation. It is entirely possible that continued population growth, rapid exhaustion of natural resources, or cataclysmic events could result in a diminished future capacity to absorb burdens.

The National Council of Churches' recent publication *Energy and Ethics* argues that because energy is as essential for survival as food, housing, or clean air, "the needs of those who are below the minimum standard take preference over the wants of those above the average"

(1979, 17). This is clearly an application of the principle of proportioning benefits to needs.

Stewardship

The roots of the stewardship principle are ancient. In both Jewish and Christian thought, the principle derives from the frequently cited passages from Genesis: "God blessed them, saying to them, 'Be fruitful, multiply, fill the earth and conquer it. Be masters of the fish of the sea, the birds of heaven and all living animals on the earth'" (1:28) and "Yahweh God took the man and settled him in the garden of Eden to cultivate and take care of it" (2:15).

The principle has other sources in post-Platonic philosophy (Passmore: 1974, 28) and need not be grounded in any religious belief. The belief that human beings are responsible to those who will come after them might be defended by an appeal to the biological connection among generations or to the human community's attempt to preserve and develop what it loves (Passmore: 1974, 185).

Whatever the source of the principle, balancing the claims of the present generation against the stewardly obligation to future generations is a very difficult ethical problem. Precisely what directives does the principle entail? In one view, it suggests an obligation to provide our descendants with a nature made more fruitful by this generation's efforts. In a different view, it suggests an obligation to refrain from any irreversible destruction of such natural goods as scenic beauty, abundant species, and so forth – this is Green's suggested minimal requirement (Green: 1977, 262). Thus it has been invoked by both pro- and antinuclear forces, the former wishing to leave a legacy of improved technology, the latter a legacy of unimpaired nature.

If the principle's implications for nuclear waste management are not clear across generations, they are simply invisible within generations. Accordingly, it is not likely to provide a standard for evaluating the institutional and technical options in waste management.

Merit (Moral Desert)

A wide variety of equity principles mandates the distribution of benefits in proportion to civic merit. Whether the relevant merit is defined as virtue, race, or perceived market value, the principle provides little guidance in the present context: the merit of future generations cannot be determined in advance. Within the current generation, a tacit acceptance of this principle may underlie the traditional practice of placing noxious facilities in poorer, rural communities; since they have failed to attract more desired enterprises, they have less merit.

Contractual Principles

One accepted and established procedure for allocating burdens and benefits is entrance into a binding contract. The process requires that agreement be voluntary, that relevant information not be withheld, that all parties abide by the agreed terms, and that the contract be enforceable (usually by law).

As noted in Chapter 4, the contractual process was used to establish the Western New York Nuclear Services Center. Explicit parties to the process included the Atomic Energy Commission, the state of New York, and the W. R. Grace Company. While the host region was not a formal signatory, it was clearly a willing participant in the process. To defend the agreement on the basis of the contractual principle of equity, one need only point out that the various parties entered into the contract under conditions which fulfill the requirements for valid contractual agreements. That contracts should be honored is taken for granted on this approach; it is difficult to imagine any society that could survive if members assumed no duty to honor agreements and commitments.

The contractual principle of equity, however, has obvious limitations. Contracts between the DOE and several states with respect to the search for high-level waste repository sites have not deterred subsequent charges of unfairness. It is inherently difficult to meet the requirement for adequate information when dealing with first-of-a-kind facilities. And, of course, it is simply not possible to contract with future generations.

Freedom of Choice

The principle of free choice is closely related to the contractual principle just discussed, but it is more general in application and less often explicitly formulated. The principle underlies the institution and processes of Western democracies, and assumes some sorts of equality—particularly equality of opportunity and of basic legal and political rights.

In contexts involving the imposition of risks or other burdens, the principle has been codified in practices of informed consent. Generally, the requirement of informed consent involves two distinct considerations: (1) the provision of sufficient information and understanding to enable the prospective consentee to comprehend the alternative choices and the consequences likely to be associated with each, and (2) the voluntary assumption of the specified risks and burdens without the influence of coercion or duress.

In practice, these conditions are difficult to fulfill. Recent research on medical consent forms, for example, indicates that relatively few individuals who provided their written consent actually had adequate understanding at the time of choice (Brody: 1980). In Chapter 14, Baruch Fischhoff indicates a variety of reasons why individuals have difficulty judging probabilities and ranges of consequences, especially low-probability/high-consequence events, even for hazards much simpler to comprehend than those presented by nuclear power or radioactive wastes. Seley and Wolpert note in Chapter 3 that individuals in communities hosting large industrial facilities tend to exaggerate benefits while underestimating the adverse socioeconomic impacts, a view also substantiated in the West Valley case study (Chapter 4). Given the long time spans involved, the intensity of the nuclear controversy, and the residual uncertainties in isolating radioactive wastes from the biosphere, achieving adequate information for meaningful consent by those who will experience the risks is a challenging task at best.

But voluntarism in choice, with the absence of coercion or duress, is also difficult to achieve. People desperate for work are not in a position to refuse jobs, and communities with inadequate or declining tax bases and high unemployment rates may find it difficult to refuse a waste repository, whatever the present or future uncertainties about public health risks. Fischhoff (Chapter 14) shows that institutional factors can also erode genuine consent. Compensation without equality may constitute bribery, and the particular environmental conditions in the consent situation may produce subtle forms of coercion.

Rawlsian Procedures

In his influential book *A Theory of Justice,* John Rawls argues that procedures for developing equitable allocations stem from the first of his two principles of justice, "each person is to have an equal right to the most extensive basic liberty compatible with similar liberties for others" (Rawls: 1971, 60).

To assure just allocational procedures, Rawls proposes a "veil of ignorance." Because of this veil, the deliberating parties are assumed to be ignorant of a variety of facts concerning their particular status. No one knows, for example, his place in society, class position, social status, or natural abilities. Further, the deliberating individual does not even know the particular circumstances of his own society or even to which generation he belongs. The veil of ignorance, in short, obliges an evaluation based solely on general considerations.

As an analtyic procedure, Rawlsian principles would appear to have potential application to radioactive waste management issues. A thoughtful application of such principles to the future generations problem has recently been undertaken by Barbour (forthcoming), who argues for the sustainability of future resources and burden/benefit concordance as ethical principles.

THE SELECTED PRINCIPLES

Our purpose in this chapter is to demonstrate how an explicit consideration of equity changes the manner in which alternative radioactive waste management proposals are analyzed and evaluated. We do not propose to identify here an absolute set of ethical imperatives, but rather to select some plausible candidate principles for use in the following analysis. Accordingly, our selection of appropriate principles is partly pragmatic. We note, first, that both distributional (or "end-state") and procedural principles of equity are widely perceived as relevant to "fairness," or equity. Second, we note that there is substantial consensus for certain principles in a variety of policy statements by a range of groups interested in the radioactive waste management problem. We suggest the following three principles as plausible and as likely to find support across diverse interests and positions.

Principle 1: *The beneficiaries of an activity should bear associated burdens proportional to the benefits enjoyed, and, conversely, the imposition of a harm or burden should be accompanied by a proportional benefit.*

Principle 2: *The experience of risk should be shared rather than concentrated within the population of beneficiaries.*

Principle 3: *The imposition of a harm or burden should be made as voluntary as reasonably achievable through observation of practices of informed consent.*

The first principle, benefit/burden concordance, is frequently recognized in discussions of equity. In fact, the first stipulation – that beneficiaries should bear the burden – is sometimes assumed to be *the* distributional test of equity. It is widely recognized in American legal precedents, as Harold Green demonstrates in Chapter 8. The principle is recommended in the discussions of such diverse parties as the DOE, ex-President Carter, the National Council of Churches, and the Sierra Club. The second stipulation of the principle – that benefits should accompany the imposition of harm – mandates that harm may not justly be imposed without a concomitant effort to restore the previous (equitable) balance.

The second principle – that actual risks should be shared broadly among the beneficiaries – imposes a particular constraint on principle 1. It, too, is a distributional ethic. Bearing the burden of waste isolation om the biosphere and even compensation of risk-bearers may not essarily involve the individual assumption of bodily or social risk. sks will of necessity be imposed on certain populations for the larger od (it is impossible to make risks and benefits wholly congruent). Prin- e 1 requires only that the burden for harms created, not the harm if, be borne by the beneficiary. Principle 2 takes account of the facts that future harms can be anticipated with only considerable uncer- inty, particularly in accidents or for the long time periods involved, (2) at there is substantial and possibly noncompensable public fear over e risks involved, and (3) that institutions may not suffice, especially for tant generations, places, and workers, to ensure full compensation harm even if it were provided by those that benefit.

inciple 3 recognizes procedural requirements for the permissible ans of imposing harms. The wording is "as voluntary as reasonably ievable" because purely voluntary means are not possible in locating ious facilities or in allocating feared risks if larger social goods are to obtained. Thus, full consent will not be realizable. But if consent is to overridden for a larger societal good, reasonable means should have en exhausted for informing the risk-bearers, for their full participa- n in public proceedings, and for obtaining the maximum degree of ievable consent. Such a social imperative will certainly exceed cur- nt program practices and existing institutional mechanisms, but does in our view, present insuperable difficulties.

e now turn to the application of these principles to waste manage- nt, considering in turn the locus, legacy, and labor–laity problems. r each we describe the issues of burden and benefit distribution and n suggest management options for addressing each of these prin- es.

THE LOCUS PROBLEM

Undoubtedly the most visible and volatile equity problem cur- ntly is the geographical separation of beneficiaries and those who will ar burdens within this generation. This we have termed the "locus" or ckyards" problem throughout this volume. The sources of inequity several, but the effects are unmistakable. Nearly every state in the on has adopted or considered legislation restricting the transport of ioactive materials and/or the search for a high-level waste repository e. By 1982, for example, over half the states had adopted bans or ratoria on the siting of such a repository. An equal number of states d restrictions on radioactive waste transport through their territories. 1979, for both technical and political reasons, the three remaining commercial low-level waste sites threatened to suspend receiving wastes, prompting Congress to enact the Low Level Radioactive Waste Policy Act of 1980, which assigned responsibility to the states for the disposal of such wastes. Federal–state conflicts have spilled over into Congress, where a diverse array of bills on radioactive waste management deal with the sources of underlying conflict.

Distributional patterns differ with type of waste. Current high-level waste inventories, for example, are dominated by the defense wastes generated over the past thirty-five years as a by-product of the production of plutonium for atomic weapons. Much of this accumulation of waste is now two or three decades old, with reduced levels of radioactivity, and new defense wastes are being generated at much lower rates (although the Reagan administration has proposed a major increase in the production of nuclear weapons). The arguable benefit of this thirty-five-year history is the national security provided to the populace as a whole, although some minor site-specific benefits of employment and local business at government installations are also entailed. But defense waste results from national decisions taken in the national interest; the nation as a whole, in short, must be considered the beneficiary. Current policy recognizes this in designating public funds as the appropriate means for dealing with defense wastes.

Much the same can be said for the radioactive wastes from medical and research facilities. This waste, nearly all of which is low-level, constitutes an insignificant amount of the total waste burden. Nevertheless, the lack of low-level waste storage capacity is a pressing problem because the radio-pharmaceutical firms that supply these nuclear materials and the hospitals and research laboratories that generate the waste lack storage space. Current plans to deregulate biomedical wastes will ameliorate this problem somewhat (Marshall: 1980). The importance of the benefits was highlighted by the 1979 suspension of waste acceptance at low-level waste burial sites, an act which nearly forced medical treatment and research to be discontinued at widely separated facilities. That this waste is viewed differently from waste from electricity generation is suggested by the exclusion of medical waste from the restrictions (recently pre-empted) enacted on out-of-state waste at Hanford by the state of Washington. As with defense waste, the beneficiary pattern is very widespread but concentrated in major urban centers, a fact that creates some disparity of interest on a local, state, or regional scale.

In comparison with the benefits of defense and medical/research activities, the benefits of commercial power reactors are more regionally concentrated. The seventy-two reactors currently licensed and the fifty or so others likely to be completed are strongly concentrated in the Northeast, Midwest, and Far West (Figure 15.1). Chicago, for example,

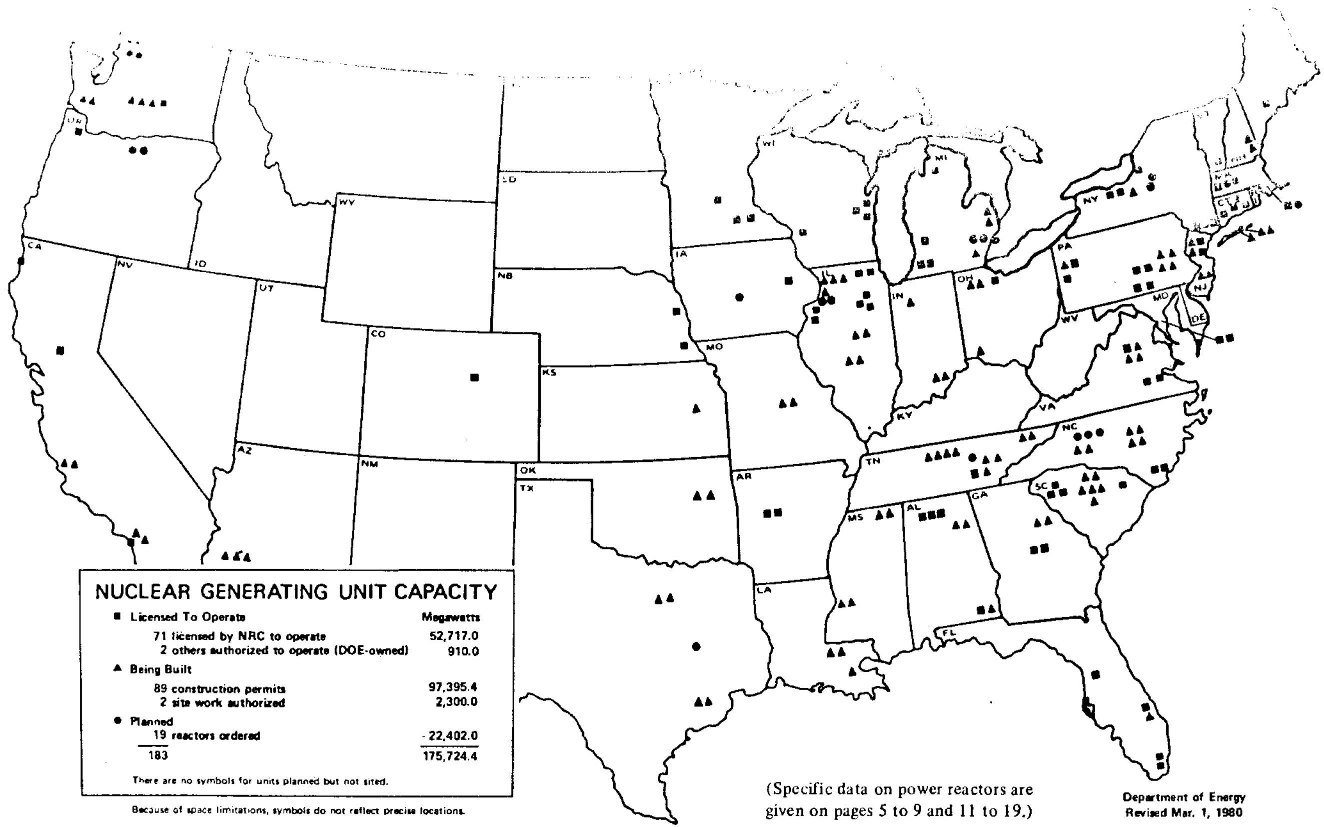


Figure 15.1. Nuclear power reactors in the United States.

currently draws 50 percent of the electricity from nuclear facilities. Comparable figures are: New England, 30 percent; New York and New Jersey, 20 percent; Michigan, 20 percent (Gilinsky: 1981). Whatever the concentration, an initial question must be whether the benefits are real or only imagined. Benefits exist only if nuclear power is actually a more efficient and reliable source of electricity than other production alternatives, an issue that is hotly debated. If the comparative advantage of nuclear power depends on national subsidies (such as the Price–Anderson Act), then regional benefits actually reflect a form of transfer payments from the nation as a whole.

Considered opinion suggests that the coal/nuclear cost comparison is too uncertain to compute (Stobaugh and Yergin: 1979, 220). Let us assume for this analysis the accuracy of utility calculations of nuclear power's relative regional advantage. The direct beneficiaries of nuclear plants are the users of electricity (including industry, commercial users, and residential users), and the benefits are the savings in the cost of electricity as opposed to fossil-fuel generation or doing without electricity. These benefits are localized in utility districts with heavy nuclear development, for although there is an integrated grid system with some long-distance electricity transport, over 90 percent of electricity is consumed within its utility of origin. An estimate of the magnitude of such benefits in a state with high fossil fuel costs, although complicated by various hidden subsidies, may be as high as the $140 million which Governor Joseph Brennan of Maine argued that the closing of the Wiscasset nuclear plant would cost Maine consumers, or as low as the $43 million conceded by its opponents.

The degree of regionalization of benefits, however, is likely overstated by designation of nuclear electricity consumers, for it ignores the distribution of secondary benefits. Presumably the manufacture of products at lower prices provides net savings to consumers elsewhere in the nation, to an enlarged gross national product, and to a more favorable trade balance. Nonetheless, if the Maine voters in the 1980 referendum had decided to close the Wiscasset plant (and had the plant actually been closed), then surely Maine residents should have been absolved of that portion of the waste burden.

The mixture of national and regional benefits from nuclear power contrasts with likely geographical patterns of costs. As suggested by Figure 15.2, current nuclear waste storage and disposal sites are relatively few – comprising some twelve commercial and defense low-level waste sites, three high-level defense waste sites, and an additional two sites (Morris, Illinois, and West Valley, New York) and seventy-two reactors where spent fuel is currently stored. Because of its relatively small volume, all the nation's high-level waste, defense and commercial, will

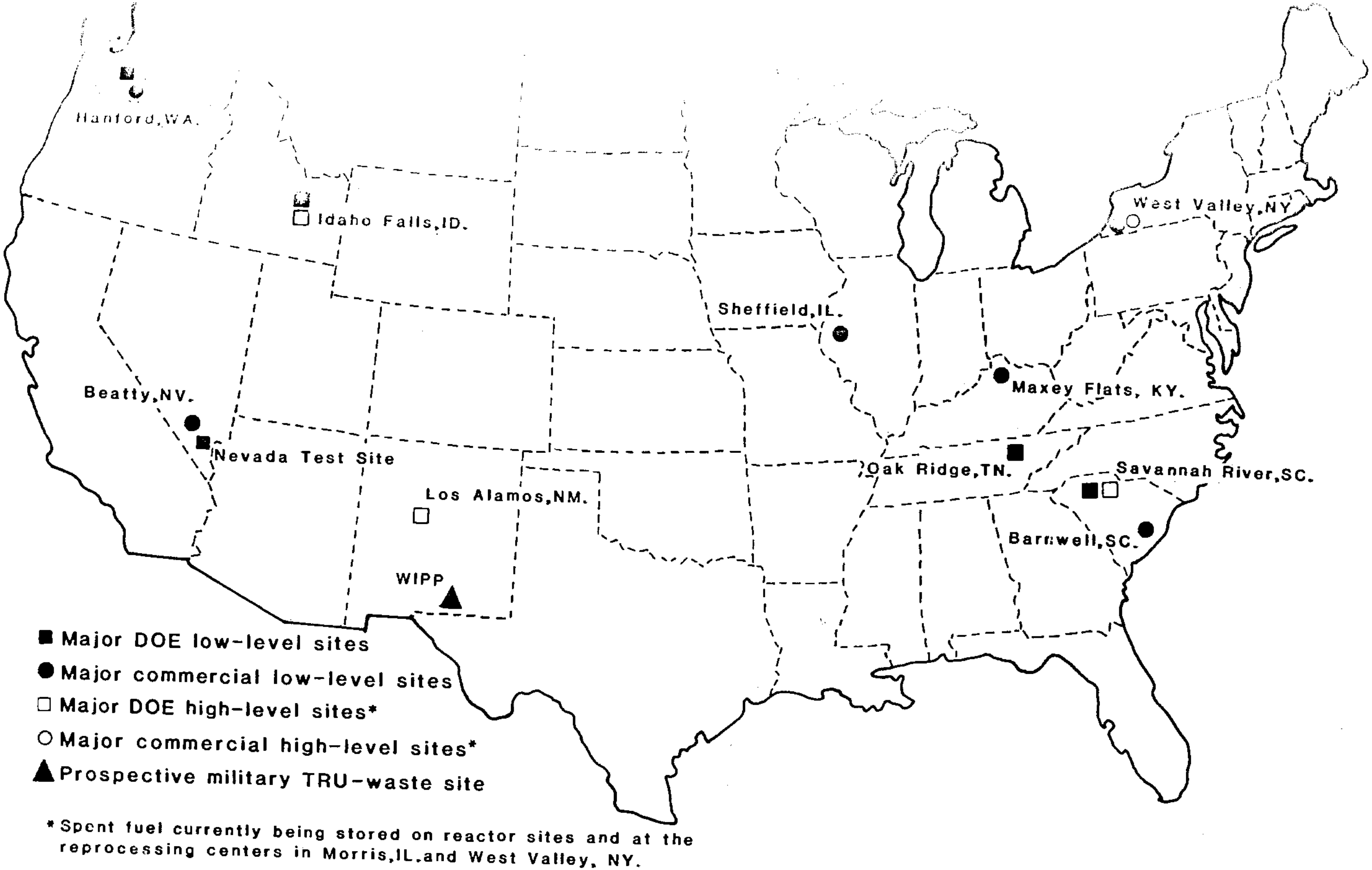


Figure 15.2. Major nuclear waste storage/disposal sites.

probably end up at somewhere between two and six repositories. Similarly, the mining and milling of uranium has produced geographically concentrated tailings that are too voluminous to be moved long distances. These are located primarily in the West, remote from most commercial nuclear power reactors. This pattern of inequity is quite apparent for low-level wastes, as shown in Figure 15.3, where the major waste-generating states are quite remote from the two western disposal sites.

An inventory of costs has yet to be calculated for a fully operational radioactive waste system serving some 150 to 300 GWe of nuclear electricity at a mature state of development (say in the year 2020). But the system would include the full network of waste-producing, interim storage, reprocessing (if it happens), and long-term storage facilities, as well as a transport system for moving the wastes. A full cost accounting would include not only the obvious logistical requirements but also the risks to public health and safety, the long-term management costs, the burdens of regulatory infrastructure, the threat of nuclear proliferation, and such less apparent social costs as public fear at sites and along routes, community disruption, and long-term institutional demands.

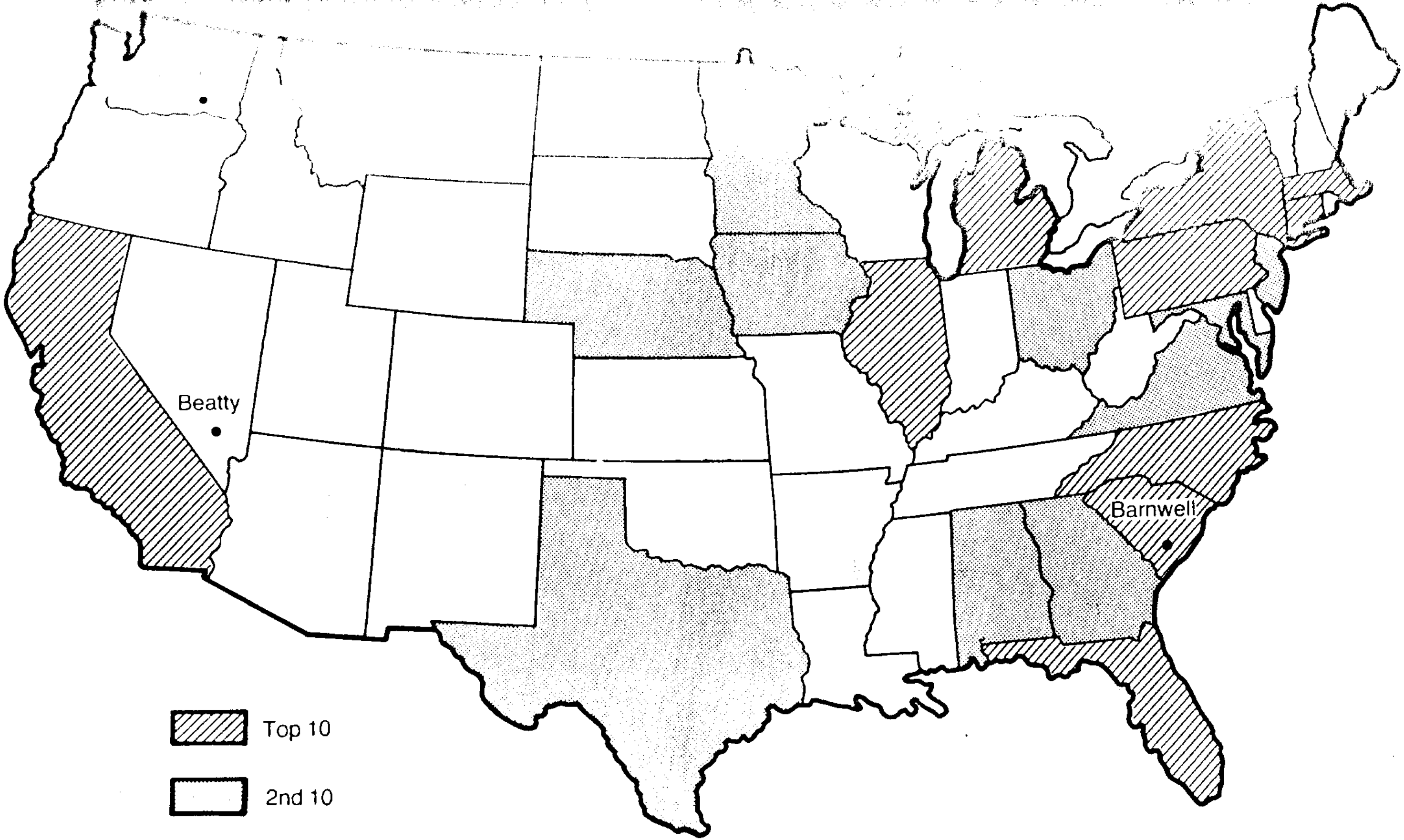
Locus Management Options

In assessing management options, each of our three equity principles will be covered sequentially.

Burden/benefit concordance. Current national policy addresses quite specifically the locus problem: "All costs of storage. . .will be recovered through fees paid by utilities and other users of the services and will ultimately be borne by those who benefit from the activities generating the wastes" (U.S. President: 1980, 4).

With the caveats noted above concerning the complexities in impact distribution, this provision would adequately achieve the equity principle were all relevant costs to be internalized. Unfortunately, this is not likely to be the case. Since only management costs are currently included, it is quite apparent that the beneficiaries will not in fact bear the full associated costs. Missing will be the human cost of exposure from the inevitable accidents at the site and along transport routes, the public fear of exposure and its effects, and a variety of ill-understood social costs. Clearly the policy stipulation needs to be broadened to embrace the full range of adverse impacts at facility sites and at nodes along corridors in the waste system.

Turning to our requirement that benefits accompany the imposition of harm, we note that the provision of benefits raises a number of vexing



Source: National Low-Level Waste Management Program: 1980, 3.

Figure 15.3. Top twenty states in commercial low-level waste generation in 1978 and currently operating disposal sites.

questions. Benefits, to be sure, in the form of employment, increased business, and increased tax revenues accompany the development of waste storage site facilities. There are also various government programs designed to mitigate the impacts of large-scale facility developments in small, rural communities. The question of site impacts has been discussed at length in Chapters 3 through 5. Suffice it to note that the benefits accruing at the site will be distributed highly unevenly over the host-region population, will not occur in a timely fashion, and will tend to be overestimated by experts.

By comparison, social costs are poorly understood, both because of the underdeveloped theoretical state of social impact assessment and because these are first-of-a-kind facilities. Meanwhile, as noted in Chapter 5, government programs designed to redress adverse impacts are beset by fragmentation, restrictions, and lack of timeliness. Implementation of the network of facilities in the nuclear waste system will, in short, require new provisions to ensure a flow of benefits to the populations harmed.

But how should the size of such benefits be calculated, how should they be distributed, and what mechanisms will prove most effective? First, there should be adequate liability and insurance provisions to compensate for public health impacts occurring at waste facilities and along routes. If the Price–Anderson Act may be construed as applying to waste transport and storage, damage from minor accidents should be recoverable. But since it is catastrophic releases which underlie much of public concern, it is especially important that liability provision be extended to cover the full range of accidents. The extent to which accident costs can be displaced to local victims is suggested by a recent Federal Insurance Administration sensitivity analysis of the Three Mile Island accident. The study found that, even with no medical or personal injury expenses included, a more severe accident involving evacuation would have caused an average Harrisburg family to lose $67,500, with only $2247 recoverable from the $560 million Price–Anderson pool (Federal Insurance Administration: 1979; Kehoe: 1980). Means should be found so that the burden of liability is not plaçed on the victims and that government does not end up in an adversarial position of resisting liability payments to the local residents.

Second, a variety of means is available for providing benefits to risk-takers. Stipulations may be placed on employment pools which both minimize social costs (by reducing the number of in-migrants) and maximize benefits (by enlarging host-region employment). Compensation for adverse impacts may be provided through impact aid or in lieu of taxes. There is precedent for such a system of incentives. For example, several countries (including France) have instituted programs to reduce electricy rates or local taxes for people residing near nuclear power plants. A imilar system of incentives has been suggested recently for U.S. clear power plants (Starr: 1981, 5–6), and such plants entail more efits than waste storage facilities. A compensation program will need address such issues as eligibility criteria, valuation criteria, mode of mpensation, financing, and distributional mechanisms (Cole and mith: 1979; O'Hare and Sanderson: 1977).

Finally, we propose consideration of a new means of site compensa-ion, one that may bypass some of the difficulties in defining the pool of mpensation according to the burden of uncertain risks. Incentives may offered beyond compensation for anticipated damages, recognizing t projected damages are essentially incalculable and may easily be erestimated, and that the service provided (furnishing a waste rage or disposal site) is itself extremely valuable for the beneficiaries. propriate sites for storing toxic and radioactive wastes are rapidly oming among the more valuable pieces of real estate in the United es. To that end, we propose that the waste management program sider a *geology rental fee* to be paid to the host region. Such a fee uld be calculated by reference to the comparative cost of engineered eguards required to provide protection equivalent to that afforded by geology. Sufficient information is becoming available to make such a mparison, at least crudely, and the pool of funds is likely to be substan-a enough to serve as a means of compensation and to provide an crow fund to ameliorate the consequences of future accidents.

Sharing the risks. There is an understandable reluctance to become e waste storage facility or *the* waste repository. The 1979 closing of w-level waste repositories was intended, in part, to force a broader aring of the waste burden. Beneficiaries, it may be argued, should not e allowed to buy out of the burden of such uncertain risks easily (as one, r example, might hire a tree surgeon or a roofer to climb where one ars to climb). In the face of risks never experienced before with both atastrophic potential and particularly dreaded consequences (cancer), eally beneficiaries should share in the experience of hazard.

Increasing the multiplicity of sites is a major means of achieving risk aring as well as simplifying the transport system. Other considera-ions, however, might conflict with this equity objective. For example, a ighly decentralized system for high-level waste disposal could enlarge the aggregate risks of waste storage, or increase social conflict and ex-and costs. Relocating uranium mill tailings to beneficiary areas makes no sense in terms of public health or economics.

Within appropriate technical and regulatory constraints, however, there are opportunities for enlarging the degree of risk-sharing associated with both low-level and high-level wastes. Mill tailings, by contrast, present a more formidable problem because of their volume.

It is apparent that the national capacity for low-level waste storage requires major expansion, and current government policy calls for state responsibility in adding more disposal facilities. Given the relative ubiquitous generation of medical and research and waste from geographically concentrated electricity-producing facilities, the intent is for regional siting. According to the Low Level Radioactive Waste Policy Act, individual states may locate disposal facilities within their border or contract with neighboring states, which might well host such a repository. A consortium of regional groups had been formed by June 1981 in six regional areas, and the State Planning Council has created a model interstate compact to facilitate such arrangements. This approach moves in the direction of a risk-sharing objective.

For high-level waste, the picture is quite different. Here current governmental efforts appear to be headed away from this goal. The network design of interim storage of spent fuel in a mature waste system provides an opportunity for reducing considerably the overall burden of radioactivity to be handled and transported and at the same time a wider sharing of the responsibility. But, as in other aspects of the waste disposal system, little has actually been done as debate continues about whether at-reactor or away-from-reactor facilities are the best interim storage solution, whether reprocessing will become a reality, and whether the West Valley (New York), Barnwell (South Carolina), and Morris (Illinois) facilities could be converted into away-from-reactor storage facilities (AFRs).

As for the repositories, current plans appear headed for a relatively centralized system (i.e., few sites), with the lead candidates (Hanford, the Nevada Test Site, and the Waste Isolation Pilot Plant) in places that are remote from nuclear power beneficiary areas but that have already assumed a significant portion of the societal risk from nuclear technology. Existing Reagan administrative policy continues to call for selecting the first repository from among several candidate sites in multiple geologic media. Meanwhile, the Senate bill (S.162) passed in 1982 calls for moving forward rapidly with a demonstration program, involving long-term monitored at-ground storage in the very near term.

We propose two innovations to help ensure a greater degree of risk sharing in the high-level waste disposal system. First, a visible institutional means is needed to ensure "fairness" in actual site selection. Without such a means, concern will remain that the selection process is stacked against the politically weak. The need for this mechanism has been enhanced by public relations efforts designed to show that suitable geologic depositories are very widespread. Thus the selection of a site, even if only for initial exploration, has evoked and will surely continue to evoke cries of "Why here?" from residents of the surrounding area. First, it is clear that no state with candidate geologic formations should be able to exclude itself from consideration, as Louisiana, for example, appears to have done. Second, we would suggest, at an intermediate stage in the site-identification process, a *lottery among candidate sites* designating those to be exempted from further consideration. A requisite number of technically qualified candidates would be needed to ensure success, of course, but the exemption of many areas by random process would reduce unnecessary tensions over siting. Lottery systems are characteristically used when fairness is desired in allocating unwanted, even dangerous assignments. (Drawing straws for dangerous missions and the military draft are examples.) Third, the host site will also need assurance that risk will actually be shared, for policy reversals have frequently characterized the waste program to date. There is considerable concern in New Mexico, for example, that the WIPP demonstration project, if it is developed expeditiously but other repositories are not, may well at some future time be converted to a permanent repository for domestic and/or foreign wastes. One simple means of providing such insurance is a *legal storage limit* to the amount of waste to be accepted at any site.

Finally, the mill tailings problem appears to be quite resistant to risk-sharing procedures. Most of the tailings are in areas with low population densities, and the volumes are very large. Stabilization *in situ* appears to be the only viable course.

To summarize, we see a strategic option for waste management which is technically sound and which realizes a high degree of risk sharing. The key elements in the strategy are:

- state responsibility for low-level wastes as currently envisioned in multiple sites;
- continued reliance upon existing facilities for defense waste storage for the near term but with prompt immobilization of the high-level waste;
- expanded reliance upon at-reactor storage for commercial waste storage, possibly augmented by one or several regional AFRs, for forty to fifty years of interim storage (as in the Swedish solution) of commercial high-level waste;
- delay of current timetables for one or two high-level waste repositories in order to create a regional system of repositories (with co-location with AFRs a possibility) in which multiple sites would begin accepting waste simultaneously;
- two institutional mechanisms to ensure fairness in risk sharing – a lottery of site exemption among qualified candidate sites and a legal

storage limit to the amount of waste to be accepted at any given site.

Such a strategy recognizes that there is, in fact, no pressing need to put high-level radioactive waste in the ground and that there is substantial advantage in regionalization of the waste handling and disposal network.

More voluntary risk assumption. Our third equity principle calls for the assumption of risk to be as voluntary as reasonably achievable. We use the term "as voluntary as reasonably achievable" in much the same way that it is used in regulatory language for risk reduction. There is, in current parlance, no such thing as zero risk. Similarly, there is no such thing as completely informed consent for risk assumption. But, beyond this, a purely voluntary system will likely deliver no sites for radioactive wastes, hazardous chemical wastes, or other noxious facilities. Sacrifices must be made for the common good. The argument here is that the burden is on the developer to inform and achieve consent by meeting the objections and concerns of those who will bear the risks.

When evaluated according to this criterion, the current waste management program, as noted in Chapter 2, has performed poorly, and it begins with a major, perhaps insuperable, debit. The Department of Energy, as an institution, bears the legacy for the past failures and inadequacies of the waste management program. At a time of general institutional distrust, particularly in regard to the management of nuclear energy, the Department of Energy suffers from a serious lack of credibility. Even if the department is dissolved, it will likely live on in some other agency. The lead agency undoubtedly faces difficulties in recovering the public trust, as does the Nuclear Regulatory Commission for its regulatory responsibilities.

Many mechanisms are available for achieving more voluntary assumption of risk in radioactive waste locational decisions, but their suitability depends on one's view of the extent to which the public is rational or irrational about risk issues in general and nuclear risk issues in particular. There is a deep-seated belief among the community of technical experts that opposition to nuclear power is anchored in the public's ignorance of nuclear technology, its inability to make risk comparisons, and its irrational response to radiation risks. This attitude is important, because one does not design processes for achieving more voluntary risk assumption if one is convinced that enlightened and rational choice is unachievable.

Despite some ingrained folklore, the relevant evidence to date does not suggest that the public is either more poorly informed about nuclear questions than other difficult technological or social policy issues or that it is irrational in its perception of technological risks. For example, research conducted by Paul Slovic and his colleagues (1979) at Decision Research, indicates that laypeople generally rank risks quite well, although they tend to overestimate some rare but well-publicized risks (for example, botulism) and underestimate more chronic common killers (for example, alcoholism, smoking). It is also apparent that the public assigns more weight to consequences, particularly those potentially catastrophic, than to the probabilities of accidents (Slovic et al.: 1979). However, the gap between expert and lay assessment of nuclear power is unusually large, which should underscore rather than deny the need for extensive public participation in decision processes. Specifically, we recommend a number of specific steps to improve the provision of information to inhabitants of prospective host regions:

- The development of objective information and improved means of public participation should be placed under the auspices of a competent group outside the DOE and should be amply funded.
- Such a group should develop a public educational research and demonstration program, adequately funded and subjected to careful professional and lay review.
- Technical and financial resources should be committed to prospective host regions and states in order that local capabilities for technical and management review be created. (A useful precedent exists in the WIPP context.)
- Aid should be provided to groups that would take part in the process (interviewers).

In addition to improved information from the managers and data and sensitivities provided by the host region and interested groups, respective roles in the decision process must be settled. Recent policy statements have wavered between such catch phrases as "consultation and concurrence" and "consultation and cooperation" with the respective states. In turn, there has been an expectation that the state will represent the specific host region adequately.

Full voluntary consent to risk bearing is not possible, in our view, if a solution to the radioactive waste problem is to be achieved. While we hope that the more equitable management program we suggest will alleviate some of the conflict which has characterized efforts to date, we are not naive enough to assume that full voluntarism can be achieved, any more than it is possible in locating prisons, town dumps, or methadone centers. Nor will voluntary consent prove a viable means for establishing the hundreds of toxic waste disposal sites that EPA says are required over the next decade. Similarly, states and localities should not have veto power over the transport of wastes through their territories.

Having said that, we do wish to make it difficult to override the concerns of those who will bear risks which are presently, for all the technological optimism, still quite uncertain and which, we know, provoke deep public anxieties. So while veto is neither feasible nor mandatory for equity, the host regions of AFRs (if instituted) and waste repositories should certainly have the right to and capability for independent competent review, negotiations for improved safety assurance and social impact reduction, and effective appeal. Such a right to negotiation was incorporated in the DOT's final rule on route selection for transporting radioactive wastes; and in early 1982 the U.S. District Court in Manhattan strengthened this right by upholding the New York City regulation banning transport of large amounts of radioactive material through its borders (Lubasch: 1982). Since the capability of independent host-region review is so essential in an atmosphere of institutional distrust, we do not find the notion of a public defender for the site desirable. In regard to appeal, the host region, as well as the host state, should have the right to appeal, for review by the state legislature in the former and for appeal to Congress in the case of the latter. Inadequately assessed or adverse social impacts should be specifically recognized as appropriate grounds for appeal. In such a proceeding, the burden of proof should be on the developer for demonstrating procedural and substantive safety adequacy.

Finally, interveners may be expected to provide a key role in testing the validity of developer assumptions and analysis. They provide systematic means for identifying doubts that the developer should have to overcome. The pluralism they provide may also lend greater credibility to the decision process as a whole. In fact, the site developer may wish to consider funding parallel studies by advocates and skeptics as a means of bracketing areas of dispute. For these reasons, substantial funding and technical resources should be provided to interveners as well as to the host state and region.

THE LEGACY PROBLEM

If the locus problem is the equity issue provoking the most intense and visible conflict—harming future generations for current gain—the legacy problem appears to be more pervasive and troublesome. Because radioactive wastes remain dangerous for thousands of years, we must decide what obligation (if any) we have to future generations and how to resolve conflicting obligations between present and future generations.

It could be argued, of course, that obligations exist only where individuals have rights and that only individuals who exist actually have rights. The future, then, can have no claim on the present. Put another way, the future lies outside our morally relevant community. We reject this line of argument that considers only existent people at the expense of people yet unborn. And while we cannot anticipate what the desires and values of distant future populations will be, we can reasonably ask what kind of legacy we will leave them.

Distributional Issues

The distribution of benefits and burdens over the many generations likely to be affected by radioactive wastes is not known nor is it knowable, even though discussions of risk in such documents as the Final Environmental Impact Statement (U.S. Department of Energy: 1981a) and the CONAES report (National Research Council, Committee on Nuclear and Alternative Energy Systems: 1979) assume the contrary. Therefore, the discussion to follow notes only gross characteristics which are pertinent to equity considerations.

The benefits of radioactive wastes are essentially the benefits of nuclear energy used for defense purposes or for the production of electricity. As noted earlier, the use of nuclear energy for weapons production is an arguable benefit for the current generation of U.S. citizens. But the massive buildup of nuclear weapons, in terms of both their legacy of weapons and proliferation threat as well as the radioactive waste generated, must be seen as a major harm that we are exporting to the future. Nuclear energy's benefits to the future, then, must be found primarily in the value of electricity production and related capital and technology, rather than in its contribution to the growing world arsenal of destructive weapons.

The use of nuclear energy for electricity production has a number of potential long-term contributions. First, to the extent to which nuclear energy is the cheapest means of meeting actual energy needs, the greater societal accumulation of wealth which results, and which may be passed on to future generations in the form of capital stock, is a net benefit. It is, however (at least for the current generation of light-water reactors), a marginal advantage largely confined to the current and next generations during the transition from fossil-based to renewable energy-based systems.

Another possible long-term impact involves the effects of nuclear power development upon the inventory of nonrenewable resources. To the extent that nuclear power releases pressure on hydrocarbons and permits their greater transfer to future generations, this may be a tangible benefit for the future. Yet the advantage appears to be quite dependent upon fuel recycling and the deployment of the breeder, for the once-through fuel cycle is also consuming easily accessible uranium supplies, a nonrenewable resource in short supply. Moreoever, within the time scales of radioactive wastes, this generation of nuclear reactors, limited by uranium supplies, appears to have benefits largely concentrated within the current and perhaps next several generations. By then (i.e., about 2050) the global transition to renewable energy sources should be complete.

Still another favorable legacy may be the technology of power generation by relatively renewable sources – the advanced converter, the breeder, and fusion. To the extent that the technology is developed linearly, one might argue that the light-water reactor and its legacy of waste are necessary concomitants to a legacy of proven and sustainable technology.

Finally, nuclear power does offer some possibility for reducing a possible global catastrophe associated with major increases in coal burning – namely, the carbon-dioxide hazard and related climatic change. It is notable that *Global 2000* designated this as the potentially most severe of the long-term global impacts of energy systems (U.S. Council on Environmental Quality and U.S. Department of State: 1980).

We now turn to the risks and burdens imposed by radioactive waste inventories. There are three major clusters of risks over time. For this and the next generation, the decision to reprocess nuclear wastes, with the attendant if uncertain risk of proliferation, dominates risk considerations. An active debate exists over the degree to which reprocessing adds to the proliferation threat, and the degree to which technical fixes (e.g., denatured fuel cycles) alleviate the problem. The CONAES report concluded that the magnitude of proliferation risks cannot be assessed in terms of probabilities and consequences (National Research Council, Committee on Nuclear and Alternative Energy Systems: 1979, 488), but the risks have been viewed seriously: in 1977 President Carter deferred the reprocessing of waste. Although the Reagan administration has reversed that decision, it is unlikely that reprocessing will actually take place without major government subsidy. In any event, reprocessing would enlarge benefits to this and the next several generations by extending uranium and fossil-fuel resources, but at an unknown increment in terms of global proliferation risks.

The other significant component of near-term risk – and one which has received scant attention to date – lies in the above-ground activities involved in the deployment of the waste disposal system and the operation of repositories prior to closure. Once high-level wastes are sequestered in a multibarrier system within repositories 2,000 feet underground, public health risks would appear quite minimal. But the system of interim storage, handling, and transport of wastes to repositories will undoubtedly have its failures and accidents. While catastrophic risks appear highly unlikely, smaller risks, both radiological and nonradiological, are entailed.

A second cluster of risks will come into play after repository closure, extending over the next 600 to 700 years; this is sometimes known as the period of fission product hazard. By 1,000 years after implacement, both the radiation and heat generated by the decay of the wastes will have diminished by about three orders of magnitude (U.S. Nuclear Regulatory Commission: 1981a, 35281). This is a period of significant potential risk to future generations, but the risk can be controlled by means of the multiple barriers to human exposure currently required by NRC regulations. The near-term risk is also the time of concern for low-level wastes, a several-hundred-year legacy problem in which failures in sound management practice appear to be the source of most of the hazard.

Finally, there is the period of very long-term risk to distant generations, extending from a thousand to a million years from the present. Although predominate attention has been given to high-level wastes, mill tailings are in fact the more significant problem during this period, because of their large volumes, because they are stored on the surface of the earth, and because 85 percent of the radioactivity in the original uranium ore remains in the tailings. Over long periods, these tailings, in the form of fine, pulverized rock, are likely to be exposed by wind and water erosion or human intrusion. Currently about 140 million tons of mill tailings exist at twenty-two inactive and twenty-one active sites; 10 to 15 million more tons are being produced annually.

Assuming a 1978 U.S. population, the mill tailings, if left uncovered and not dispersed, would cause about three premature cancer deaths per year averaged over the long term (according to NRC estimates) from random exposure alone (see Table 15.1). Although this number is not large, especially when compared with the estimated 1,594 annual premature cancer deaths from radon exposure in buildings, the absolute numbers of deaths in the future – when calculated over the period of hazard – cumulate to the hundreds of thousands or millions. Current NRC approaches would reduce fatalities by a factor of 100 but still would leave a significant residual risk over time, even without major failures or human intrusion. If populations were to increase markedly in the mill tailings areas over the very long term, the aggregate risk to the future would increase correspondingly.

Compared with mill tailings, high-level wastes from both commercial and defense sectors appear to represent a more tractable risk over the long term. Although such wastes also remain hazardous over very long

Table 15.1. Comparison of Continuous Long-term Releases of Radon from Uranium Mill Tailings to Other Continuous Radon Releases[a, b]

	Estimated Annual Release (Ci/yr)	*Estimated Annual Population Dose to U.S. (organ-rem to the bronchial epithelium)*	*Potential Annual Premature Cancer Deaths*
Natural soils	1.2×10^8	1.6×10^7	1,152
Building interiors	2.8×10^4	2.2×10^7	1,594
Evapotranspiration[c]	8.8×10^6	1.2×10^6	86
Soil tillage	3.1×10^6	4.2×10^5	30
Fertilizer used (1900–1977)	4.8×10^4	6.9×10^3	0.50
Reclaimed land from phosphate mining	3.6×10^4	4.9×10^3	0.35
Postoperational releases from tailings[d]			
Base case	5.5×10^5	4.0×10^4	2.9
Proposed limit	3.9×10^3	2.8×10^2	0.020

Source: Table provided by the U.S. Nuclear Regulatory Commission, October 1980.

[a]Estimates of all radon releases except those from mill tailings are taken from an investigation of natural and technologically enhanced radon sources performed in support of this generic statement by Oak Ridge National Laboratory. Population doses were derived using a dose conversion factor of 0.625 mrem/yr/pCi/m³. Exposures to mill tailings in regions around mills are included.

[b]Population at risk is taken to be the United States 1978 population, for purposes of comparison. Predicted exposure and health effects for the United States would be about 88 percent of the total for North America and about 70 percent of the global total.

[c]Evapotranspiration is the collective release of water vapor from soil surfaces and vegetation.

[d]For purposes of comparison, risks in this table are only those due to exposures of bronchial epithelium from inhalation, as opposed to total risks from ingestion and inhalation.

periods, the risks decline below those of mill tailings after 5,000 years. The EPA's emerging standard for high-level waste will, it is estimated, result in 1,000 fatal cancers for the first 10,000 years. Thereafter, the risk is calculated at approximately that of the natural ore body from which the uranium occurred, a risk apparently seen as "acceptable" by the EPA.

The comparison with the natural ore body is frequently made by regulators and other technical experts in discussions of "risk acceptability" for protecting future generations from radioactive waste hazards. At first glance, such a comparison appears appropriate and helpful. If, after all, the emplaced waste adds no risk, then surely it should define the limit of responsibility. This reasoning is very much behind the EPA's current thinking on its general HLW standard and the NRC's technical criteria (U.S. Nuclear Regulatory Commission: 1981a) for high-level wastes, each of which "end" the future at 10,000 years. But, for both technical and social reasons, the analogy may be greatly misleading:

- The comparison generally fails to take into account two facts: that other releases occur during the fuel cycle and that most of the radioactivity remains in the mill tailings.
- The hazards of nature inherited by humans provide no guidance for the acceptability of hazards created by human actions; rather, the use of uranium poses choices which must find their justifications elsewhere.
- The disposal of radioactive wastes exposes different people, usually at concentrated locations, from those exposed at uranium ore body locations.

Finally, it is also important to note that, beyond public health risks, there is the danger that the burden of dealing with risks may be passed on to the future. We have noted that this was the case at West Valley. The high-level defense waste problem has been passed on to the future for the past three decades and, given the formidable price tag associated with such wastes, this export of burden to the future could well continue. Several options for the current waste program–long-term monitored surface facilities and current approaches to mill tailings–potentially involve a large displacement of burden onto the future.

While this discussion has indicated that the distributions of risks and benefits over very long time periods can be described in only a gross way, the major time discrepancy is unmistakable. Benefits are largely concentrated in this and the next generation, but there is substantial export of risk, and possibly managerial burdens, to distant generations. The legacy problem is, in short, at least as fundamental an equity concern as the locus problem.

Legacy Management Options

To assess legacy management options, we refer again to our three equity principles:

Burden/benefit concordance. Since the benefits of nuclear power are concentrated strongly in this and the next generation, responsible management suggests that the obligation to reduce risks extends beyond that which is acceptable to this generation. For various waste classes, this would suggest time-phased regulatory objectives – with greater stringency for the protection of distant generations who do not share the benefits. Specifically, the objective should be for near-zero risk after 100 years (or roughly near the end of the period of retrievability as now planned for high-level wastes), and approaches should emphasize best available technology rather than "feasibility" or "reasonable achievability."

Current approaches to mill tailings badly miss this objective. In the past mill tailings have been neglected; they have not been properly stabilized or controlled and have been removed for building purposes. In fact, as recently as 1976 the Nuclear Regulatory Commission had only two people working part-time on this issue. A remedial program is now underway, under the Mill Tailings Radiation Control Act of 1978, to clean up the inactive sites. A program is also beginning for the long-term immobilization of tailings. But it is strikingly less ambitious and protective of the future than efforts on high-level waste, even though mill tailings pose the greater long-term problem.

The final NRC rules (1980) on uranium mill licensing recognize the long-term hazards and the need to control the hazards without requiring active care and maintenance by future generations. But the NRC chose a disposal technology which offers only minimal long-term protection despite the low cost involved in more adequate disposal technologies. The envisioned disposal involves earth covering of tailings, means to reduce seepage (for example, liners), and below-grade burial. While providing for a token $250,000 pool to cover long-term surveillance, the commission decided against an insurance fund to guard against unforeseen events on the grounds that the likelihood of such occurrences was "small" and design against them "impractical" (U.S. Nuclear Regulatory Commission: 1980b, 65527). Although increased protection could be achieved for the future through advanced treatment (as through fixation or nitric acid leaching) for less than half a mill per kilowatt-hour of electricity (see Table 15.2), the commission decided in favor of the less adequate technology. The envisioned program for mill tailings is, in our view, the most inadequate component of radioactive waste management

Table 15.2. **Total Costs of Alternative Disposal Modes at Model Mill**

Disposal Mode	Percentage Price of U_3O_8	Mills/kWh
Base case	0.2 (0.16)	0.002
Active care mode	2.0	0.025
Passive monitoring mode		
Below grade	2.2–4.0	0.03–0.0
Above grade	2.5	0.038
Advanced Treatment		
Fixation—cement	15–40	0.2–0.5
Nitric acid leaching	20	0.25

Source: Data provided by the U.S. Nuclear Regulatory Commission (1981).

in regard to the legacy problem. It should be substantially upgraded to include, at minimum, advanced treatment of tailings as well as continued attention to means of extracting the long-term actinides. Further, as described below, adequate insurance funds should be included as part of responsible long-term protection.

Turning to high-level waste from commercial power reactors, the current program for continental geologic disposal appears consistent with the long-run protection of the future. In particular, it is much preferable to the indefinite storage of such wastes in engineered-surface or near-surface facilities. Continued attention should be given to seabed disposal and to the strategy of many widely dispersed deep holes up to 4 kilometers with resistant waste forms as proposed by Ringwood (1980), for both may prove preferable over the long-term.

Several changes in the high-level waste management program would further reduce potential inequities. First, as already noted, there is considerable advantage to a program of lengthy (forty to fifty years) interim storage followed by a decision of whether to reprocess spent fuel or dispose of it immediately. Spent fuel can be safely stored for such a period, the storage simplifies the disposal problem, and reprocessing, if it can be achieved without adding to the proliferation problem (which may be resolved by then), would increase benefits while reducing the very-long-term hazards. Second, high-level defense wastes should be subjected to the same licensing requirements as commercial high-level wastes, and a program for the immobilization and disposal of such wastes, despite the financial temptations, should not be deferred.

Low-level wastes do not constitute a major legacy problem, but poor past management has passed on significant financial if not public health burdens. Improved disposal, ensuring safe isolation of such wastes over several hundred years, is clearly needed; the recently proposed NRC criteria appear adequate to that end (U.S. Nuclear Regulatory Commission: 1981b). One potential problem in the greater locus equity achieved through state responsibility for such waste is an increased risk for the future through potentially poorer or delayed state management.

Finally, an institutional mechanism is needed to meet our equity principle that the imposition of a harm or burden should be accompanied by a proportional benefit. Whatever the success in reducing risks to the future, accidents will occur, assumptions will be contraverted, and harm and burdens will be imposed. An equitable management program will recognize this and provide for means of compensation, perhaps as a financial pool, similar to the superfund for hazardous waste, held in perpetuity.

Sharing the risks. Since the beneficiaries of nuclear power, as noted above, are largely concentrated in this and the next generation, this principle is moot for the distant future. The distribution of risk will likely be spread over the next 100 years, but benefits also will occur during this period.

More voluntary risk assumption. Inherently, future populations cannot consent to actions taken by this generation: the transfer of risk is necessarily involuntary. This is added reason for the obligation to reduce risk to the maximum extent possible.

Several opportunities exist, however, for ameliorating this problem. First, it is important to preserve options for the future. We have proposed lengthy interim storage followed by a decision on reprocessing. This retains flexibility on a central issue in waste management. Beyond this, the retrievability of the waste once stored in a repository maintains the capability of the future to respond to errors and current gaps in knowledge. In its technical criteria, the U.S. Nuclear Regulatory Commission (1981a) requires a 110-year retrievability capability, divided into three phases. When added to lengthy interim storage, some 150 years of choice are built into the disposal of high-level waste, a period sufficiently long to provide options only to the first several generations.

Finally, a substantial problem exists because future populations cannot participate on their own behalf in current decisions about waste management. In the previous discussions of the locus problem, we noted the importance of developing the host community's capability of assessing impacts and participating in siting decisions. The decision process is inherently flawed because most of those who will bear the risk cannot participate in the process. In such situations where individuals cannot represent their own interests, it may be necessary to create institutional mechanisms, however artificial, to ensure that those concerns are inserted into the decision process. One possibility would be a *public defender for the future,* who would be equipped with a technical staff and would have the authority to challenge proposed regulation and developmental plans.

THE LABOR/LAITY PROBLEM

Of the three equity problems treated in this volume, the differential treatment of workers and publics is undoubtedly the least visible and debated in deliberations over radioactive waste management. In fact, Melville (Chapter 10) illustrated that the hiring of temporary workers has emerged as a widespread practice in the nuclear power industry and has been allowed to grow without evident public concern. In 1981, the new Reagan administration began a concerted campaign to relax workplace health standards, with the likely outcome that workers will be forced to bear burdens for the benefit of society more generally. And, as Derrkow indicated in Chapter 12, there is strong reason to suspect that the market will not suffice to compensate workers. Since the processing, handling, and storing of radioactive wastes necessarily will involve exposure to workers, it is likely that workers will bear disproportionate risks in this generation.

Distributional Issues

There is not a good understanding of the allocation of risk during the next 50 to 100 years of worker involvement in radioactive waste management. But it is likely that workers, and not the public, will bear the major radiation exposure burden. The DOE's final environmental impact statement on commercially generated waste contains only a fragmented and cursory account of occupational exposure, but it suggests that both the predisposal (above-ground) activities and the operation of the repository carry greater worker risk than public risk. The DOE estimates that routine radiological releases from the normal operation of geologic repositories would produce negligible impacts (1 person-rem) upon the regional public of 2 million people but an estimated 0 to 130 health effects in a workforce of about 8000 (with individual worker doses averaging about 1 rem per year) (U.S. Department of Energy: 1981a, 5.60). Similarly, it estimates operational accidents as producing less than 6,000 person-rems for twenty years of waste emplacement but potential fatalities (in a canister drop) among workers (1981a, 1.10).

Similarly, patterns of differential exposure are expected to occur in the operation of an AFR and in waste transport (1981a, 4.78 and 4.79).

The exposures are very small, however, when compared with either natural background or the risks presented in more dangerous occupational environments. On the other hand, the accuracy of such estimates will not be validated until the waste system is actually deployed. At Three Mile Island, the accident and associated waste cleanup involves greater worker exposure (10,000 to 20,000 person-rems) than public exposure. Other such accidents will surely occur and must be anticipated, and included, as part of the overall systems cost of radioactive waste management. Decommissioning and decontaminating reactors, at-reactor or away-from-reactor storage facilities, reprocessing plants (if necessary), transport facilities, and repositories will all involve a worker radiation burden. In the meantime, standards permit ten times as much exposure to workers as to members of the public, and workers apparently do not receive additional salary for working in radiation environments.

Labor/Laity Management Options

To assess responses to these inequities, we again turn to our equity principles.

Burden/benefit concordance. Several means are available for producing greater concordance among benefits and burdens. First, to encourage the maximum use of remote-control handling of the waste, the occupational exposure standard could, despite recent action to the contrary, be lowered by a factor of 10. This would recognize that a "safe" level of worker exposure is the same as that of public exposure. Beyond that, strict ALARA (as low as reasonably achievable) principles should be observed in the design and operation of the waste-handling and disposal system.

Second, risky work in nuclear waste facilities should be compensated by means of higher wages. In the event that the occupational exposure standard is not lowered, wage compensation would allow for a less satisfactory means for greater concordance of benefits and burdens.

Third, it is impossible to discern trade-offs between worker and public exposure in waste system technical options. The various environmental impact statements and other documents supporting policy decisions should make such trade-offs explicit so that technical choices reflect such difference.

Finally, the industry practice of using temporary workers as a way of meeting the formal requirements of radiation standards should not be extended to the waste system. An extension of this practice would almost surely increase the total occupational exposure burden, decrease the use of remote-control equipment, and make more difficult the voluntary assumption of risk.

Sharing the risk. The proposed reduction of the occupational health standard restrictions on the use of temporary workers would decrease the probability that waste management risks would be concentrated on workers. The costs of increased use of remote-control equipment and compensation of workers for risky jobs should be fully recovered, as noted above, through charges to electricity users from taxes for defense wastes.

More voluntary risk assumption. Finally, although nuclear power is in the forefront of industries in the provision of accurate information concerning workplace hazards and in monitoring actual exposure, more can be done to inform workers of risks they will bear. The Nuclear Regulatory Commission has formulated a new information dissemination procedure (U.S. Nuclear Regulatory Commission: 1980a), which promises better and more helpful information on radiation risks to workers, particularly in providing the context needed to assess the danger involved. This proposal should, in our view, be adopted and vigorously implemented.

TOWARD A JUST AND SOCIALLY ACCEPTABLE MANAGEMENT SYSTEM

A satisfactory resolution of the radioactive waste problem is inextricably linked with the fate of nuclear energy as a technology. It is doubtful that just or socially acceptable solutions for radioactive wastes can be found as long as the conflict over nuclear power continues. But the proposals offered here head in the right direction. Although they depart significantly from the government's emerging waste system, we believe that our proposals are technically sound and offer potential for winning the needed social acceptance and public confidence.

In sum, the key features of the proposed management system are the following:

- Interim storage of spent fuel at reactors, possibly augmented by one or several regional AFRs, for forty to fifty years with the decision of whether to reprocess made at a later time.

- Delay of current timetables for high-level waste repositories in order to create a regional system of technically qualified repositories in which multiple sites will begin accepting waste simultaneously.
- A lottery of site exemption among qualified candidate sites for high-level waste in the site selection process and a legal storage limit to the amount of waste to be accepted at any given site.
- State responsibility for low-level waste, as currently envisioned, but with substantial upgrading in disposal technology as indicated in the recently proposed NRC licensing requirements.
- Defense wastes to continue to be stored at existing sites, but with prompt immobilization and waste subject to commercial licensing criteria for eventual disposal.
- Substantial upgrading in program plans for mill tailings, to include at minimum advanced treatment but with continued attention to the feasibility of separating out long-lived actinides.
- Creation of a legacy fund, to be funded from the mill rate on nuclear electricity use and from general taxes, to be used for site mitigation and compensation for future impacts at repository and tailing sites as well as at key nodes in waste transport corridors. At the sites, the size of the fund will be determined by reference to a geology rental fee.
- The creation of an independent technical and financial capability in host localities and host states so that those bearing risks can participate effectively in their own behalf. Funding for these new institutions, and interveners, would be provided by the beneficiaries of nuclear power.
- The right of localities to appeal siting decisions to the state legislature and states to appeal DOE decisions to the Congress.
- A public defender for the future, equipped with an independent technical staff and possessing the authority to challenge proposed regulations and developmental plans.
- Lowering of the standard of occupational radiation exposure by a factor of 10, strict adherence to ALARA principles for such exposure, and/or compensation for risky work.
- Restrictions on the use of temporary workers in nuclear waste facilities.

REFERENCES

Barbour, Ian G., forthcoming. "Nuclear Energy and Future Generations," in Warner Klugman (ed.), *Nuclear Power: Ethics and Public Policy*.

Bell, Wendell, 1974. "A Conceptual Analysis of Equality and Equity in Evolutionary Perspective," *American Behavioral Scientist,* 18, No. 1 (Sept./Oct.), 3–34.

Bell, Wendell, and Robert V. Robinson, 1978. "An Index of Evaluated Equality: Measuring Conceptions of Social Justice in England and the United States," in Richard S. Tomasson (ed.), *Comparative Studies in Sociology,* Vol. 1 (Greenwich, Conn.: JAI Press), 253–270.

Ben-David, Shaul, Allen V. Kneese, and William D. Schulze, 1979. "A Study of the Ethical Foundations of Benefit-Cost Analysis Techniques," University of New Mexico, Department of Economics, Program in Resource Economics, Working Paper Series (August).

Brody, Jane E., 1980. "Consent Form: A Patient's Chance to Challenge the Doctor's Orders," *New York Times,* July 30.

Callahan, Daniel, 1978. "Ethical Uses of Risk/Benefit Analysis," in J. A. Staffa (ed.), *Symposium on Risk/Benefit Decisions and the Public Health* (Rockville, Md.: Food and Drug Administration), 71–74.

Cole, Roland J., and Tracy A. Smith, 1979. *Compensation for the Adverse Impacts of Nuclear Waste Management Facilities: Application of an Analytical Framework to Consideration of Eleven Potential Impacts, B-HARC-311-022* (Seattle: Battelle Human Affairs Research Centers).

Federal Insurance Administration, 1979. "Sensitivity Analysis of the Three Mile Island Incident" (Washington, D.C.).

Gilinsky, Victor, 1981. "Remarks before the College of Natural Science Alumni Association, Michigan State University, April 9, 1981."

Green, Ronald M., 1977. "Intergenerational Distributive Justice and Environmental Responsibility," *Bioscience,* 27, No. 4 (April), 260–265.

Kehoe, Keiki, 1980. *Unavailable at Any Price* (Washington, D.C.: Environmental Policy Center).

Lipset, S. M., 1968. "Social Class," in D. L. Sills (ed.), *International Encyclopedia of the Social Sciences,* Vol. 15 (New York: Macmillan and Free Press), 296–316.

Lubasch, Arnold H., 1982. "City Ban of A-Waste Shipments Upheld," *New York Times,* February 20, 25.

Marshall, Eliot, 1980. "NRC Plans to Deregulate Biomedical Waste," *Science,* 210 (12 December), 1228–1229.

Martin, Kenneth A., 1980. "Biblical Mandates and the Human Condition," *Journal of the American Scientific Affiliation,* 32, No. 2 (June), 74–77.

McKeon, Richard (ed.), 1941. *The Nicomachean Ethics: The Basic Works of Aristotle* (New York: Random House), Book 5, Chapter 3.

National Council of Churches, 1979. *Energy and Ethics* (New York).

National Low-Level Waste Management Program, The, 1980. *Managing Low-Level Radioactive Wastes: A Proposed Approach* (Idaho Falls: EG&G Idaho, Inc.).

National Research Council, Committee on the Biological Effects of Ionizing Radiation, 1980. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation,* BEIR III Report (Washington, D.C.: National Academy Press).

National Research Council, Committee on Nuclear and Alternative Energy Systems, 1979. *Energy in Transition, 1985–2010* (San Francisco: W. H. Freeman and Co.).

National Research Council, Committee on Radioactive Waste Management, 1980. Letter to Dr. Colin A. Heath, U.S. Department of Energy, April 18.

O'Hare, Michael, 1977. "Not on My Block You Don't – Facilities Siting and the Strategic Importance of Compensation," *Public Policy,* 25 (Fall), 407–458.

O'Hare, Michael, and Debra R. Sanderson, 1977. "Fair Compensation and the Boomtown Problem," *Urban Law Annual,* 14, 101–133.

Passmore, John, 1974. *Man's Responsibility for Nature* (New York: Scribner's).

Pitkin, Hannah, 1965. "Obligation and Consent – I," *American Political Science Review,* 59 (December), 990–999.

Rawls, John, 1971. *A Theory of Justice* (Cambridge, Mass.: Harvard University Press).

Ringwood, Ted, 1980. "Safety in Depth for Nuclear Waste Disposal," *New Scientist,* 88, No. 1229 (27 November), 574–575.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein, 1979. "Rating the Risks," *Environment,* 21 (April), 14–20, 36–39.

Starr, Chauncey, 1981. "Coping with Nuclear Power Risks: A National Strategy," paper presented at the International Workshop on the Analysis of Actual and Perceived Risk, June 1–3, Washington, D.C.

Stobaugh, Robert and Daniel Yergin (eds.), 1979. *Energy Future* (New York: Random House).

U.S. Council on Environmental Quality and U.S. Department of State, 1980. *The Global 2000 Report to the President,* 3 vols. (Washington, D.C.).

U.S. Department of Energy, 1980. *Statement of Position of the United States Department of Energy in the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste,* DOE/NE-0007 (Washington, D.C., 15 April).

U.S. Department of Energy, 1981a. *Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste,* DOE/EIS-0046F, 3 vols. (Washington, D.C.).

U.S. Department of Energy, 1981b. *The National Plan for Radioactive Waste Management,* Working Draft 4 (Washington, D.C., January).

U.S. Interagency Review Group on Nuclear Waste Management, 1979. *Report to the President,* TID-29442 (Washington, D.C.).

U.S. Nuclear Regulatory Commission, 1980a. "Draft Regulatory Guide and Value/Impact Statement: Instruction Concerning Risk from Occupational Radiation Exposure" (Washington, D.C., May).

U.S. Nuclear Regulatory Commission, 1980b. "Uranium Mill Licensing Requirements: Final Rules," *Federal Register,* 45, No. 194 (October 3), 65521–65538.

U.S. Nuclear Regulatory Commission, 1981a. "Disposal of High-Level Radioactive Waste in Geologic Repositories," *Federal Register,* 46, No. 130 (July 8), 35280–35298.

U.S. Nuclear Regulatory Commission, 1981b. "Licensing Requirements for Land Disposal of Radioactive Wastes," *Federal Register,* 46, No. 142 (July 24), 38089–38105.

U.S. President, 1980. *Message from the President of the United States Transmitting a Report on his Proposals for a Comprehensive Radioactive Waste Management Program,* 96th Congress, 2d Session, House Document 96-266 (Washington, D.C.).