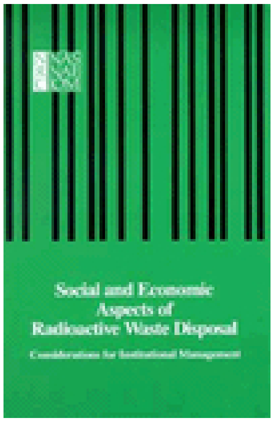


Social and Economic Aspects of Radioactive Waste Disposal: Considerations for Institutional Management

Panel on Social and Economic Aspects of Radioactive Waste Management, Board on Radioactive Waste Management, National Research Council

ISBN: 0-309-59543-6, 189 pages, 6 x 9, (1984)

Social and Economic Aspects of Radioactive Waste Disposal

Considerations for Institutional Management

Panel on Social and Economic Aspects of Radioactive Waste Management
Board on Radioactive Waste Management
Commission on Physical Sciences, Mathematics, and Resources
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1984

National Academy Press 2101 Constitution Avenue, NW Washington, DC 20418

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the panel responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

This study was supported by the U.S. Department of Energy under DOE Contract No. DE-AT01-80NE93030.

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed or represents that its use would not infringe privately owned rights.

Library of Congress Catalog Card Number 84-60101
International Standard Book Number 0-309-03444-2

First Printing, April 1984
Second Printing, April 1986
Printed in the United States of America

Panel on Social and Economic Aspects of Radioactive Waste Management

ROGER E. KASPERSON, Clark University, Chairman
FREDERICK R. ANDERSON, University of Utah
IRVIN V. BUPP, Harvard Business School
NANCY DORFMAN, Massachusetts Institute of Technology
E. LINN DRAPER, Gulf States Utility Company
JAMES A. FAY, Massachusetts Institute of Technology
GERALD GARVEY, Princeton University
JIM HARDING, Friends of the Earth Foundation
TODD R. LAPORTE, University of California, Berkeley
KAI N. LEE, University of Washington
SAMUEL LEINHARDT, Carnegie-Mellon University
ALAN S. MANNE, Stanford University
DENTON E. MORRISON, Michigan State University
JOHN E. SELEY, Queens College, The City University of New York
JULIAN WOLPERT, Princeton University
GARY L. DOWNEY, National Research Council Fellow

Staff

SUSAN M. DOWNEY
PETER B. MYERS
JOHN S. SIEG

Board on Radioactive Waste Management

Commission on Physical Sciences, Mathematics, and Resources

IN MEMORIAM

Angus Campbell

1910-1980

Angus Campbell was chairman of the Panel on Social and Economic Aspects of Radioactive Waste Management until his death on December 15, 1980. Noted for his pioneering work in survey research, Dr. Campbell was a professor of psychology and sociology at the University of Michigan. He helped to found and then directed the University's Institute for Social Research.

Dr. Campbell wrote several books and was considered an authoritative source on voting behavior, race relations, and the quality of life. He helped to establish the University of Michigan's Political Behavior Program, under whose sponsorship The American Voter (1960) was published. Consisting of a series of monographs with which Dr. Campbell was heavily involved, this document is considered to have had a seminal influence on the discipline of political science. His final book, The Sense of Well-Being in America, was published shortly before he died.

He was elected to the National Academy of Sciences in 1980.

Preface

In the spring of 1979 the National Research Council (NRC) Committee (later Board) on Radioactive Waste Management (BRWM) had the opportunity to comment on a presentation by a U.S. Department of Energy (DOE) contractor on a proposed study of nontechnical criteria for siting geologic repositories for high-level nuclear wastes. As a result of its consideration and ensuing discussions with DOE staff, the BRWM elected to submit a proposal to DOE for an assessment of what is known about these important criteria. The proposal was favorably received, and a DOE contract was awarded for a study of the social and economic aspects of radioactive waste disposal. Specifics on the panel mandate appear in Chapter 1 of this report.

The panel established under the aegis of the BRWM held the first of its nine meetings in March 1980 under the chairmanship of Angus Campbell. Following Dr. Campbell's untimely death in December 1980, Roger Kasperson accepted the responsibilities of chairman.

The panel benefited from briefings by members of the DOE technical staff and the Department's contractors and from the staff of the Oak Ridge and Sandia National Laboratories with particular attention to radioactive waste transportation. Additional helpful briefings and information were provided by representatives of the Mitre Corporation, the Office of Technology Assessment, and others.

In an effort to obtain a broad range of reactions from interested public sectors on the scope and methods of its study, the panel solicited views from almost a thousand individuals and organizations that had demonstrated previous interest in government activities involving radioactive waste management. Slightly less than 10 percent of those solicited responded. The panel also devoted a substantial portion of one of its meetings to a wide-ranging open discussion of its approach to its study with four representatives of environmental organizations selected by the panel.

In addition to providing counsel throughout the study, members of the BRWM conducted a formal review of the panel's report, as did selected members of the parent Commission on Physical Sciences, Mathematics, and Resources. A. Henry Schilling of the Battelle Human Affairs Research Centers provided a critical review of the treatment of institutional issues in Chapter 5.

The panel thanks Gary Downey, who worked with them as a National Research Council Fellow.

The project's first staff officer was Susan Stuen Downey. After her resignation from the National Research Council staff late in 1981, John Sieg served as staff officer until early 1983, when the Staff Director of the BRWM, Peter Myers, added the role of staff officer to his duties and saw the project through to completion. The study secretaries were, initially, Dee Cooper and, later, Betty King.

Contents

Social and Economic Aspects of Radioactive Waste Disposal Considerations for Institutional Management

1

Summary

The socioeconomic and institutional issues associated with high-level radioactive waste management are complex and challenging. Waste management decisions involve the allocation of uncertain risks and benefits to different regions of the country, to different generations, and to different social groups. Many of these decisions are linked to the national debate over the role of nuclear energy and the future of nuclear weapons.

In 1980, the U.S. Department of Energy (DOE) requested the National Research Council to conduct a study of socioeconomic aspects of nuclear waste repository siting, and a panel was established under the aegis of the Board on Radioactive Waste Management. The request was made, and the panel responded in the framework of the policy of several past administrations, since enacted into law with adoption of the National Nuclear Waste Policy Act of 1982, that high-level nuclear waste from commercial power reactors shall eventually be permanently isolated in mined geologic repositories.

Despite the difficulties in fashioning an acceptable strategy for high-level nuclear waste management, there is agreement that the present storage arrangements are not acceptable for the ultimate disposition of very-long-lifetime hazardous nuclear wastes. Selecting sites for geologic repositories and deploying a nuclear waste system that transports and manages those wastes must be accomplished with sensitivity to the complex socioeconomic issues involved.

The study mandate called for the identification of major socioeconomic considerations in the location, construction, and operation of a generic radioactive waste repository; an assessment of what is known about these considerations, the extent of the data base associated with them, and the applicability of what is known to the repository siting process; and finally, suggestion of an approach or approaches for incorporating socioeconomic considerations into the repository selection process. The panel took no position on the desirability or merit of permanent isolation in a geologic repository as the ultimate disposition of high-level radioactive waste.

In conducting its work, however, the panel did expand the mandate to incorporate other aspects of the radioactive waste disposal system, including issues related to transportation of wastes and temporary storage. This expanded focus allowed the panel to address key socioeconomic aspects of the nuclear waste management system that would not have been possible with a more limited focus on repositories. The panel paid particular attention to the etiology of public concern over nuclear wastes, to above-ground effects (especially on cost and equity) of different repository site locations, and to means for channeling public concerns (including those of states and local communities) into effective participation in decision making.

The panel found an incomplete and inadequate body of social science knowledge available to guide the formulation and implementation of an effective radioactive waste management system. The basis for assessing socioeconomic effects of comparable projects only partially exists, because of the underdeveloped state of the theory and methodology of social impact assessment, the limited scale of the research program enacted to date, and the difficulty of comparing the radioactive waste management program to other large-scale industrial projects. The panel explicitly rejected the idea that specific socioeconomic criteria could be developed at this time to supplement physical science and engineering criteria in the repository selection process. However, through its attention to waste transportation and facility location, effects at a repository site, intergovernmental relations, and the basis for public concern, the panel has identified socioeconomic issues that it views as among the more important social questions facing implementation of a workable radioactive waste management strategy. Moreover, the panel believes that the current state of knowledge precludes identification of a satisfactory means for integrating socioeconomic criteria into siting decision making and also that such decisions should be the result of a participatory process. The panel, however, views its work on this study as contributing to such goals.

In 1982, Congress enacted the Nuclear Waste Policy Act (NWPA), which outlined a comprehensive strategy for permanent disposal of commercial nuclear power wastes. Throughout the complex debate that led to this legislation, two issues—technical feasibility and public acceptance—were of paramount importance. This report examines the social science knowledge base appropriate to the latter issue, though it also addresses many technical, logistical, and institutional questions that fall between feasibility and acceptance. This analysis is intended to illuminate those key issues facing the DOE and other agencies responsible for the implementation of the NWPA.

The panel's limited resources prevented it from analyzing comprehensively the broad set of socioeconomic considerations that it identified. It examined, for example, only one scenario for nuclear power's future (a scale equal to the plants that are in existence or under construction) in terms of a few of the many radioactive waste management alternatives under consideration. The panel chose to allocate primary attention to spent-fuel management, leaving aside the implications of nuclear fuel reprocessing for waste generation, shipment, and social impact. The panel excluded consideration of commercially generated low-level nuclear wastes, and it has not addressed questions directly relevant to the management of defense wastes, except to note those experiences that offer lessons. The results of this effort are most properly viewed as suggestive of research that can be performed and as indicative of major gaps that need to be filled.

APPROACH OF THIS STUDY

The study panel found that there are several conceptions of the term "socioeconomic." At one extreme is the narrow view that the term should be limited essentially to measurable changes in employment, housing, and demographic characteristics that would be caused by a new facility. At the other extreme is the broad view that socioeconomic should refer to virtually any nontechnical effect, whether psychological, political, or behavioral. Clearly all the effects of a given facility cannot be reasonably anticipated or accounted for in the short run. While the narrow conception of the term socioeconomic has the advantages of simplicity and ease of measurement, its use may be greatly misleading to the decision maker.

Site selection is a political as well as social issue, involving complex value judgments and a wide range of poorly understood "effects." Both the state of the art of social impact theory and the complex nature of nuclear waste repository siting argue, in the panel's view, for adopting a wide view of the term. Even though methods for measuring and comparing many kinds of effects are not yet fully developed, the panel concluded that both methodological and political realities require us to go beyond the relatively narrow definition usually employed in environmental impact statements.

Efforts to identify criteria for making decisions are founded on the assumption that there is an adequate body of knowledge that can be used to link particular programs with particular results. Where such a body of knowledge is available, choices can be made among options based on an assessment of beneficial or harmful effects. If socioeconomic criteria are to be used in selecting repository sites, however, two conditions must be met:

1. The effects likely to result from choosing one or another option must be specified, in regard both to an individual repository and to the progressive deployment of an entire waste management system. This suggests that effects caused by the waste management operations for a U.S. nuclear energy system involving at least twice the currently licensed 75 nuclear power plants must be assessed. In addition, there are effects from the waste generated by the military program.
2. The social values relevant to the concerns and goals of different social groups, particularly as they bear on the socioeconomic effects experience, must be specified. In other words, the social values (e.g., equity, quality of life) should be described in ways that allow the public to judge the degree to which the waste program realizes or fails to realize them.

Both of these analytical elements should be addressed. However, when the panel took up its work it discovered that only limited progress had been made in the first and little or no progress in the second area. Although a data base of useful studies and surveys has been emerging, little systematic work has been done in integrating the results or assessing their relevance to policy choices in a radioactive waste management system. Experiential information on the socioeconomic effects of a high-level waste repository is not available because no such facility has been established in the United States. Instead, assessment must draw on the siting of other nuclear fuel cycle facilities, highways, and noxious functions (e.g., drug treatment centers, prisons, hazardous waste disposal sites) and interpret this experience in light of possible relevance to nuclear waste facilities. Further, there has been little attempt to specify the conditions that would signal the attainment of various social or economic outcomes.

The panel believes that further research is required for sound estimates of the social, economic, and political consequences of locating and operating a nuclear waste repository at a particular site in the United States. The panel is also quite certain that those sponsoring and conducting research are in full agreement with this statement; in fact, it is explicitly acknowledged in reports and briefings. Even greater information and analyses are needed on the effects of waste management systems composed of more than one repository, for such a system is likely needed to service present and future reactors.

The panel necessarily limited itself to near-term socioeconomic considerations (i.e., the next 50 years). Owing to the very long duration of radioactive waste hazards, there may be socioeconomic effects far beyond this. However, since the predictive powers of social science are very limited, the highly uncertain long-term considerations cannot play a definable role in repository site-selection criteria. What the panel has sought to do is identify the relatively near-term socioeconomic and institutional considerations that should be addressed in locating, building, and operating high-level waste repositories, to explore the nature of the considerations, to assess the adequacy of the current data base and understanding, and to suggest the implications of alternative strategies for addressing these considerations. In doing so, the panel has identified a variety of assumptions that could constrain current policy choices and conceptions of the management system. The panel did not, however, restrict its analysis to fit those preconceptions. This report, in fact, points out areas where such assumptions should be explicitly debated.

As noted earlier, the study focuses on the isolation of unreprocessed spent fuel produced in commercial nuclear power reactors. Consistent with its study mandate, per manent isolation of the waste in stable geologic formations within the continental United States was the only disposal concept considered. Because the configuration of the network of waste facilities influences the number of potentially affected states and communities, the panel addressed facility locations and the associated transportation system that would be required to move the wastes from the places where they are generated to repository sites. The managerial and socioeconomic issues involved in storing spent fuel temporarily at reactors or away-from-reactor storage facilities were also considered.

The panel did not address the question of the overall role of nuclear power in the United States, nor did it compare the effects of nuclear power and its wastes with those of nuclear power's alternatives. Potential health effects and the adequacy of the technology for isolating radioactive wastes were considered only to the extent that they impinge on social issues and public concerns.

MAJOR SOCIOECONOMIC CONSIDERATIONS

In its mandate to the panel, the U.S. Department of Energy (DOE) requested an identification of major socioeconomic considerations involved in repository siting, construction, and operation. As noted above, the social science knowledge base does not at present permit detailed predictions or development of siting criteria. Nonetheless, the panel has developed a list of major socioeconomic considerations that ideally should be addressed in siting nuclear waste repositories over the next several decades. The list is, of course, not exhaustive, and a different group of social scientists would certainly identify other considerations. Nevertheless, those identified herein suggest the scope and types of issues that require analysis by the DOE.

The considerations are stated in the form of questions and follow the organization utilized in this report. The list, of course, is much larger than could be addressed by the panel in one study. Those issues assessed either partially or fully by the panel are indicated by an asterisk.

A. Public Response

1. What are the trends, magnitude, and characteristics of public concerns over radioactive wastes?*

2. How do public concerns over these wastes compare with concerns over nuclear power, hazardous wastes, and other technological hazards?
3. What explains public concerns over radioactive wastes?*
4. How may public trust and confidence be developed in the institutions responsible for radioactive waste management?*
5. How may public values best be accommodated in repository site selection, in weighting various socioeconomic and institutional effects, and in avoiding or mitigating adverse effects?
6. How should public concerns and values be compared, and weighted, with technical criteria?

B. The Waste Management Network

1. How will the number and location of waste repositories affect the socioeconomic and institutional burdens associated with radioactive waste management?*
2. What socioeconomic effects will be associated with at-reactor, away-from-reactor, or interim storage facilities co-located with repositories?*
3. What significance should be attached to psychological stress occurring at facility sites and along transportation corridors?
4. Should socioeconomic effects occurring along transport corridors be included in impact mitigation programs?
5. How will scale and the rate at which the waste system is brought to scale affect the magnitude of socioeconomic effects and institutional burdens?*
6. What socioeconomic and institutional considerations are involved in the mix of transport modes (railroads, trucks, barges) used in transporting radioactive wastes?*
7. How sensitive are overall waste management costs to transportation designs, cask costs, and repository development?
8. How should waste management costs be compared, and weighted, with long-term safety and intergenerational equity?
9. How adequate are state and local monitoring, regulatory, and emergency response capabilities, given the demands that may be placed on them during the deployment of the waste management system?

10. How are the beneficial and adverse effects of radioactive waste management distributed over generations, geographical regions, social groups, and beneficiaries and nonbeneficiaries over nuclear power?*

C. Site Effects

1. To what extent will the socioeconomic effects of a nuclear waste repository resemble those associated with other large industrial facilities located in rural areas?*
2. Which effects are amenable to quantitative expression, and which must be stated in qualitative terms?*
3. Which effects can be reasonably predicted in advance, and which are likely to become apparent only as the site is developed?*
4. How significant are rates as compared with types of social and economic change in the host repository region?
5. What are likely to be the most beneficial impacts of a repository on the host community and region?
6. How may socioeconomic changes in one locale be compared with those at another?
7. How may local citizens best participate in identifying, assessing, and proposing means to ameliorate siting effects?*
8. What is the likely magnitude of socioeconomic effects associated with postclosure or unexpected premature closure of the repository?
9. How adequate are provisions in the Nuclear Waste Policy Act of 1982 and other existing governmental programs for assuring the time and equitable flow of incentives, impact mitigation, and compensation measures?*

D. Institutional Issues

1. what is the nature of this generation's responsibility to future generations?
2. What are the institutional prerequisites for effective management and disposal of radioactive wastes?*
3. What means exist for resolving conflict over repository siting at both federal/state and state/local levels, and how adequate are they?*
4. How adequate are the scientific and managerial resources of the major institutions responsible for radioactive waste management for identifying and

responding to the social and economic obstacles to the timely implementation of the Nuclear Waste Policy Act of 19827

5. What types of failure identification and contingency planning are required for effective implementation of the Nuclear Waste Policy Act of 1982?*
6. What are the alternative modes of conflict resolution available for siting controversies, and what are their potential applicability to the radioactive waste problem?
7. How may the integrity and stability of the radioactive waste management program be insulated from changing political administrations?
8. Given the complexity of a National High-Level Waste Program, what long-range institutional effects will need to be addressed?*
9. How is experience with siting low-level radioactive waste and other hazardous waste facilities likely to affect (if at all) the siting of a high-level radioactive waste repository?
10. How may public information and involvement programs for radioactive waste management best be designed, managed, and evaluated?*
11. What should be the relationship (if any) in the management of high-level commercial and defense radioactive wastes?

MAJOR FINDINGS

All the above issues could not, of course, be addressed in the panel's study. As noted above, the panel has evaluated a number of those issues judged among the more important and within study scope and panel expertise. Generally these fall within the major chapter headings—public concern, effects of facility location and transportation, site-related effects, and institutional issues.

1. Although the electoral, legislative, and administrative sectors in the United States have historically demonstrated substantial support for the economic benefits of nuclear power, over the past 15 years (and particularly since 1979) support has weakened significantly in all three sectors. In the same period, an articulate organized opposition has emerged, one with support among a significant minority of the population.

2. There is widespread perception that nuclear energy entails risks to health and safety. This perception is exacerbated by the fact that most of the public groups do not distinguish clearly between the risks of nuclear weaponry and those of nuclear power plants. The extent to which fear over nuclear weapons enters into attitudes on nuclear wastes is difficult to pinpoint, but it is undoubtedly an element in the formation of public opinion. Concern over catastrophic accidents in nuclear power plants appears to add to these fears of the technology.
3. The level of knowledge about nuclear power and radioactive wastes remains low among the general public. This limited knowledge, however, does not explain the high level of concern. It is uncertain whether greater amounts of information would reduce or increase public concern, but improved public understanding of waste management problems is a central need for developing an informed public policy and a socially acceptable management program.
4. Public concern and the perception of threat are exacerbated by mistrust of government in general and by the appearance of secrecy or desire to exclude the public from governmental decisions about radioactive waste and repository siting.
5. A substantial disparity exists between the amount of research effort expended on technical aspects of underground nuclear waste storage and the limited efforts expended on the above-ground design of a waste system. Specifically, the socioeconomic and institutional issues associated with facility location and transport modes, routes, distances, and scheduling require greater attention than they have received to date. While the panel believes that the logistical and institutional challenges involved can be met, it finds substantial tasks ahead that merit attention in a formulation and implementation of a national radioactive waste management strategy. The panel also emphasizes that the kinds of problems involved are not readily amenable to easy technical solutions; they must be considered in the overall system design and in institutional policies that include socioeconomic as well as technical criteria.
6. The socioeconomic and institutional effects associated with the network of nuclear waste facilities and transportation are quite sensitive to the number and location of repositories. These effects, as suggested by the panel's analysis, include transport system complexity, shipping costs, public concern and conflict, vulnerability

to possible transport system bottlenecks, and institutional burdens on states and localities. One problem—interregional inequity—viewed as particularly important by the panel, could be minimized through regional siting. The relationships among these factors and effects have received only limited research attention and require further explicit analysis. They will also need to be weighed against geologic criteria and overall waste management system costs.

7. The socioeconomic effects of establishing temporary away-from-reactor facilities for interim storage depend on specific assumptions and scenarios chosen and are at present not well understood. Whether such storage facilities are co-located with repositories, located at reactors, or located away from both reactors and repositories appears to affect significantly total system transport costs, regulatory and emergency response burdens on state and local governments, and public concern along transport routes. At-reactor storage, in particular, may have potential for reducing these effects. At the same time, the panel recognizes the potential usefulness of the limited away-from-reactor storage provided for in the Nuclear Waste Policy Act of 1982.
8. Current DOE plans assume that the transportation of waste will be primarily by rail. The panel has identified a variety of obstacles to a predominantly rail transportation system. The rail industry appears to have few economic incentives and a stated reluctance to take on radioactive waste transport. Rail also does not appear to have a decisive economic advantage over truck transport, and the rail system is less responsive to possible demands for routing changes. These obstacles should receive further review from the DOE. If these problems lead to greater use of truck transport, differing socioeconomic and institutional effects will need to be anticipated.
9. The research base that exists to support the selection of sites for a nuclear waste repository and the formulation of programs for impact mitigation is limited and uneven. The underdeveloped state of theory in social impact assessment theory and methodology and the cursory efforts thus far in comparative analysis of impact mitigation are particularly problematic. The limited research program sponsored by the DOE has not sufficed to fill this void. As a result, no authoritative statements can be made at this time about the magnitude, types, or

rates of adverse socioeconomic effects to be expected at a repository site nor criteria that should be formulated for site suitability or an appropriate program of impact mitigation.

10. Adverse socioeconomic effects will likely be strongly site-specific and will be related in particular to the population size and rural qualities of the host region as well as to the overall waste system design. These effects will be difficult to predict on the basis of experience with other types of facilities at other sites. These effects have the potential, however, for substantial harm to the host community and region and should, therefore, receive more thorough assessment than has been accomplished to date.
11. The special effects associated with the radiological mission of the repository will interact with, and may well exceed, the more conventional effects resulting from the location of any large industrial facilities in rural communities.
12. A number of significant effects will not become evident until the siting process begins. Accordingly, careful monitoring of socioeconomic effects at the site and a program for timely and flexible provision of resources to reduce or mitigate adverse impacts are required. The panel finds that an appropriate mechanism for assuring the active involvement of local residents in assessing site effects and in monitoring mitigation and compensation programs does not now exist and should receive attention by the DOE.
13. A sound program to anticipate and respond to the effects of siting a radioactive waste repository should, in the panel's view, comprise (a) analysis of socioeconomic effects, with participation by the residents; (b) development of plans and policies to avoid and to mitigate adverse effects, with participation by the residents; (c) capital, provided by the beneficiaries of nuclear power, to fund mitigation of expected adverse conventional effects; (d) compensation for adverse effects, conventional and special, that cannot reasonably be avoided or further mitigated; and (e) means of redress for effects resulting directly from the siting of a repository or from overall changes in the radioactive waste program that alter site characteristics.
14. An ambitious program of technical and financial support to mitigate adverse effects at repository sites will be needed. While the Nuclear Waste Policy Act of 1982 provides for this need, several problems may be

expected in implementation. The goals and levels of funds for impact mitigation are set at an early stage in site development, yet many effects cannot be anticipated and will become apparent with the development of the site and the beginning of operations. Moreover, no assurance exists that the states will adequately assess the needs of the host locality and allocate funds in an effective manner.

15. A major institutional gap exists in the framework defined in the Nuclear Waste Policy Act of 1982. There is no institutionalized process for relating the concerns of locally affected populations to the actions of state governors or legislatures. Institutional designs for bridging this gap have been utilized in other policy areas and may provide possible means to fill this void.
16. The site-selection timetable outlined in the Nuclear Waste Policy Act (NWPA) is likely to force the DOE to choose between an open, consultative approach to planning that fails to meet deadlines and a closed, executive approach that meets schedules. A decision to adhere to the tight schedule of the NWPA could contribute to insufficient attention to local concerns and participatory opportunities or result in inappropriate compromises.
17. Informal processes of planning and conflict resolution can provide valuable supplements to the official administrative and judicial processes outlined in the Nuclear Waste Policy Act. Environmental mediation is one such process that deserves further exploration.
18. An ambitious program of public participation is needed to meet the challenges posed by high levels of public concern and the complexity of issues surrounding the siting of nuclear waste repositories. Previous research and experience suggest that an effective participation program will include (a) the direct involvement of affected public groups in impact assessment; (b) early and broad public involvement in both site searching and site selection, within the context of technical criteria; (c) the development of an independent technical review capability, similar to that created for the state of New Mexico for a Waste Isolation Pilot Plant, among citizens of the communities hosting the repositories or those exposed to extraordinary waste transportation flow at major points along the waste funnel; (d) a variety of techniques and mechanisms of public participation, since the state of social science theory does not indicate a preferred mode of public

participation. The participation program may be designed as a major research effort, with participation of citizens, peer review, and careful monitoring and evaluation.

19. Transportation of radioactive wastes by truck could be carried out either by a federally owned and operated fleet or by private trucking companies subject to federal and state regulation. Whether private companies or the federal government transport the waste, a sound federal regulatory system requires (a) a sufficiently broad-based and uniform regulatory regime, (b) the elimination of redundancies and incompleteness in the existing Nuclear Regulatory Commission-Department of Energy regulations for transportation, and (c) addressing the desire of states to deal with safety on their own highways.

2

Public Concerns

There exists a long and extensive legacy of disputes over the siting of facilities, both public and private (Popper 1981, Seley 1983). Various public groups have objected to gas stations, airports, highways, group homes (community residences for the mentally retarded), recombinant DNA laboratories, and, of course, nuclear power plants. During the past decade, the list of controversial facilities appears to have expanded. It is evident that a waste repository will engender strong reaction from local public groups, independent of the reactions, both in support and opposition, of official government entities. In siting some types of facilities, a low-profile or Machiavellian approach has worked in the past. Particularly notable is the group home, which was rarely opposed when first introduced but is now subject to predictable controversy. Estimates range from a 30 percent to a 75 percent rate of rejection for proposed group homes, despite little evidence of any real harm to host communities (Seley 1983).

Power plants, too, underwent a cycle of acceptance prior to the Three Mile Island accident and subsequent public response. In the few instances involving commercial high-level radioactive waste, efforts to search for sites have been subject to controversy. It is apparent that any effort to find a site for a repository (or repositories) will engender a range of concerns that must be addressed if siting is to proceed without undue delay and social disruption. This is a conclusion based on both historical evidence and the demands of societal equanimity.

This chapter has four objectives: (1) to assess the trends and characteristics of public concerns about the management of radioactive wastes, (2) to evaluate the adequacy of current scientific understanding of these public concerns, (3) to examine critically the hypotheses that have been put forth to explain patterns of public concerns, and (4) to note the major limitations of the data base and methodology for current understanding and inferences.

THE DATA BASE

This section examines the various subsets of the data base available for assessing the attitudes of the general public and some of the major characteristics of public response. Later in the chapter we address the limitations to both the data and the methods for making inferences from them. Inasmuch as the problem of isolating radioactive wastes has been a matter of public concern for less than a decade, it is not surprising that social science research on public response to the problem is also of recent vintage. Government agencies have funded extensive research on the technical issues of waste isolation, but far less funding has supported investigations of the social issues raised by nuclear power. Hence, the data base for assessing the attitudes of the general public has a number of deficiencies. Nevertheless, there exists a sizable amount of past work that, if tapped judiciously, can suggest major characteristics of public response.

Several collections of relevant public opinion polls have appeared in Public Opinion Quarterly (Erskine 1963, de Boer 1977). In 1978 the Battelle Human Affairs Research Centers published a comprehensive overview of more than 100 national, state, and areawide polls and surveys dealing with public attitudes on nuclear power (Melber et al. 1977). This overview was subsequently updated by the Battelle group to include polls and surveys taken from 1977 through the summer of 1979 (Melber et al. 1979). For the past decade, national polling agencies such as Cambridge Reports, Opinion Research Corporation, Louis Harris and Associates, and, more recently, the Gallup Poll, have regularly sampled opinion on nuclear power and nuclear wastes. Finally, Robert Cameron Mitchell of Resources for the Future has carefully appraised the various surveys of nuclear power (Mitchell 1978, 1980).

A second body of data consists of psychometric studies conducted by Decision Research Inc., by the International

Institute for Applied Systems Analysis (IIASA), and by the Netherlands Organization for Applied Scientific Research. Decision Research Inc. has asked people to make judgments about risky technologies and activities, to rate their risks and benefits on as many as 18 different risk attributes (e.g., newness, severity of consequence), and to state their preferences for risk reduction (or "acceptable" risk). Nuclear power has been included in the studies, along with some 29 (recently broadened to 93) other technologies and activities. Three groups of subjects—college students, a local chapter of the League of Women Voters, and a local businessmen's organization—have given answers so far. Decision Research has also asked college students to write scenarios of the maximum credible nuclear power disaster that might occur during their lifetimes. The work of Vlek and Stallen (in press) and of Stallen and Thomas (1981) is similar to that of Decision Research but has involved a representative sample of the population of the greater Rotterdam area. Scholars at IIASA have utilized an attitude formation model to inquire into public beliefs about nuclear power, obtaining the views of energy experts, a heterogeneous sample of the Austrian population, and participants in a nuclear energy referendum in the United States (Otway et al. 1978).

A third collection of studies has used clinical methods to explore personal fears and emotional responses to nuclear energy. Prominent among these are the works of Robert Jay Lifton, which include Death in Life (1968) and The Broken Connection (1979), based on interviews of the survivors of the atomic bombing of Hiroshima. Psychological analysis has also been conducted by Pahner (1976), who reviewed behavioral literature, press reports, interviews, and public demonstrations at reactor facilities to identify the conscious and unconscious fears that influence public attitudes to nuclear power. Robert L. DuPont (The Media Institute 1980) has analyzed the news media handling of nuclear power issues, while others have examined the attitudes of media representatives (Rothman and Lichter 1982). Recent studies of psychological stress in the people who live near the Three Mile Island nuclear plant have provided additional empirical data on public fear and anxiety (U.S. President's Commission on the Accident at Three Mile Island 1979, Bromet 1980, Houts et al. 1980).

There have also been a number of public votes on nuclear power issues. In 1976 there were unsuccessful referenda in California and six other states aimed at restricting nuclear power. The California referendum, defeated by a 2-1 margin, has been the subject of several detailed analyses (Groth and Schutz 1976, Hensler and Hensler 1979). Questions involving nuclear power appeared on 1980 ballots in an additional six states, and nuclear waste was a primary issue in all but one. Voters approved three and rejected three of these initiatives.

Organized political activity on nuclear energy has been examined as part of the broader study of political interest groups. Energy and environmental groups differ markedly from interest groups whose principal motive is economic interest in government decisions (McFarland 1976, Berry 1977). Both staff and member-supporters place high value on influencing public policy per se rather than measuring success in immediately tangible economic terms. These "public interest" groups have organized successfully around both promotion of and opposition to nuclear power.

Antinuclear groups have used a variety of means, including ballot initiatives and protest and civil disobedience (Nelkin 1981a, 1981b). How these means are selected through the internal decision processes of these and other protest groups is not well understood (Lipsky 1968), although Berry (1977) and Douglas and Wildavsky (1982) agree that the internal structure and dynamics of voluntary groups shape their public positions significantly (see also Wilson 1973, Chaps. 13 and 14).

Attention has also been paid to public attitudes to nuclear power in a number of other societies. Poll data comparable with those in the United States are available for a number of other countries (see, for example, Greer-Wooten and Mitson 1976, Renn 1981). Nelkin (1977), Nelkin and Pollock (1981), Zinberg (1982), and Paige and associates (1980) have provided comparative overviews of the nuclear controversy, public information campaigns, and public reaction in European countries.

The data base, nonetheless, is uneven, as discussed below.

THE EMERGENCE OF PUBLIC CONCERNS

Public attitudes to civilian uses of nuclear power were generally positive until the last decade. Generally, there was little concern prior to the late 1950s about the risks posed by the few reactors in operation. There was, to be sure, considerable concern over the development of nuclear weapons and substantial public support for efforts to limit them (Erskine 1963). There was also concern over the dangers of atmospheric fallout of radioactivity from the testing of nuclear weapons (Kraus et al. 1963, Kopp 1979).

As the debate over the dangers of fallout continued, the press began to report incidents that raised questions about the safety of nuclear power (Figure 2.1): an accident at Sylvania Electrical Products in New York, control problems at the Argonne National Laboratory reactor, an accident at an experimental military reactor in Idaho, and the Windscale accident in Great Britain. In 1957 the AEC published its first major report (WASH-740) on safety, citing the potentially catastrophic consequences of a major reactor accident unless strict protective measures were engineered, and Congress debated federal insurance for nuclear power plants. This attention to nuclear power plant safety coincided with the intense debate over fallout, suggesting that media attention to nuclear safety was related to the widespread anxiety over fallout (Mazur 1975).

An early test of public sentiment toward nuclear waste occurred in a 1960 survey of attitudes on the siting of the Indian Point reactor, which revealed that 57 percent of respondents felt confident that waste isolation was safe and only 13 percent had some questions (Rankin and Nealey 1978, p. 112). A national survey by the Sindlinger Company in the same year found that none of the respondents who opposed nuclear power gave waste management problems as a reason (Rankin and Nealey 1978, p. 112).

Nuclear power was not a major political issue during most of the 1960s. However, there were protests over the construction of some individual nuclear power plants, and in 1968 the environmental movement revived dormant public concerns over nuclear power and elicited new ones as well. At first the focus was largely on possible adverse environmental impacts, particularly thermal pollution. During the 1970s, however, public attention shifted from environmental to safety issues, prompted by such incidents as the leaking of radioactive wastes from storage tanks at the Hanford Reservation in Washington State in 1973. In 1974, a survey by Opinion Research Corporation found that 52 percent of the respondents believed that waste management was a serious problem. That was more than the combined percentages of respondents who cited radiation, nuclear accidents, and thermal pollution as concerns.

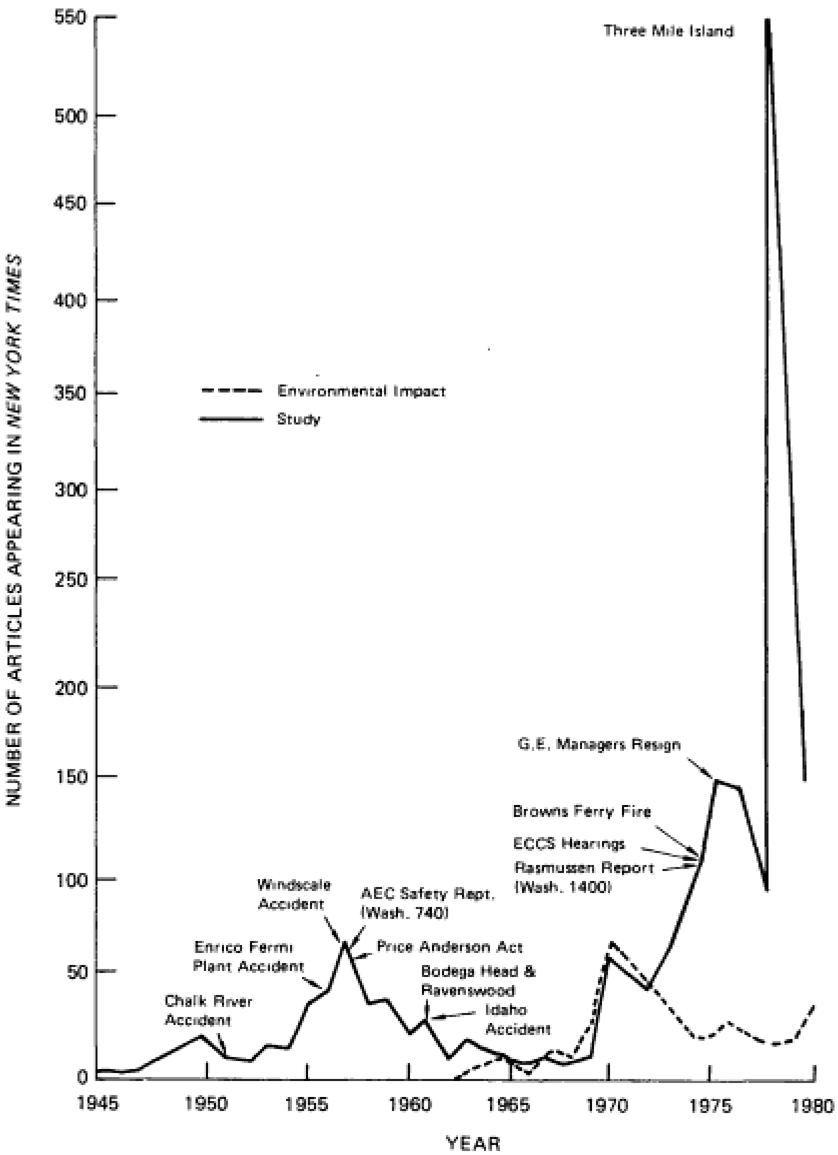


Figure 2.1 Media concern as indicated by attention in The New York Times. Source: Updated from R. A. Kasperson. 1980. The dark side of the radioactive waste problem. P. 159 in Progess in Resource Management and Environmental Planning, T. O'Riordan and K. Turner, eds. New York: Wiley, 1980), Chap. 6, p. 159.

Waste issues continued to rank at or near the top of public concerns over nuclear power during the latter half of the 1970s, and state and local governments began to pass laws restricting the use of their areas for disposal. Meanwhile, public support for nuclear power waned (de Boer 1977). The long-term impacts of the accident at Three Mile Island (Figure 2.2) are not yet apparent but are likely to include some loss of enthusiasm among supporters of nuclear power and the movement of more people into opposition (Mitchell 1980, pp. 18-19). Since 1978, Harris polls have found respondents opposed by nearly 2-1 majorities to nuclear plants being built within 5 miles of their homes. A 1980 Harris poll also found that a majority of the public continued to support nuclear power, but more than 8 of every 10 respondents believed that fundamental changes in regulation were needed to keep the risks of nuclear power "within tolerable limits" (Marsh and McLennan 1980, p. 39). Moreover, a Resources for the Future survey in 1980 found that nuclear power stood at the bottom of the public's list of preferred energy sources. Thus, if the high level of concern about radioactive wastes persists public acceptance will be a difficult goal to achieve for any large-scale waste management program.

DEMOGRAPHIC CORRELATES OF PUBLIC CONCERN

Public opinion about nuclear power varies according to certain characteristics. The *most* noteworthy difference is that between men and women. Polls and surveys have revealed a consistent tendency for women to be more uncertain about or opposed to nuclear energy than men are. The 1977 Battelle review, for example, found that among men the mean support for nuclear power was 65 percent, as compared with 46 percent among women. Polls conducted after the accident at Three Mile Island suggest that it may have further widened these sex differences. The Cambridge Reports opinion polls indicate that these sex differences also extend to opinions on nuclear waste, with women significantly less confident than men that the problem can be solved (Rankin and Nealey 1978, p. 116). A Rand Corporation study of the California nuclear referendum revealed sex to be one of the few demographic factors that correlated significantly with nuclear attitude (Hensler and Hensler 1979). Another study, which involved reinterviews with respondents to obtain

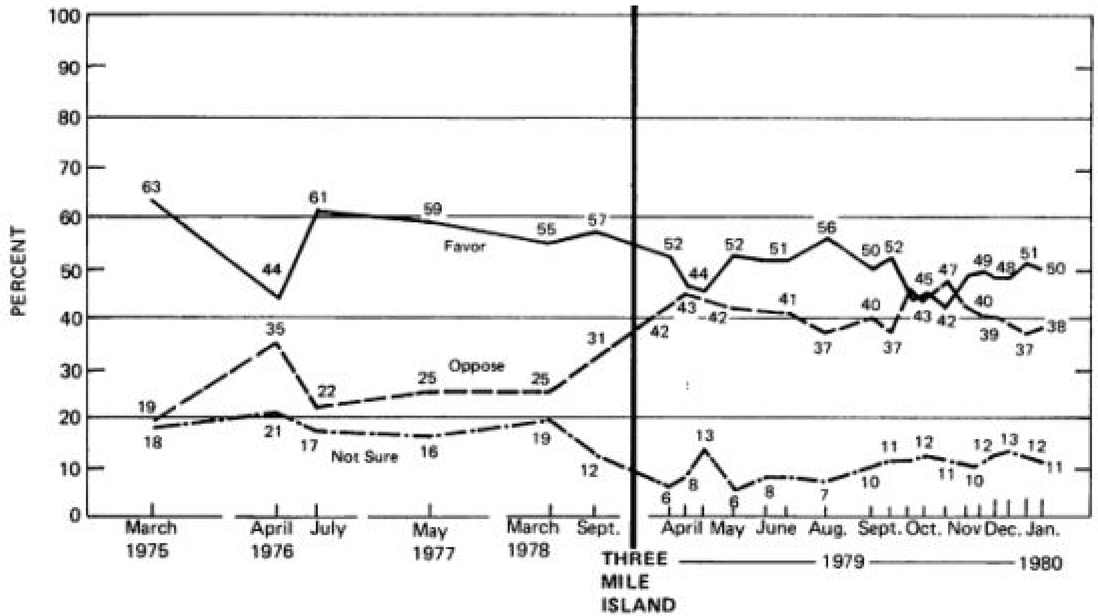


Figure 2.2 Harris poll trend line on building more nuclear power plants. In general, do you favor or oppose the building of more nuclear power plants in the United States?

Source: March 1975 to June 1979 data made available by Louis Harris Associates. The remainder of the data were made available by the Edison Electric Institute. All polls are national but sample sizes vary. Some are personal interview, and others, including most of the post-Three Mile Island data, are telephone surveys.

their views about a nuclear waste facility in New York State, found that exposure to the controversy that surrounded it increased negative attitudes among women but not among men (Mazur and Conant 1978). Studies of the Three Mile Island accident also indicate higher levels of continuing psychological stress in mothers of young children (Bromet 1980). The contrast between the sexes is all the more striking given that it appears to be independent of other socioeconomic factors and that recent polls have shown few differences between the sexes in their attitudes to environmental issues (U.S. Council on Environmental Quality 1980, p. 29).

A prime ingredient in this differential response is concern over the catastrophic releases of radioactivity from nuclear plants. All recent polls reveal that women are significantly more concerned (and uncertain) about nuclear power than are men. Even the stated uncertainty may mask latent concern; the woman who is "not sure" may actually be signifying dissent (Duncan 1978). The common but erroneous belief that nuclear plants can explode like nuclear weapons may also play a role, for it is known that women across a variety of cultures are less prone to violence and more concerned about loss of life than men are (Setlow and Steinem 1973, Steinem 1972). One study, using free-association questions, found women significantly more fearful than men that nuclear plants might "explode" and more concerned about the long-term effects of radiation (Kasperson et al. 1980). A survey of 1,004 Massachusetts residents found that women were opposed to nuclear power not because they were less knowledgeable or because they harbored antitechnological values but rather because they felt more concern about safety and moral questions rather than about economic growth (Reed and Wilkes 1980a). One analysis of women's magazines and the feminist press has concluded that the genetic effects of radiation on women and, hence, on future generations particularly influence the concerns of women (Nelkin 1981a). While considerable evidence exists of a differential response between the sexes, however, a searching and authoritative explanation has not yet been forthcoming.

Other demographic correlates of concern about nuclear power and nuclear wastes are less well understood. Younger persons (those under 30) are more likely to oppose nuclear power than are older persons. Correlations with education and income tend to be ambivalent or inconsistent. Some survey results indicate that more highly educated and higher income groups support nuclear power, whereas others provide contrary results or show no significant association. In their review of polls on nuclear wastes, Rankin and Nealey found few differences related to education and income on the question of whether such wastes "are too dangerous" to produce, although they did find a greater tendency for low income and less educated respondents to be unsure.

Despite the polarization over nuclear power in the scientific community and the extensive media coverage of nuclear issues, the public has largely refused to join either side. A national survey in 1978, in fact, revealed that only 2 percent of the respondents were active participants in the controversy over nuclear energy, with another 27 percent sympathetic and 21 percent unsympathetic to the antinuclear movement (Mitchell 1978, p. 5). The remaining 44 percent of those polled defined themselves as neutral. This division contrasts with the larger active public participation in and support for the environmental movement as a whole (Figure 2.3). Mass public support for environmental activism does not imply similar support for antinuclear activism (Mitchell 1980).

The Three Mile Island accident appears to have had only a marginal impact on public sentiment, increasing the active segment from 2 to 4 percent and the sympathetic from 27 to 29 percent. These changes, however, are balanced by an increase in the unsympathetic from 21 to 26 percent (Mitchell 1980), and attitudes may not yet have stabilized. Thus, while several small minorities are active in supporting or opposing nuclear power, the broad middle of the public, while certainly wary of nuclear power and more positive toward other energy sources, thus far remains uncommitted.

Finally, an apparent difference of opinion exists between technical experts on the one hand and the lay public and public officials on the other. Technical experts tend to see high-level waste management as a more solvable problem than do members of the public. This difference in attitude has been demonstrated by research at Battelle (Maynard et al. 1976) and is also apparent in the different responses of the business and regulatory communities in the 1980 Marsh and McClennan national poll on risk (Table 2.1). These results suggest that technical experts may underestimate the degree and misperceive the reasons for public concerns.

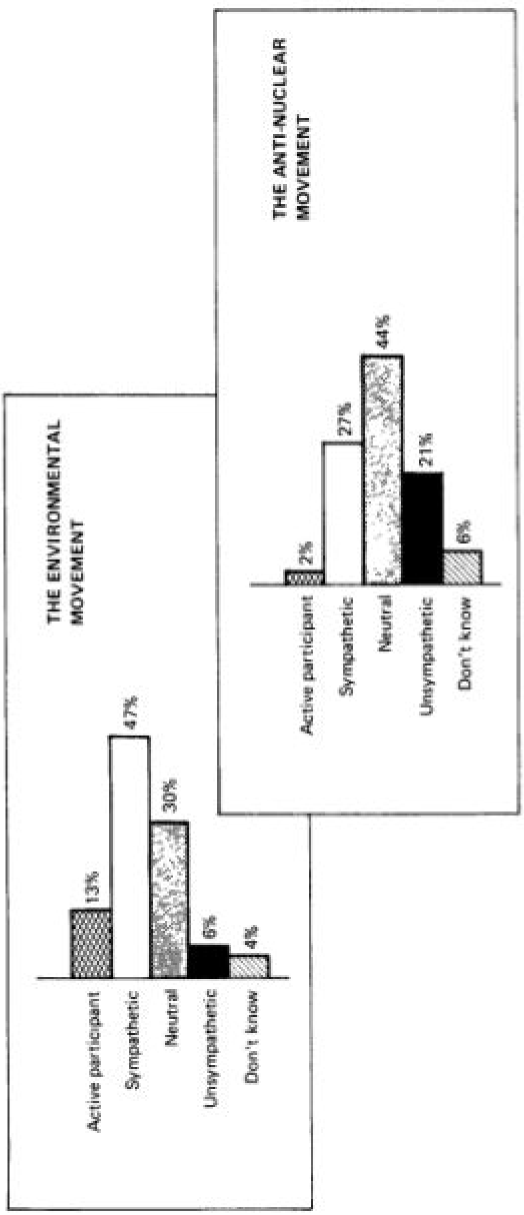


Figure 2.3 Comparison of public sentiment on the environmental and antinuclear movement.
Source: Robert Cameron Mitchell, "The Public Speaks Again: A New Environmental Survey," Resources, No. 60 (September-November 1978).

TABLE 2.1 Attitudes toward Nuclear Power Issues

(Number of respondents)	Top Corporate Executives (402) %	Investors/ Lenders (103) %	Congress (47) %	Federal Regulators (47) %	Public (1,488) %
Fundamental regulatory changes are necessary if the risks of nuclear energy are to be kept within tolerable limits					
Agree	47	57	81	72	84
Disagree	46	35	17	19	9
Not sure	7	8	2	9	7
The disposal of nuclear waste is a problem that can be solved in an acceptable way					
Agree	90	85	66	66	62
Disagree	2	1	21	11	26
Not sure	8	14	11	23	12
Nuclear power is too dangerous to permit its continued expansion					
Agree	2	-	30	17	34
Disagree	98	98	70	72	59
Not sure	-	2	-	11	7

SOURCE: Marsh and McClennan, Risk in a Complex Society, a Marsh and McClennan Public Opinion Survey, conducted by Louis Harris and Associates, Inc., 1980), p. 39.

THE CAUSES OF PUBLIC CONCERN: ALTERNATIVE HYPOTHESES

Speculation abounds as to the reasons for the evident public concern over nuclear power. Some see concern as the result of technical ignorance of the public and its inability to see nuclear power and waste issues in the context of other natural and technological risks. Some attribute the concern to a connection that people make between nuclear power and nuclear weapons. Others point to a broad and growing public intolerance of technology. Still others believe that there are significant technical risks that have not been recognized by the proponents of nuclear power. Note that the hypotheses are not mutually exclusive: more than one may be valid, and the effects may interact synergistically.

In this section the various hypotheses that have been put forward to explain public concerns are examined in the light of existing data and analyses.

Public concern over nuclear power, it has been argued (Firebaugh 1981), is largely a product of unfounded fears and misinformation. The recent report of the Committee on Nuclear and Alternative Energy Sources calls attention to this problem:

> The foremost of these [political and institutional] barriers is misunderstanding by the public of the nature of the problem. As evidenced by local hostility in many places to investigation of sites, it appears that the public is under the misapprehension that waste management poses local, high-intensity risks, rather than (at worst) widespread, low-intensity risks (National Research Council 1979, p. 316).

If public ignorance does indeed lie at the base of public concern, the democratic answer is surely that stated by a former Energy Research and Development Administration assistant administrator for nuclear energy: ". . . the best answer to the problem of public perception, public attitudes, is information . . . the more people understand about nuclear power, the more they tend to favor it" (Roberts 1975).

It is clear that the general public has limited knowledge of nuclear power and radioactive wastes. Various surveys of public attitudes prior to the Three Mile Island accident revealed that most people possessed little factual knowledge of nuclear power (Melber et al. 1977). A 1978 survey of Washington state residents, for example, found that most respondents had little knowledge of the origins and forms of waste or of their decay over time (Nealey and Rankin 1978). In a Massachusetts study, out of five relatively simple multiple-choice questions on nuclear power, 51 percent of the respondents answered no more than one of the questions correctly (Reed and Wilkes 1980b). Limited knowledge also characterizes other technical and social policy issues on which the public historically has had a role in the decision-making process.

Recent research has questioned the view that greater knowledge produces a more favorable attitude to nuclear energy. An Oak Ridge study found no relationship between knowledge and support or opposition, but the test concerned specific factual data about a particular plant rather than the technology itself (Sundstrom et al. 1977, pp. 39-40). A study of college student opinions about breeder reactors also found no relationship between knowledge and attitudes (Clelland and Bremseth 1977, pp. 31-32). On the other hand, while a detailed study (Nealey and Rankin 1978) in Washington state found no significant difference in knowledge between opponents and supporters of nuclear power, it did show that strong supporters of nuclear power were the most knowledgeable group. The Rand Corporation study of the 1976 California referendum found that whereas knowledge was low, it was largely independent of attitudes to nuclear power (Hensler and Hensler 1979). Overall, the results to date, though not conclusive, suggest that knowledge serves primarily to confirm rather than to shape attitudes, that individuals selectively "fit" new information to pre-existing positions. This is consistent with a national survey (U.S. Council on Environmental Quality 1980, p. 35), which found that levels of knowledge did not correspond with views about environmental protection or the environmental movement.

Added confirmation of these results has been provided by a number of informational campaigns and consensus-building efforts on nuclear power and other technical issues in various European countries. One comparison of three such efforts, in Austria, the Netherlands, and Sweden, concluded that ". . . there is little evidence that efforts to improve public knowledge about uncertain technical issues have actually reduced conflict." Indeed, the Swedish study indicated that access to more information may in fact increase confusion and conflict, for many people are reluctant to accept and evaluate the uncertainties inherent in many technical areas (Nelkin 1977, pp. 96-97).

The panel's appraisal of this body of work is that sufficient evidence does not exist to allow a searching test of the relation between knowledge and attitude, for studies to date have largely assessed the possession of general information rather than technical understanding. The direction of research results, however, does not support the inference that public concern is the product of inadequate information or lack of education.

Fear

The H. G. Wells novel The World Set Free (1914) portrays a cataclysmic world war during the 1950s that leaves cities uninhabitable through the use of induced-radioactivity bombs the size of a handbag. John Hersey's widely read factual account, Hiroshima, describes in detail the death and destruction caused by an atomic bomb. In 1959 the film based on Nevil Shute's novel On the Beach portrayed the end of humanity as a result of worldwide nuclear war.

These films and novels have received added credence from events since World War II. Civil defense drills were commonplace during the 1950s, and school children were taught to fall to the floor and cover their heads. A series of polls taken between 1954 and 1963 revealed that about two thirds of the public consistently expressed the view that hydrogen bombs would be used against the United States in the event of another world war (Erskine 1963). The Cuban missile crisis of 1962 made the prospect of global nuclear war even more vivid, and 15 years later a national poll found 4 of 5 Americans convinced that if too many countries acquired a nuclear capability, "some irresponsible country is bound to set off a bomb that could blow up the earth in World War III" (de Boer 1977, pp. 407-408).

These strong fears of nuclear weapons have likely contributed to anxiety over the civilian uses of nuclear energy. Pahner (1976) argues, for example, that a substantial part of the public concern over nuclear power plants represents anxiety "displaced" from the fear of nuclear weapons. Public concern over nuclear risks, according to Pahner, stems from (a) pre-existing images of the horror of nuclear war, (b) conscious or unconscious fears related to the invisibility of radiation and the uncertainty of exposure, and (c) conscious and unconscious fears of the immediate and long-term effects of radiation on genetic processes. Since nuclear weapons and nuclear power plants both present danger of exposure to radiation and death, people tend to see them as similarly threatening, even though they may not be fully aware of what upsets them, may not have a fully conceptualized knowledge of the threat, and may be unable to articulate their concerns (Pahner 1976, p. 11).

Lifton (1967, 1976) has explored also the unconscious fears raised by nuclear energy. The development of nuclear weapons, he argues, has evoked a powerful new image—man's extermination of himself as a species with his own technology. The widespread belief, attested to by various polls, that nuclear weapons may be used again during the course of one's life evokes the idea of total biological destruction, of the possible interruption of all human continuity. In his discussions with young American adults, Lifton found three characteristic psychological themes:

> "The equation of death with annihilation—early childhood exposure to the prospect of the nuclear holocaust leads to a psychic deformation in which one's own death becomes merged with total death, and thus more terrifying,
> "the unmanageability of life—the sense that any attempt to order existence is countered by the possibility of its absolute interruption,
> "the perception of craziness—the idea that human beings would make nuclear weapons and the prescription for responding (ducking under a desk, going down to the cellar) both seem strange and unreal" (Lifton 1979, pp. 365-366).

The public, in short, extends its fears of nuclear weapons to nuclear power plants, which evoke similar primal fears about the integrity of the human body. Lifton argues that these fears cannot be eliminated by rational-probabilistic assessments of risk, such as that of the Reactor Safety Study (U.S. Nuclear Regulatory Commission 1975), because it may be the mode rather than the number of deaths that is critical. The "most important human feelings are precisely those least susceptible to mathematical equations" (Lifton 1976).

Sufficient evidence to confirm the various psychological mechanisms through which fear of nuclear weapons interacts with fear of nuclear power plants does not exist, but some evidence is available to support the widely held view that such a connection is real. Polls in recent years have consistently revealed that about half of the public harbors the belief that explosions or the possibility of explosions in nuclear plants are a major problem (Mitchell 1980, Table 3), and a 1980 survey found that 52 percent of respondents believed that nuclear power plants could explode and "cause a mushroom-shaped cloud like the one at Hiroshima" (U.S. Council on Environmental Quality 1980). When visitors at three reactor sites were asked to complete simple sentences* about

* "When I think of nuclear power plants, I . . . ."

their feelings, more than half cited anxiety (30 percent), war (19 percent), or disease (7 percent) (Kasperson et al. 1980). The authors of the Rand study, by contrast, while finding that about one fifth of the respondents used doomsday imagery in free-association responses to nuclear energy, did not believe this to be a significant factor in attitudes to nuclear power (Hensler and Hensler 1979, Vol. I, p. 4).

Safety has been the dominant theme in the public's expressions of reservations about nuclear power and nuclear wastes. Concern consistently focuses on the release of radioactivity, potential catastrophic accidents, and waste management problems. In 1980, Marsh and McLennan found that 73 percent of those polled agreed with the suggestion that there was no guarantee against a catastrophic accident at a nuclear power plant, and 84 percent agreed that fundamental changes were necessary if the risks of nuclear energy were to be kept within tolerable limits (Marsh and McLennan 1980, p. 39).

THE NATURE OF HAZARD

Although many experts hold that the risks posed by nuclear wastes and nuclear power plants are no greater than, and perhaps substantially less than, the risks posed by other generally accepted technologies (National Research Council 1979), public concern over safety persists. One hypothesis for this is that nuclear power, as compared with other technologies, elicits extraordinary concern because of the characteristics, rather than the gross amount, of its risks.

Psychologists at Decision Research have investigated this hypothesis. Three groups of respondents—college students, members of the League of Women Voters (LOWV), and businessmen—were asked to judge the risks and benefits of nuclear power and 29 other technologies or activities on 9 characteristics—voluntariness of risk, immediacy of effect, knowledge about risk, control over risk, newness, whether known to exposed, and chronic-catastrophic, common-dread, and severity of consequences. Nuclear power had the dubious distinction of scoring at or near the high-risk end on most of the characteristics. This profile of risk is shown in Figures 2.4 and 2.5, which contrast the response to nuclear power with the response to nonnuclear electric power and x rays. Furthermore, nuclear power was "dreaded" far more than any of the other hazards (Slovic 1979, p. 38).

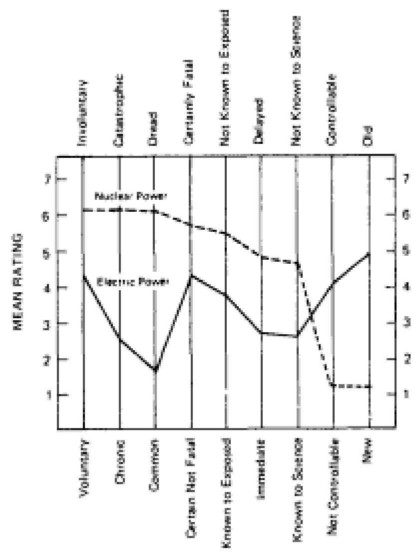


Figure 2.4 Comparison between nuclear power and nonnuclear electric power on 9 risk characteristics (from Fischhoff et al., 1978).

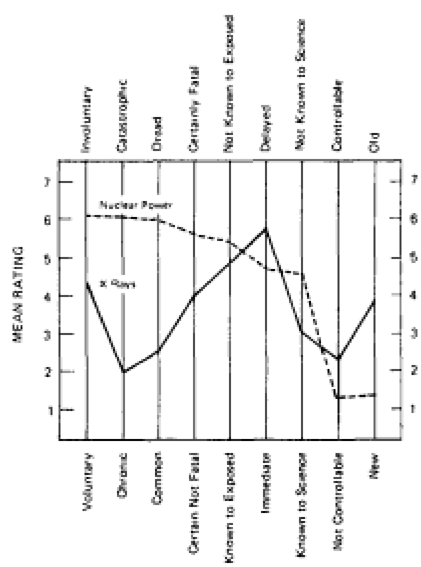


Figure 2.5 Comparison between nuclear power and x rays on 9 risk characteristics (from Fischhoff et al., 1978).

Respondents were later asked to estimate the frequency of death to be expected from the 30 activities and technologies. As a guideline it was pointed out that the total number of deaths each year in the United States averages about 2 million. The respondents were also asked to indicate how many times more deaths than the average would occur if next year were "particularly disastrous" for the technology or activity, thus providing a measure of opinion about the technology's or the activity's potential for catastrophe (Table 2.2). Interestingly, the expected number of fatalities from nuclear power in an average year was smaller than for any other activity or technology. But for the worst year nuclear power was unique in terms of respondents' judgments about fatality multipliers. In fact, more than 40 percent of the respondents presented multipliers for nuclear power that were greater than 1,000. The respondents, in short, expected nuclear power to lead to disasters of immense proportions.

The researchers also asked a new group of 28 students to write scenarios of the maximum credible disaster that might be produced during the respondent's lifetimes by a nuclear power plant or by commercial airplane flights. One third of the scenarios postulated an explosion within the reactor, and the expected number of fatalities tended to be several orders of magnitude greater than the Worst case estimated in the Reactor Safety Study (3,300 prompt and 45,000 latent fatalities, with a probability of 5×10^{-9} per reactor year). Three respondents wrote scenarios postulating worldwide radioactive contamination and death. These results are indicative of the degree of public concern. Researchers generally have found that members of the lay public have been modestly successful in ordering other risks according to their probabilities and consequences.

These results are directly relevant to radioactive waste management because the public apparently links it (despite differences in the nature of the hazards) with nuclear power issues more generally. In fact, as noted above, concern over nuclear wastes ranks at or near the top of all concerns over nuclear power.

VALUE CONFLICT

It has been argued that nuclear power is a victim of its time and that the political polarization over its survival symbolizes a more basic struggle between contending value systems. It is apparent that value questions have been prominent in the nuclear debate. There have been internal debates and positions taken by religious groups such as the World Council of Churches and the National Council of Churches, with the latter more critical of nuclear power (National Council of Churches 1979). Perhaps it was inevitable that a technology first used in weapons would be the subject of debates involving values from the very beginning.

TABLE 2.2 Fatality Estimates and Disaster Multipliers for 30 Activities and Technologies

	Geometric Mean Fatality Estimates Average Year		Geometric Mean Multiplier Disastrous Year	
Activity or Technology	LOWV[a]	Students	LOWV[a]	Students
1. Alcoholic beverages	12,000	2,600	1.9	1.4
2. Bicycles	910	420	1.8	1.4
3. Commercial aviation	280	650	3.0	1.8
4. Contraceptives	180	120	2.1	1.4
5. Electric power	660	500	1.9	2.4
6. Fire fighting	220	390	2.3	2.2
7. Food colouring	38	33	3.5	1.4
8. Food preservatives	61	63	3.9	1.7
9. General aviation	550	650	2.8	2.0
10. Handguns	3,000	1,900	2.6	2.0
11. High school and college football	39	40	1.9	1.4
12. Home appliances	200	240	1.6	1.3
13. Hunting	380	410	1.8	1.7
14. Large construction	400	370	2.1	1.4
15. Motorcycles	1,600	1,600	1.8	1.6
16. Motor vehicles	28,000	10,500	1.6	1.8
17. Mountain climbing	50	70	1.9	1.4
18. Nuclear power	20	27	107.1	87.6
19. Pesticides	140	84	9.3	2.4
20. Power mowers	40	33	1.6	1.3
21. Police work	460	390	2.1	1.9
22. Prescription antibiotics	160	290	2.3	1.6
23. Railroads	190	210	3.2	1.6
24. Skiing	55	72	1.9	1.6
25. Smoking	6,900	2,400	1.9	2.0
26. Spray cans	56	38	3.7	2.4
27. Surgery	2,500	900	1.5	1.6
28. Swimming	930	370	1.6	1.7
29. Vaccinations	65	52	2.1	1.6
30. X rays	90	40	2.7	1.6

SOURCE: P. Slovic, S. Lichtenstein, and B. Fischhoff. 1979. Images of disaster: perception and acceptance of risks from nuclear power. In Energy Risk Management, pp. 223–245. G. Goodman and W. Rowe, ed. London: Academic Press.

[a]League of Women Voters

President Eisenhower's inauguration of the Atoms for Peace program in 1956 was praised as a clear demonstration of the willingness of the United States to share the anticipated benefits of nuclear technology with the nations of the world that did not possess it. On the other hand, Commoner (1969) has emphasized the possible burdens of nuclear wastes for future generations, an issue subsequently taken up by the Sierra Club but given its most compelling expression in Weinberg's "Faustian bargain" metaphor (Weinberg 1972). Issues of democratic process and political accountability have also received considerable attention over the past decade (Green 1975, Ebbin and Kasper 1974).

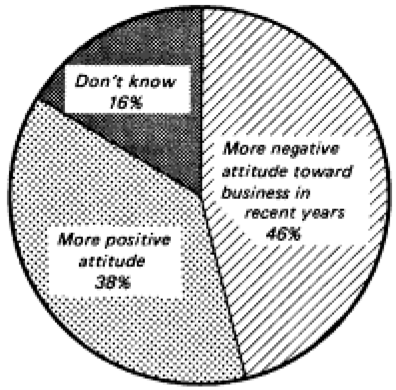
Congressional hearings in 1973-1974 on nuclear power safety showed that the controversy embraced a host of social, political, moral, and other issues about the regulation and use of technology in a democratic society (del Sesto 1980). Pro nuclear advocates stressed the benefits that would accrue to human welfare through improving the standard of living, increasing the rate of economic growth, and achieving energy self-sufficiency. Nuclear opponents stressed the inequity to future generations, the dangers to civil liberties and the democratic process, and the global threat of proliferation.

The evidence so far suggests that there is substantial concern of an ethical nature among activist opponents of nuclear power, although the studies are, in the panel's judgment, too few and too limited to provide definitive conclusions on this hypothesis (see also Douglas and Wildavsky 1982). Hence, the resolution of the issues posed by nuclear power will require attention to broad social goals as well as to the narrower questions of safety and technology.

INSTITUTIONAL CREDIBILITY AND DISTRUST

Public concern over radioactive wastes, it has been hypothesized, reflects a distrust of the institutions that manage them (Office of Technology Assessment 1982). This distrust, it may argued, is part of a general decline in public trust of most social institutions, ranging from the family to the federal government (Figure 2.6).

Evidence for this hypothesis is forthcoming. Various public opinion polls have shown a long-term decline in the confidence people have in governmental institutions, public officials, and the press. A 1976 poll revealed



Erosion of confidence in business . . .
Question: Would you say your attitude toward business has become more positive, or more negative in recent years?
Note: When asked in 1977, 51% of those who were 18-34 years old said they had become more negative toward business and 37% had become more positive. In the 1978 survey, 41% of 18-34 year olds expressed the negative attitude and 46% answered that they had become more positive in their attitudes toward business.
Source: Survey by the Gallup Organization, May 1978.

Question: As far as *people in charge of running* (Read list) are concerned, would you say you have a great deal of confidence, only some confidence, or hardly any confidence at all in them? . . . Major companies.

. . . AND ITS LEADERS OVER TIME

Confidence in leaders of institutions

	1966	1971	1973	1974	1975	1976	Feb. 1977	Nov. 1977	1978	1979	1980
Average of nine major institutions	43%	27%	33%	28%	24%	20%	24%	27%	25%	23%	NA
Major companies	55·	27	29	21	19	16	20	23	22	18	19

Note: "Average of nine major institutions" is a composite of the following: television news, medicine, the military, the press, organized religion, major companies, Congress, the Executive Branch, and organized labor. In 1980 the other institutions asked were: the military = 33%, television news = 31%, the press = 22%, the White House = 18% and Congress = 11%. Average could not be computed for 1980 since all nine institutions were not included. Question wording varied slightly over time.

Source: Surveys by Louis Harris and Associates, 1966-August 1978; ABC News/Louis Harris and Associates, latest that of January 10-13, 1980.

Figure 2.6
Erosion of public confidence in business and other major social institutions. Source: Public Opinion, Volume 3, Number 2, April/May 1980, p. 26.
Source: Surveys by Louis Harris and Associates, 1966-August 1978, ABC News/Louis Harris and Associates, latest that of January 10-13. 1980

that only scientists commanded "a great deal" of confidence on nuclear power issues (58 percent), with the Nuclear Regulatory Commission (39 percent), the President of the United States (24 percent), the heads of electric power companies (19 percent), and the companies that produce equipment for nuclear power plants (12 percent) lagging far behind (Harris & Associates, 1976, p. 29). A 1980 survey of Wisconsin residents revealed that most of them did not believe that the government was moving fast enough to solve the problem or was interested in what local citizens thought about having a waste repository in their community. These respondents ranked the federal government behind the news media, university scientists, and environmental groups, and just ahead of friends and acquaintances, as the most reliable source of information about nuclear wastes (Kelly 1980). The Office of Technology Assessment (1982, p. 31) also recently concluded that "the greatest single obstacle that a successful waste management program must overcome is the severe erosion of public confidence in the Federal Government," citing policy instability, the capacity of the federal government to implement policy, and perceptions of trustworthiness (pp. 31-34).

As inheritor of the Atomic Energy Commission's difficulties in waste management, the Department of Energy bears the burden of an unfortunate legacy. It is not surprising that the Keystone Group, composed of leading industry, environmental, and university representatives, could quickly agree that DOE's lack of credibility was a major obstacle to an effective waste management program (Keystone Group 1978), or that a 1979 General Accounting Office report suggested creation of an overall planning institution outside of DOE as a means of fostering public acceptance (General Accounting Office 1979, p. 11). In this respect, current institutional changes may provide some opportunities, an issue the panel addresses in Chapter 6.

METHODOLOGICAL AND DATA-BASE LIMITATIONS

Despite this social research on public concerns about nuclear energy, the body of knowledge developed thus far is limited in two important ways in its utility to administrative policymakers. First, in a democracy the government's authority to control or shape public behavior is subject to constitutional constraints. Even if it were possible to predict political behavior accurately and to change it at will, there would be legal and political limits on the government's ability to bring about those changes. Second, much social research is limited by small sample size, often atypical sample populations, and complexity of behavior. Research relevant to public policy is only rarely amenable to controlled experimentation, and the "natural experiments" provided by governmental actions are rarely documented or controlled well enough to permit clean inferences.

Risk psychology investigations have chosen to focus on small, atypical sample populations in an effort to examine the complex cognitive and affective processes at work. While such studies have contributed to a richer scientific understanding of how beliefs develop, their emphasis on individuals' motivations do not yet allow unambiguous analyses of organized social behavior, including reaction to waste repository site selection.

Studies of political opposition to nuclear energy in other nations face a problem of a different kind. Behavior is affected by social and cultural setting, so that patterns observed in one nation may not apply in another. In addition, comparative studies face the methodological difficulties of social research in general. The emergence of the Green Party in the Federal Republic of Germany as a significant electoral force, accordingly, does not presage antinuclear candidacies in other electoral systems—much less the success of such political campaigns.

These limitations do not, of course invalidate comparative studies. Awareness of the relationship between governmental structure (e.g., a parliamentary system in the FRG) and political behavior (the possibility of successful single-issue parties) bears on the design of decision processes. Moreover, both radioactive waste management and antinuclear activism are international activities, in which transfer of information across national boundaries plays a significant role. Thus, comparative studies are valuable as a form of intelligence in the short run and as a source of basic understanding for institutional design in the long term.

Studies of political action and polls estimating potential electoral response are based on relevant samples: political action involves the self-selected fraction of the population that chooses to participate, and opinion polls rest on solid statistical foundations. This considerable strength is tempered, however, by problems in the reliability of the data and the legitimacy of policy inferences based on the data.

The history of opposition to nuclear energy itself demonstrates the fluidity of the public agenda; the concept that the attention span of mass societies is limited has been developed in some detail by political scientists (Downs 1972, Cobb and Elder 1976, Berry 1977). Ballot initiatives in several states have shown considerable (if declining) support for nuclear power, but more detailed inferences are harder to establish. The wording of referenda varies from place to place, as do margins of victory, voter turnout, and the collateral effects of other items on the ballot.

Demonstrations and civil disobedience exhibit even larger variations. All are energized by particular facilities, and their organizers seek to take advantage of favorable circumstances such as weather or the opening of the school year (a time when students can be more easily recruited). Yet these regularities serve to underscore the irregular nature of these events, and thus the unpredictability of their occurrence. Finally, their unpredictability as events is a major element of their power as a medium of social expression. The threat of violence, in particular, commands media attention.

Opinion polls, perhaps the most highly validated of these measures, also face significant problems of method. Re-interviewing the same persons over a period of time (panel studies) demonstrates that opinion-poll responses change substantially over time, for reasons that are poorly explained. In part, instability of opinion estimates is caused by differences in the wording of poll questions and variation in respondents' understanding of the wording. Mitchell finds that changes of up to 40 percentage points result from changes in the wording of questions about nuclear power plants and their safety (Mitchell 1980, p. 12).

These questions about the quality of political data are compounded by problems of interpretation. The republican framework of American government accords fundamental legitimacy to voters and those whom the voters elect as representatives. The repeated affirmations of support for nuclear power, in Congress and the Executive Branch and in state referenda, have therefore set the directions of public policy. The rise of controversy has nonetheless led to major adaptations of public policy—a measure of the responsiveness of the American political process.

Despite the clear power of the majority, the history and current texture of American government is replete with instances in which well-organized minorities with intensely held beliefs have influenced the public agenda and the action of government. Studies of antinuclear groups and their activities provide measures of the intensity of opposition. The prominence of the nuclear controversy is due in part to the success of this minority in raising its concerns among the wider public and within the institutions of government. Moreover, the trend of opposition and its success within government may be leading indicators of the challenges to be faced in repository siting.

It remains difficult, however, to convert these general observations into specific qualitative inferences, much less make quantitative estimates. Political action is both an art and a sport: innovation and competition matter (Hirschman 1970). The competition ranges over many different dimensions, and there is no simple measure of effectiveness or figure of merit with which to keep score. Indeed, the emergence of quality of life and the ever-lower expectations of acceptable risk reflect innovation in the dimensions along which competition takes place.

Because they are widely used in electoral strategy, opinion polls illustrate the problems of interpretation and legitimacy with special clarity. Social scientists have debated the significance of opinion polls for several decades (Roll et al. 1972, Bennett 1977). The portrait of the American voter remains controversial in ways that bear directly on complex policy matters such as radioactive waste: how stable are attitudes? How well informed are they? How are they affected by social setting? While there is a rough consensus among political scientists and sociologists on these questions, it has been a difficult one to win and sustain in the face of new findings. In the judgment of the panel, extending the conclusions of this body of research to policy applications in repository siting is of doubtful merit. More pragmatically, survey data seem to be in a state of flux, with evidence that the majority support for nuclear energy is eroding.

These imperfections in quality of social scientific data, the scientific interpretation of them, and the use of social science in governance all limit the policy applicability of studies of public concerns. The panel is mindful, however, of the risk that these caveats may lead to the conclusion that social research is useless in repository siting. The reverse is true.

The diversity of research methods that has been applied to analyzing public concerns leads to qualitative findings that are robust and that merit careful attention in the siting of nuclear waste repositories.

FINDINGS

1. While electoral, legislative, and administrative behavior in the United States have historically demonstrated substantial support for the economic benefits of nuclear power, over the past 15 years (and particularly since 1979) this support has weakened significantly at all three levels. In the same period, an articulate organized opposition has emerged, one with support among a significant minority of the population.
2. There is widespread perception that nuclear energy entails risks to health and safety. This perception is exacerbated by the fact that most public groups do not distinguish clearly between the risks of nuclear weaponry and nuclear power plants. The extent to which fear over nuclear weapons enters into attitudes on nuclear wastes is difficult to pinpoint, but it is undoubtedly an element in the formation of public opinion. Concern over catastrophic accidents in nuclear power plants adds to these fears of technology.
3. The level of knowledge about nuclear power and radioactive wastes remains low among the general public. This limited knowledge, however, does not explain the high level of concern. It is uncertain whether greater amounts of information would reduce or increase public concern, but improved public understanding of waste management problems is a central need for developing an informed public policy and a socially acceptable management program.
4. Public concern and the perception of threat are exacerbated by mistrust of government in general and by the appearance of secrecy or desire to exclude the public from governmental decisions about radioactive waste and repository siting.

REFERENCES FOR CHAPTER 2

Bennett, W. L. 1977. The growth of knowledge in mass belief studies: an epistemological critique. American Journal of Political Science 21:465-500.

Berry, J. 1977. Lobbying for the People. Princeton, N. J.: Princeton University Press.

Bromet, E. 1980. Three Mile Island: Mental Health Findings Pittsburgh: University of Pittsburgh, School of Medicine.

Clelland, D., and M. Bremseth. 1977. Student reactions to breeder reactors. Paper presented at the Annual Meetings, American Sociological Association, Chicago, September.

Cobb, R., and C. Elder. 1976. Participation in American Politics. Baltimore, Md.: Johns Hopkins University Press.

Commoner, B. 1969. The myth of omnipotence: the hidden costs of nuclear power. Environment 11:8-13, 26-28.

de Boer, C. 1977. The polls: nuclear energy. Public Opinion Quarterly 41:402-411.

del Sesto, S. 1980. Conflicting ideologies of nuclear power: congressional testimony on nuclear reactor safety. Public Policy 28:39-70.

Douglas, M., and A. Wildavsky. 1982. Risk and Culture. Berkeley: University of California Press.

Downs, A. 1972. Up and down with ecology: the issue-attention cycle. Public Interest 28:38-50, Summer.

Duncan, O. D. 1978. Sociologists should reconsider nuclear energy. Social Forces 57:1-22.

Ebbin, S., and R. Kasper. 1974. Citizen Groups and the Nuclear Power Controversy. Cambridge, Mass.: MIT Press.

Erskine, H. G. 1963. The polls: atomic weapons and nuclear energy. Public Opinion Quarterly 27:155-190.

Firebaugh, M. W. 1981. Public attitudes and information on the nuclear option. Nuclear Safety 22:147-156.

Fischhoff, B., P. Slovic, S. Lichtenstein, S. Read, and B. Combs. 1978. How safe is safe enough? A psychometric study of attitudes toward technological risks and benefits. Policy Sciences 8:127-152.

General Accounting Office. 1979. The Nation's Nuclear Waste—Proposals for Organization and Siting. EMD-79-77. Washington, D.C.

Green, H. 1975. The risk benefit calculus in safety determinations. George Washington Law Review 43:791-804.

Greer-Wooten, B., and L. Mitson. 1976. Nuclear Power and the Canadian Public. Institute for Behavioral Research, York University, Toronto.

Groth, A. J., and H. G. Schutz. 1976. Voter Attitudes on the 1976 Nuclear Initiative in California. Environmental Quality Series, No. 25. Institute of Governmental Studies, University of California, Davis, December.

Harris, Louis, & Associates. 1976. A Second Survey of Public and Leadership Attitudes Toward Nuclear Power Development in the United States. Summary, N.Y.: Ebasco Services.

Hensler, D. R., and C. P. Hensler. 1979. Evaluating Nuclear Power: Other Choice on the California Nuclear Energy Initiative. R-2341. Santa Monica, Calif.: Rand Corporation.

Hirschman, A. O. 1970. Exit, voice and Loyalty. Cambridge, Mass.: Harvard University Press.

Houts, P., R. Miller, G. Tokuhata, and K. Ham. 1980. Health-Related Behavioral Impact of the Three Mile Island Nuclear Incident. Report submitted to the TMI Advisory Panel on Health Research Studies of the Harrisburg, Pennsylvania Department of Health.

Kasperson, R., G. Berk, D. Pijawka, A. B. Sharaf, and J. Wood. 1980. Public opposition to nuclear energy: retrospect and prospect. Science, Technology, and Human Values 5:11-23.

Kelly, J. E. 1980. Testimony on Behalf of the State of Wisconsin Regarding the Statement of Position of the United States Department of Energy in the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste, Docket No. PR 50-51. U.S. Nuclear Regulatory Commission, Washington, D.C.

Keystone Group. 1978. Letter to Frank Press, September 19.

Kopp, C. 1979. The origins of the American scientific debate over fallout hazards. Social Studies of Science 9:403-422.

Kraus, S., R. Mehling, and E. El-Assal. 1963. Mass media and the fallout controversy. Public Opinion Quarterly 27: 191-205.

Lifton, R. J. 1967. Death in Life: Survivors of Hiroshima. New York: Random House.

Lifton, R. J. 1976. Nuclear energy and the wisdom of the body. Bulletin of the Atomic Scientists 32:16-20.

Lifton, R. J. 1979. The Broken Connection: On Death and the Continuity of Life. New York: Simon and Schuster.

Lipsky, M. J. 1968. Protest as a political resource. The American Political Science Review 62:1144-1158.

Marsh and McClennan. 1980. Risk in a Complex Society. A Marsh McClennan Public Opinion Survey Conducted by Louis Harris and Associates, Inc. Summary, N.Y.: Ebasco Services.

Maynard, W. S., S. M. Nealey, J. A. Hibert, and M. K. Lindell. 1976. Public Values Associated with Nuclear Waste Disposal. Seattle, Wash.: Battelle Memorial Institute, Human Affairs Research Centers.

Mazur, A. 1975. Opposition to technological innovation. Minerva 13:58-81.

Mazur, A., and B. Conant. 1978. Controversy over a local nuclear waste repository. Social Studies of Science 8:235-243.

McFarland, A. 1976. Public-Interest Lobbies: Decision Making on Energy. Washington, D.C.: American Enterprise Institute.

The Media Institute. 1980. Nuclear Phobia—Phobic Thinking about Nuclear Power: A Discussion with Robert L. DuPont, M.D. Washington, D.C.: The Institute.

Melber, B. D., S. M. Nealey, J. Hammersla, and W. L. Rankin. 1977. Nuclear Power and the Public: Analysis of Collected Survey Research. U.S. DOE Report PN2-2430. Seattle, Wash.: Battelle Memorial Institute, Human Affairs Research Centers.

Melber, B. D., S. M. Nealey, A. Weiss, and W. L. Rankin. 1979. Nuclear Power and the Public: Update of Collected Survey Research. Draft. Seattle, Wash.: Battelle Memorial Institute, Human Affairs Research Centers.

Mitchell, R. C. 1978. The public speaks again: a new environmental survey. Resources 60, September-November.

Mitchell, R. C. 1980. Polling on nuclear power: a critique of the polls after three mile island. Pp. 66-98 in Polling on the Issues, A. H. Cantris, ed. Washington, D.C.: Seven Locks Press.

National Council of Churches. 1979. Energy and Ethics. New York.

National Research Council. 1979. Energy in Transition, 1985-2010. Committee on Nuclear and Alternative Energy Sources. Washington, D.C.: National Academy of Sciences.

Nealey, S. M., and W. L. Rankin. 1978. Nuclear Knowledge and Nuclear Attitudes: Is Ignorance Bliss? Seattle, Wash.: Battelle Memorial Institute, Human Affairs Research Centers.

Nelkin, D. 1977. Technological Decisions and Democracy: European Experiments in Public Participation. Beverly Hills, Calif.: Sage.

Nelkin, D. 1981a. Nuclear power as a feminist issue. Environment 23:14-20, 38-39.

Nelkin, D. 1981b. Anti-nuclear connections: power and weapons. Bulletin of the Atomic Scientists 37:36-40.

Nelkin, D., and M. Pollack. 1981. The Atom Beseiged: Extraparliamentary Dissent in France and Germany. Cambridge, Mass.: MIT Press.

Office of Technology Assessment. 1982. Managing Commercial High-Level Radioactive Waste. Summary. Washington, D.C.

Otway, H., D. Maurer, and K. Thomas. 1978. Nuclear power: the question of public acceptance. Futures 10:109-118.

Pahner, P. D. 1976. A Psychological Perspective of the Nuclear Energy Controversy. RM-76-67. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Paige, H., D. S. Lipman, and J. E. Owens. 1980. Assessment of National Systems for Obtaining Local Acceptance of Waste Management Siting and Routing Activities. International Energy Associates Limited, Washington, D.C.

Popper, F. J. 1981. Siting LULU's. Planning 47:12-15, April.

Rankin, W. L., and S. M. Nealey. 1978. Attitudes of the public about nuclear wastes. Nuclear News 21:112-117.

Reed, J. H., and J. M. Wilkes. 1980a. Sex and attitudes toward nuclear power. Paper delivered to the Annual Meetings, American Sociological Association, August.

Reed, J. H., and J. M. Wilkes. 1980b. Nuclear knowledge and nuclear attitudes: an examination of informed opinion (unpublished paper) .

Renn, O. 1981. Man, Technology and Risk: A Study on Intuitive Risk Assessment and Attitudes towards Nuclear Energy. Julich, West Germany: Kernforschungsanläge Julich.

Roberts, R. 1975. Public acceptance of nuclear energy—the government's role. Speech to the Atomic Industrial Forum, San Francisco, 29 November.

Roll, Jr., C. W., and A. H. Cantril. 1972. Polls: Their Use and Misuse in Politics. New York: Basic Books.

Rothman, S., and S. R. Lichter. 1982. The nuclear energy debate: scientists, the media and the public. Public Opinion 5:47-52, August/September.

Seley, J. E. 1983. The Politics of Public Facility Planning. Lexington, Mass.: D.C. Heath & Co.

Setlow, L., and G. Steinem. 1973. Why women voted for Richard Nixon? Ms Magazine 2:66-67, 109-110.

Slovic, P., S. Lichtenstein, and B. Fischhoff. 1979. Images of disaster: perception and acceptance of risks from nuclear power. In Energy Risk Management, G. Goodman and W. Rowe, eds. London: Academic Press.

Stallen, P. J. M., and A. Thomas. 1981. Psychological Aspects of Risk: The Assessment of Threat and Control. Paper prepared for the International School of Technological Risk Assessment, Erice-Sicily, 20-31 May.

Steinem, G. 1972. Women voters can't be trusted. Ms Magazine 1:47-51, 131.

Sundstrom, E. P., E. J. Costimiris, D. A. DeVault, D. A. Powell, J. W. Lounsbury, T .J. Mattingly, Jr., E. M. Passino, and E. Peelle. 1977. Citizens' Views About the Proposed Hartsville Nuclear Power Plant: A Survey of Residents' Perceptions in August, 1975. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

U.S. Council on Environmental Quality. 1980. Public Opinion on Environmental Issues: Results of a National Opinion Survey. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1975. Reactor Safety Study—An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants. Wash-1400, NUREG-75/014. Washington, D.C.

U.S. President's Commission on the Accident at Three Mile Island. 1979. The Need for Change: The Legacy of TMI. Washington, D.C.

Vlek, C. A. J., and P. J. M. Stallen. In press. Risk perception in the small and in the large. Organizational Behavior and Human Performance.

Weinberg, A. 1972. Social institutions and nuclear energy. Science. 177:27-34.

Wilson, J. Q. 1973. Political Organizations. New York: Basic Books.

Zinberg, D. S. 1982. Public participation: U.S. and european perspectives. Pp. 160-187 in The Politics of Nuclear Waste, E. Colglazier, ed. New York: Pergamon Press.

3

The Waste Management Network: The Role of Transportation and Repository Location

The Nuclear Waste Policy Act of 1982 mandates that the President recommend a first site for the geologic disposal of high-level radioactive waste no later than March 31, 1987, and a second site no later than March 31, 1990. The placement of these sites will be part of a nuclear waste management system comprising reactors; transportation casks, modes, and corridors; a repository; and, conceivably, interim storage facilities, reprocessing plants, or both. The geographical design of this network will create social, economic, and institutional effects that deserve major consideration in the development and implementation of the Department of Energy's Mission Plan, which has been formulated to achieve the intent of this legislation. Involved are such issues as the scheduling of spent fuel shipments from reactors, scheduling of waste emplacement in repositories, design of an efficient transportation system, development of an appropriate regulatory system, and development, if necessary, of interim away-from-reactor storage facilities.

Chapter 1 noted that the assessment of socioeconomic effects at individual sites requires an understanding of the entire management network, not simply the repository site. The panel examined the socioeconomic effects of the above-ground radioactive waste management system from three perspectives: the number and location of repositories, the type of transport used (rail or truck) to move fuel, and the effect of temporary above ground storage of waste in special facilities. Very little analysis has been done on the socioeconomic effects associated with these choices. This restricted the panel's ability to develop definitive, quantitative estimates of alternatives and also narrowed the range of alternatives that it was able to assess. Instead, the panel sought to identify the types of socioeconomic and institutional effects that may be expected to occur and the policy issues that will need to be addressed in the implementation of the Nuclear Waste Policy Act.

THE WASTE MANAGEMENT SYSTEM IN OPERATION

The production of electricity from uranium fission requires a fuel supply and preparation system, a power plant system, and a system for long-term isolation of spent fuel and radioactive by-products, with or without reprocessing.

For many years it was assumed that all spent fuel from commercial reactors would be reprocessed to recover unused fissionable material. This has not happened, and spent fuel has accumulated at reactor sites pending a decision as to whether it will remain in long-term on-site storage or be shipped to interim or final disposal facilities. Commercial nuclear power reactors licensed, under construction, and planned as of January 1, 1982, are shown in Figure 3.1.

Because spent fuel is highly radioactive, all operations involved in moving it to interim storage or to a repository site for final isolation will require a high degree of care in handling, transportation, and disposal. Receiving the fuel at a repository site, for example, will require highly specialized operators, supervisors, and inspectors (U.S. Department of Energy 1979). In addition, if the number of power plants in operation increases from the current 79 to the projected 144, including those in existence, ordered, or under construction, the number of spent fuel shipments that must ultimately be handled will increase proportionately. Utility estimates provided to the panel called for these shipments to begin from 15 plants in the mid-1980s, growing substantially to shipments from more than 100 plants shortly after 2000. If reprocessing or interim storage is added, this would increase transportation activities further.

The siting of nuclear waste repositories will require the transportation of spent fuel across many states. Shipments through local jurisdictions at the outer fringes of the transportation network would be relatively infrequent, but, within the main transportation corridors, the closer a community is to a repository site, the more frequently shipments pass by. Alternative designs of waste

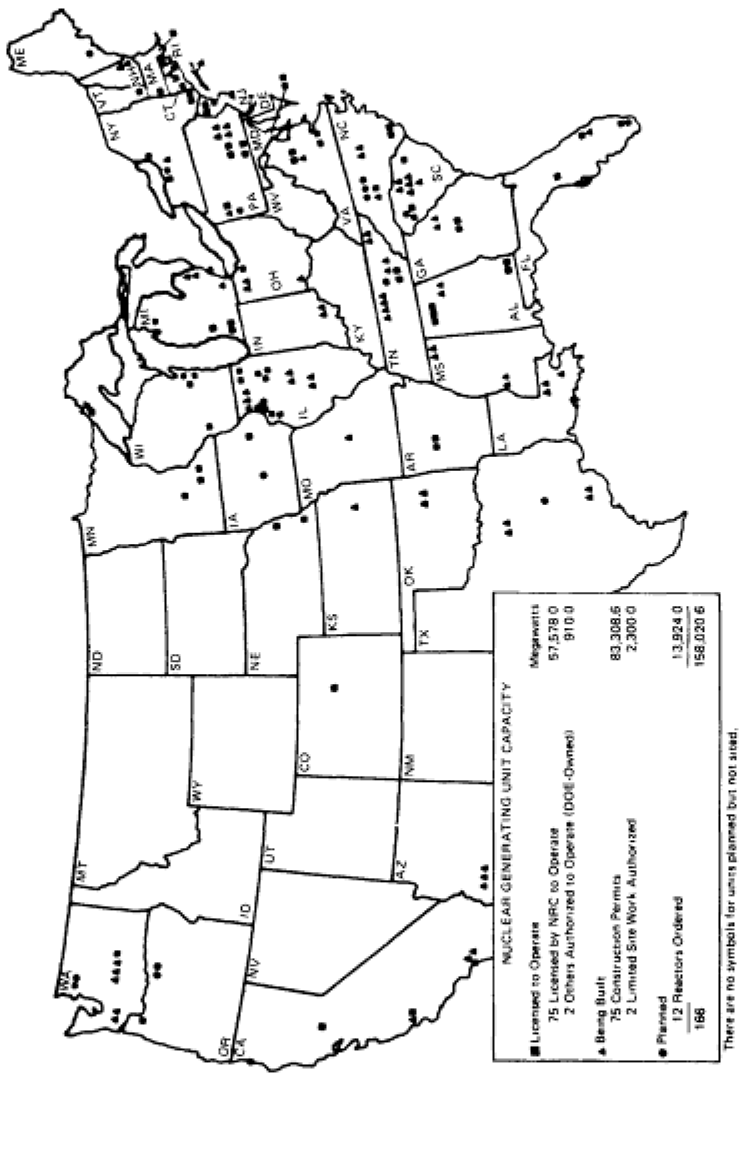


Figure 3.1 Commercial Nuclear Reactors in the United States (because of space limitations, symbols do not reflect precise locations). From Department of Energy, revised January 1, 1982.

transport and handling systems may vary significantly in their operational requirements, their effects on different regions of the country, and their regulatory burdens. In this chapter, the panel considers the system-wide economic and social effects associated with the impacts of repository location and spent fuel transportation. In formulating a Mission Plan, the U.S. Department of Energy (DOE) will need to compare these effects explicitly with the site-specific effects (see Chapter 4) and geologic criteria used to assess individual proposed repository sites.

A REFERENCE CASE

By early 1983 there were 79 nuclear reactors with operating licenses or authorizations, 60 with construction permits, 3 with construction permits pending, and 2 units on order. Of the 60 under construction, 54 are now more than 25 percent complete and, according to utility estimates (Behnke 1980), 39 of these are likely to be completed. Thus, by the early twenty-first century, there are likely to be more than 100 reactors discharging spent fuel in the United States. The panel took an estimate of 113 reactors as its reference case to identify socioeconomic and institutional considerations involved in deploying the waste management system. This estimate is close to the DOE's January 1983 preliminary low case estimate of 115 reactors by 2000 (Diedrich 1983). This is, therefore, a relatively low case assessment of potential effects related to program size.

The Oak Ridge National Laboratory (ORNL) was asked by the panel to use its computer program and planning assumptions to provide detail on rail and truck access to reactors, transportation routes, transportation cask inventories, system costs, and transport speeds to several hypothetical sites stipulated by the panel. These calculations show the projected movement of spent fuel from operating and planned reactors to possible repositories. The volume of transported fuel is only that which must be shipped, owing to the exhaustion of spent-fuel pool capacity. The mix of rail and truck transport is based on the availability of rail access to a reactor; if such access exists, shipments travel by rail. Otherwise they travel by truck. (A least-cost mix would therefore probably involve a higher proportion of truck shipments than is given here, with shorter routes favoring truck shipment and longer shipments favoring rail.) The number of annual shipments from 113 plants (a mix of boiling and pressurized water reactors), their transportation routes, distances, costs, and cask requirements are itemized for the years 1986 to 2004.* (Appendix A describes this analysis and the DOE data and planning assumptions.)

Table 3.1 shows a set of radioactive waste management systems and the one chosen by the panel as its reference case.

The Waste Funnel

The transport of spent reactor fuel entails a variety of activities: loading on trucks or rail cars, or both; possible collection at depots or transfer points (for rail shipments); monitoring passage along highways or rail lines; and offloading at the storage facilities. This network of activities can be viewed as a "waste funnel" in which spent fuel from widely dispersed power plants is transported via waste corridors to one or more storage sites. The effects of this activity are thinly distributed at the network's many origins at the outer range (i.e., the wide end) of the funnel but increase rapidly as the fuel moves toward depots, heavily traveled routes, and repositories at the mouth of the funnel.

In the past, DOE has assumed that 90 percent of spent reactor fuel and waste material would be moved by rail (DOE/EIS-0046F 1980, Chapter 4.5), an assumption that is consistent with planning in Western Europe and Japan, where essentially all spent fuel is shipped by rail. The primary reason for this is the scale economy of being

* Time and resource constraints did not allow the panel to review the validity of each ORNL assumption or to adjust the timing and schedule assumptions that had been over-taken by events. The same constraints also restricted the number of variant cases that the panel could address. It should be noted that the appraisal of logistical properties of a radioactive waste management system was done not so much as a realistic scheduling exercise as to illuminate socioeconomic and institutional issues. The implementation of a waste program will necessarily involve a broader set of scenarios and deeper understanding of assumptions than has been possible in this review (cf. DOE/EIS-0046F 1980, Chapter 7).

TABLE 3.1 An Illustrative set of Radioactive Waste Management Systems: Two Handling Strategies and Four Levels of Overall Deployment for Geological Isolation

	Scale of Deployment in U.S., Reactors			
	74	113[b]	300	500+
General Handling strategies:	Once through, without Reprocessing			Reprocess/LMFBR
Direct from reactors to repository (no AFR storage)		"Reference System"		
AFR storage, then geological isolation (waste held 40 + yr)[a]		Partially reviewed		
year scale level reached	1980	1995-2000	2025-2030	2050 or later

[a] This is similar to the swedish plan of holding waste for 40 years before isolation in order to reduce storage temperatures.

[b] While 152 reactors have been built or authorized, planning data utilized by the panel include only 113 plants estimated to be discharging spent fuel by 2004.

able to move wastes from one year's operation of a 1000-MW pressurized water reactor with 7 rail shipments rather than 75 by truck (based on cask sizes from our reference case).*

In the panel's reference case, a small number of rail and truck shipments would be required initially, but the number would rise with time, reaching a rate of 575 by rail and 2480 by truck in 2004 (Table 3.2). This suggests a 30 percent truck/70 percent rail system in terms of fuel carried. In the early years, many shipments would require at least some truck service, as only 8 of 24 reactors expected to ship fuel by 1990 are currently accessible by rail (Appendix A and Tables A.1 and A.7). Approximately 900 truck shipments and 44 rail cars would be required in that year, which implies a 63 percent truck/37 percent rail breakdown.

Changes in the study assumptions could substantially alter estimated transportation requirements. If, as is likely, a new generation of truck and rail casks that can carry more spent fuel per trip is designed and licensed for older spent fuel, total cask requirements and numbers of shipments would be lower and capital costs could decline. If rail lines were to carry spent fuel on dedicated trains, transit speeds may change and carrier costs will increase. The panel recognizes that transportation technology, and especially cask design, is undergoing rapid change. Refinements and sensitivity analysis for costs and logistical requirements should be performed to assist DOE's preparation of a Mission Plan.

This rate of waste movement, however, is for a system in which spent fuel is shipped to a repository in accordance with the ORNL planning assumptions. If the opening of a repository were delayed until the early twenty-first century, inventories of spent fuel would certainly be cooler (therefore more fuel could be transported in a

* A boiling water reactor (BWR) would require a few more truck shipments because BWR truck casks used in these calculations hold slightly less spent fuel. Rail casks for the two reactor types have roughly equivalent capacity. Data on shipment dates and quantities were originally supplied to Oak Ridge National Laboratory by the DOE's Savannah River Laboratory and its subcontractor, the S. M. Stoller Company. The data on required shipment dates and volumes have changed considerably in the past and are likely to change in the future (see Appendix A).

single cask) but would have grown in volume to 8 times the annual generation of spent fuel in 2004. The rate transporting this backlog will depend on future decision concerning interim storage, longer at-reactor storage, cask technology, and reprocessing, but any backlog would add to the scheduling, logistical, and impact-related effects of the transport system.

TABLE 3.2 Annual Spent Fuel Shipments to a Single Storage Facility

	Mixed Mode		Truck
Year	Rail	Truck	Only
1986	11	188	312
1987	13	575	711
1988	29	288	612
1989	41	1053	1527
1990	44	916	1404
1991	58	635	1281
1992	90	1214	2202
1993	121	1110	2424
1994	166	760	2582
1995	217	1385	3765
1996	248	1593	4275
1997	273	1348	4314
1998	322	1857	5371
1999	396	2030	6322
2000	402	1677	6023
2001	514	2145	7699
2002	502	2262	7652
2003	532	1903	7655
2004	575	2480	8748

SOURCE: Appendix A, Table A.3.

System Characteristics

By the year 2004, there would be, in our reference system, 113 reactors shipping spent fuel, a combined truck/rail transportation system with average transport speeds of 6 mph for rail cars and 35 mph for trucks*

* For the selection of rail and truck speeds, see pp. 77 and 78 below.

(carrying 134 casks at any one time), and, at the repository, 1 rail and 3 truck handling bays in continuous operation accommodating a steady flow of spent fuel. The transportation system would pass through most of the states, whether they had operating nuclear power plants or not. The system would be required to have a high degree of reliability, under the probable close scrutiny of local officials and concerned public groups.

Implications of differences in the design of an aboveground predisposal system, especially in the distribution of socioeconomic and institutional effects, have not been specifically addressed in previous analyses (such as the Generic Environmental Impact Statement, DOE's National Plan, DOE's National Siting Plan, or the Proposed General Guidelines for Recommendations of Sites for Nuclear Waste Repositories). We next examine several of the variant designs for our scenario of once-through spent-fuel management system handling discharges from 113 reactors.

A SINGLE, CENTRALIZED REPOSITORY OR A REGIONAL SYSTEM?

The Nuclear Waste Policy Act of 1982 calls for specific consideration of regional siting of nuclear waste repositories, but most early site characterization, much of which predates this Act, has been concentrated in western states. The repository selection process will require consideration of many issues—the results of geologic characterization, the likelihood of finding more than one technically adequate site, the direct and indirect costs of the entire radioactive waste management system, and many of the socioeconomic issues addressed in this report. Here the panel viewed these options primarily from the point of view of the transportation system, recognizing that many subsurface technical and economic considerations must also enter into this choice.

A possible waste management system would be one with a single repository located in the West. It is possible that the system will fail to develop beyond one single large repository. Alternatively it is possible that only western sites will be found for the first two repositories. Such a system, with several repositories located in close proximity, would be essentially indistinguishable from the transportation-related effects of a single western site.

The panel asked ORNL to use its model and planning assumptions to project the annual number of spent-fuel shipments in the year 2004 to repositories at a western site in southern Nevada, in South Carolina, and in southern Mississippi on the Gulf Coast (cf. DOE/EIS-0046F 1980). These repositories reflect no preference of the panel as to location; they are merely intended to illustrate the range of differences associated with alternative locations. The flows of waste are shown in Figures 3.2, 3.3, and 3.4. Summary data on the characteristics of the single repository system are provided in Table 3.3 (see Appendix A for full data sets).

ORNL was also asked to use its model for a system of regional repositories in the West, Midwest, and Southeast. These locations were picked to minimize the aggregate distances between nuclear power plants and repository sites, and, again, reflect no preferences of the panel. Figure 3.5 illustrates the transportation corridors for truck-only shipments to regional repositories.

The site of the repository could well affect the mix of rail and truck transport used. Because truck shipment is more cost-effective for short hauls than is rail shipment, the choice of regional repositories would tend to favor trucks, whereas a western repository would favor greater use of rail transport.

Costs

In capital cost, the largest element of the transportation system is in the casks themselves (estimated at $1 million for a truck cask and $5 million per rail cask, cf. DOE/EIS-0046F 1980, Chapter 7).* It is unlikely that the combined cost of all other facilities—loading and unloading cranes, road tractors, and rail cars—would be more than double the investment required for the shipping casks alone. Thus, the total capital cost for a spent-fuel

* ORNL provided the panel with rough estimates of the annual costs in 1981 dollars and the number of casks required to ship spent fuel to a single (Tables 3.4 and 3.5) and to multiple repositories (Tables 3.6 and 3.7). Because these estimates depend on many untested assumptions, they are primarily useful for gaining insight into differences in relative magnitude.

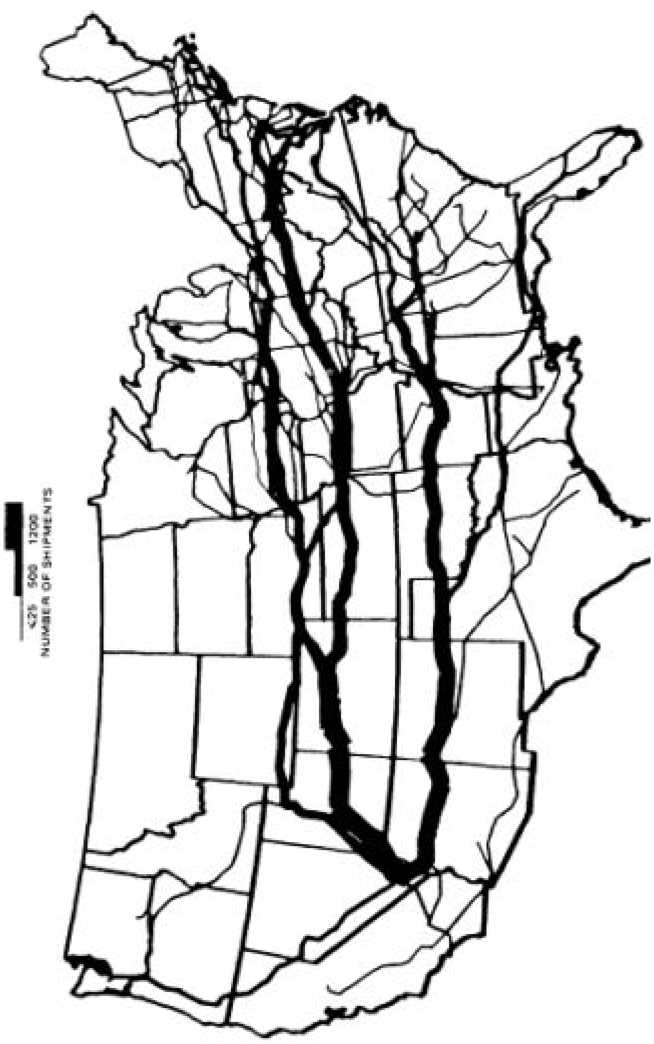


Figure 3.2 Projected annual spent-fuel shipments to a western storage site in 2004. Basis: reactors with rail service using rail; all others using truck service (for demonstration purposes only).

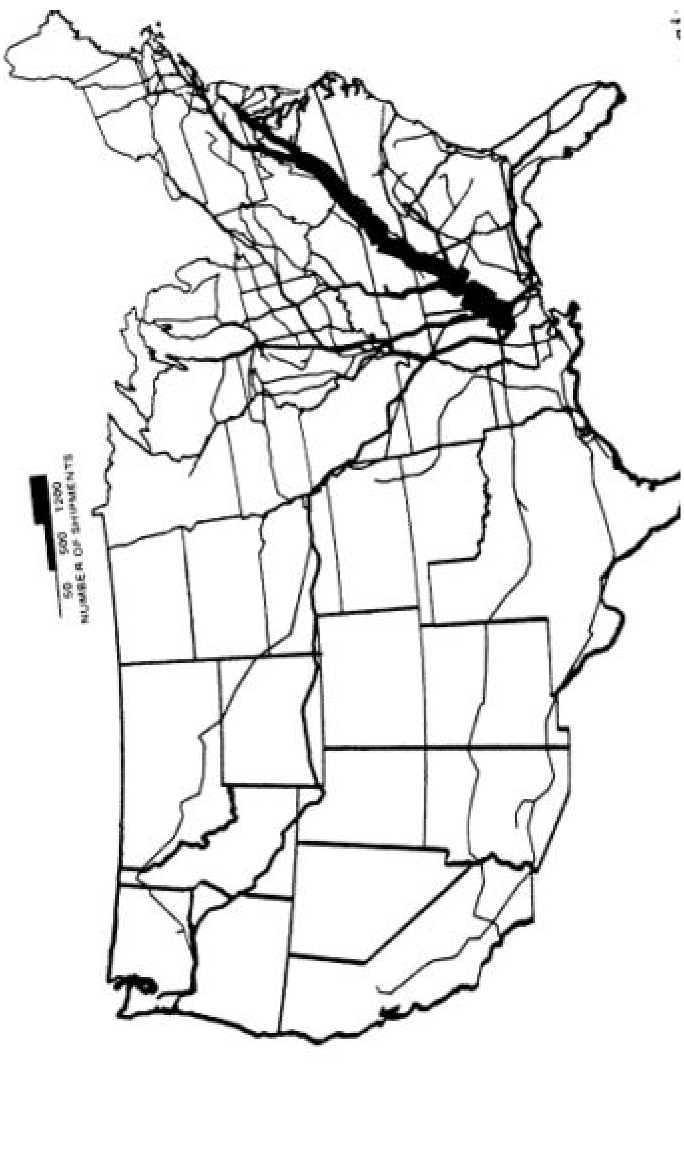


Figure 3.3 Projected annual spent-fuel shipments to a Gulf Coast storage site in 2004. Basis: reactors with rail service using rail; all others using truck service (for demonstration purposes only).

Figure 3.4 Projected annual spent-fuel shipments to a southeastern storage site in 2004. Basis: reactors with rail service using rail; all others using truck service (for demonstration purposes only).

transportation system is not likely to exceed $1.2 billion.*

TABLE 3.3 The Radioactive Waste Management System: Summary characteristics on the Reference System by the Year 2004a [113 Reactors Discharge Approximately 3600 MTU, Based on 32 MTU (Average Mix of PWR and BWR) Discharge of Spent Fuel per Reactor Yearb]

	Combined Rail/Truck	Truck Only
1. Number of shipments (-0.42 MTU per truck load; 4.2 MTU per rale car)	575/2480	8750
2. Number of casks needed (centralized western repository)	65/69	220
3. Cost of casks 0.51 million per truck, $5 million per rail cask	394 million	220 million
4. Total capital cost of above-ground operations	1.2 billion	1.2 billion
5. Number of workers per cask for transport operations (5 trip tenders 10-15 loaders and handlers)	-20/15	-15
6. Number of monitor regulators (needed to follow, report, and respond to mishaps)	?	?
7. Cost of regulatory system	?	?
8. Approximate level of operational activity at repository (with a single emplacement shaft):		
a. Number of emplacements per day (2 shifts per day)	32	
b. Number of handling bays operating in parallel to maintain even flow	1 Rail bay 3 Truck bays	5 Truck bays
c. Maximum number of emplacements per yr	9600	
9. Number of reactors served by one shaft (@ 9600 casks per year, 75 casks per reactor)	128	
10. Total number of shafts required in simultaneous	1	

[a] The estimates of summary characteristics in this table are those of the panel defined by consultation with ORNL and other (particularly industry) sources; the costs are in 1981 dollars.
[b] These estimates are based on the annual discharges of spent fuel from 113 1000-MW reactors with no older spent-fuel backlogs.

* This estimate is based on discussions with executives at Tri-State Motors and with staff at ORNL. The logic is as follows. Historically the cost of tractors and trailers has been on the order of 0.1 the cost of shipping casks. This relationship could change with possible requirements for more sophisticated equipment. But it is extremely unlikely that tractors and trailers could exceed 0.2 the

Shipping costs in a single repository system are estimated at $102-177 million per year, depending on location. The higher figure is for a Western site (Table 3.4). In either a truck-only or mixed truck/rail system, total transport miles to the southeastern or midwestern sites would be less than half that of the mileage associated with the western site (Table 3.8). In a regional system, total shipment costs would, in our reference case, total only $71 million in 2004, reflecting both lower carrier and cask leasing costs. These conclusions are generally consistent with the findings of a 1979 Office of Nuclear Waste Isolation (ONWI) study, which found that optimal regional siting of two to three repositories would decrease transportation costs and risks relative to those for a single site by as much as a factor of 2 (Kirby et al. 1979). The panel cautions that these transportation cost considerations must be weighed against many other considerations, technical, social, and economic, in the choice between regional repositories and a single national site.*

Social and Institutional Effects

In the case of a single western repository, each state, except for a handful in the Mountain or Great Plains area would be crossed in the transport system. The waste transport funnel would expose many states—including some

cost of casks even assuming a single tractor-trailer combination for each cask, which is also unlikely. Similarly, it is difficult to imagine that the aggregate cost of all the other handling equipment could exceed the cost of the tractors and trailers. Assuming as a "worst case" that the handling equipment equals the tractors and trailers in cost, and rounding upward to recognize the uncertainty in the estimates, the total cost for all noncask facilities and equipment is roughly half that of the casks.

If this logic is even approximately correct, doubling the estimated aggregate cost of casks should provide a very conservative upper bound for the full capital cost of a spent-fuel transport system, exclusive of the repositories.

* McSweeney and Peterson (1983) estimate the cost of repository development at $5 billion.

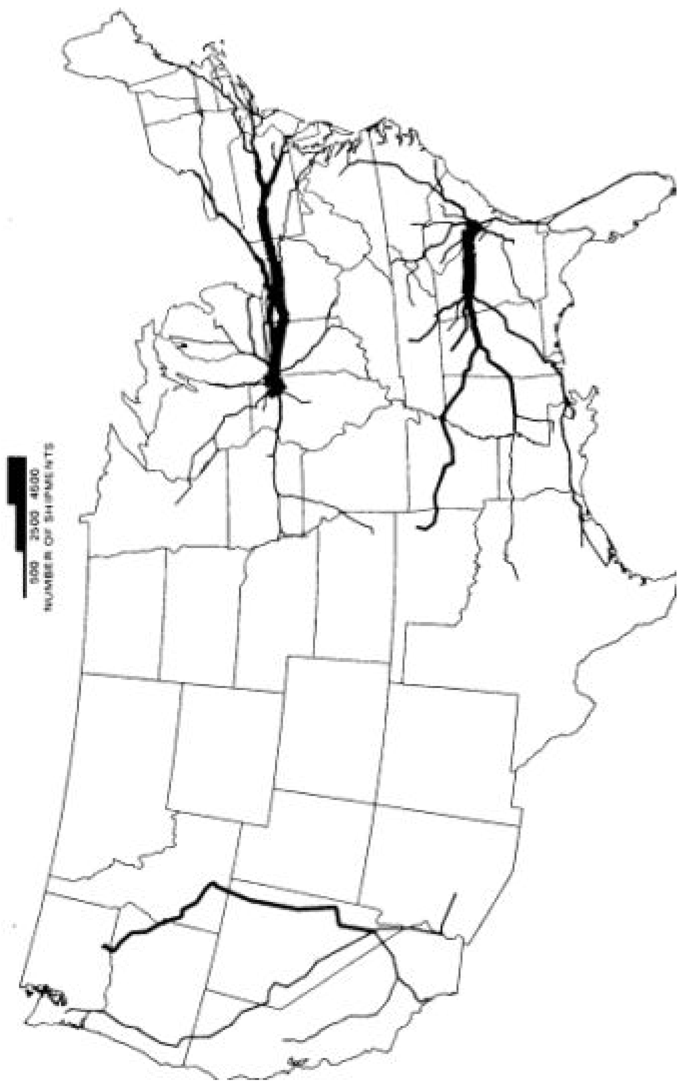


Figure 3.5 Projected annual spent-fuel shipments to regional storage sites in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

TABLE 3.4 Transportation Costs of Shipping Spent Fuel to a Single Storage Facility Using Both Rail and Truck Modes, and Truck Only (Annual Operating Costs in 1981 Dollars)

	Southeastern Facility		Gulf Coast Facility		Western Facility	
	Costs ($\$ \times 10^6$)		Costs ($\$ \times 10^6$)		Costs ($\$ \times 10^6$)	
Year	(Rail and Truck)	Trucks Only	(Rail and Truck)	Truck Only	(Rail and Truck)	Truck Only
1986	2.0	2	3.0	3	7.0	7
1990	14.0	13	17.0	17	31.0	31
1995	42.0	39	45.0	44	79.0	78
2000	70.0	67	72.0	70	126.0	118
2004	102.0	97	103.0	100	177.0	168
Totals of all Years, 1986-2004	851.0	806	895.0	866	1558.0	1493

SOURCE: Appendix A, Tables A.6 and A. 10.

TABLE 3.5 Cask Fleet Requirement for Shipping Spent Fuel to a Single Storage Facility Using Both Rail and Truck Casks, and Trucks Only

	Southeastern Facility (NO. of Casks)			Gulf Coast Facility (NO. of Casks)			Western Facility (No. of Casks)		
Year	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only
1986	1	3	5	1	4	6	2	6	9
1990	4	14	23	4	16	26	6	27	39
1995	17	20	63	16	24	68	25	40	100
2000	27	29	104	27	32	107	47	47	154
2004	41	40	151	39	44	154	65	69	220

SOURCE: Appendix A, Tables A.4 and A.8.

TABLE 3.6 Cask Fleet Requirements for Shipping Spent Fuel to Regional Facilities Using Rail and Truck Casks, and Trucks Only

	Western			Southeastern			Midwestern			Total		
Year	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only
1986	0	0	0	1	3	4	1	1	1	2	4	3
1990	1	0	1	1	7	8	2	7	12	4	14	21
1995	2	0	5	2	10	18	6	11	31	10	21	54
2000	3	4	10	7	7	30	9	16	48	19	27	88
2004	6	4	18	10	15	49	11	19	59	27	38	126

SOURCE: Appendix A, Tables A.13 and A.17.

TABLE 3.7 Transportation distances and costs (in 1981 Dollars) of Shipping Spent Fuel to Regional Facilities Using Rail and Truck Casks, and Trucks Only

	Distance (Miles × 10^6)		Cost ($ × 10^6)	Distance (Miles × 10^6)	Cost ($ × 10^6)
Year	Rail and	Truck	Rail and Truck	Truck	Truck
1986	0.01	0.15	2.8	0.19	2
1990	0.05	0.93	11.0	1.43	11
1995	0.22	1.53	28.3	3.61	29
2000	0.48	2.29	50.0	6.68	49
2004	0.68	29.94	71.0	9.26	70
Totals of all years, 1986-2004	5.24	29.65	602.0	78.66	594

TABLE 3.8 Summation of Cask Round-Trip Mileage per year to Ship Spent Fuel to a Single Repository Using Both Truck and Rail Casks, and Truck Casks Only and the Number of Places that State Borders Are Crossed

	To a Southeastern Facility			To a Gulf Coast Facility			To a Western Facility		
	(Cask Miles × 10^6)			(Cask Miles × 10^6)			(Cask Miles × 10^6)		
Year	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only	(Rail and Truck)		Trucks Only
1986	0.01	0.19	0.28	0.02	0.32	0.50	0.06	0.90	1.44
1990	0.12	0.98	2.03	0.13	1.60	2.80	0.19	4.30	6.21
1995	0.54	1.49	6.27	0.51	2.46	7.43	0.91	6.59	15.67
2000	0.87	2.93	10.93	0.86	3.64	11.71	1.73	7.40	23.54
2004	1.34	3.59	15.91	1.25	4.75	16.05	2.39	10.91	33.28
Totals of all years, 1986-2004	11.00	34.00	130.00	10.00	48.81	145.00	19.00	115.00	298.00
Twice the number of places states boundaries crossed[a]	180	80	130	130	62	142	132	94	144
Combined rail and truck	260			192			226		

[a] For each column, the number shown is twice the number of places state lines are crossed by the particular transport network. Some states may wish to assure themselves that the hazardous materials are safely packaged before entry and that nothing has gone awry on their way through the state.

that may not generate spent fuel—to nuclear transport hazards (however small) and to regulatory and emergency response responsibilities.

For a site in Nevada, the states of Utah, Colorado, Nebraska, Arizona, and New Mexico might face significant transportation-related effects. For other proposed centralized sites, the burdens fall differently. A repository located in South Carolina, for example, would create waste corridors through Georgia, North Carolina, and Virginia, whereas a Gulf Coast site would affect Mississippi, Alabama, Tennessee, and Virginia. For a western site, Iowa would see considerable traffic, whereas Kentucky would see almost none. In the South Carolina case, the reverse would be true. Alternative repository locations may be expected to produce different systemwide effects with implications for interregional equity (Kasperson 1983).

The transport mode can also affect these impacts. Later in this chapter a variety of obstacles to a predominantly rail transportation system are noted. Since extensive use of truck transportation appears quite possible, the panel requested ORNL to use its model to project some of the characteristics of truck-only transportation. Figures 3.6, 3.7, and 3.8 show possible routes along interstate highways. Many of the state-by-state differences that were apparent earlier are still evident, although the number of individual shipments on each highway can be seen to be much greater if the widths of the bands defining the routes to each repository are compared for rail/truck and truck-only systems (e.g., Figure 3.2 versus Figure 3.6).* The total number of truck shipments in such a system would increase at a rate of about 500 loads per year to a level of about 9000 shortly after the turn of the century (about one per hour).**

The increased frequency of shipments associated with all truck transport could be quite visible and could

* Note the differences in scale of shipments for truck/rail versus truck-only maps.

** To place these numbers in perspective, some 1530 shipments per hour of gasoline, 341 shipments per hour of propane, and 6.3 shipments per hour of liquid chlorine were projected to be leaving various depots via truck or train in 1980-1985 (Rhoads 1978, PNL 2133; Geffen 1980, PNL 3308; Andrews 1980, PNL 3376).

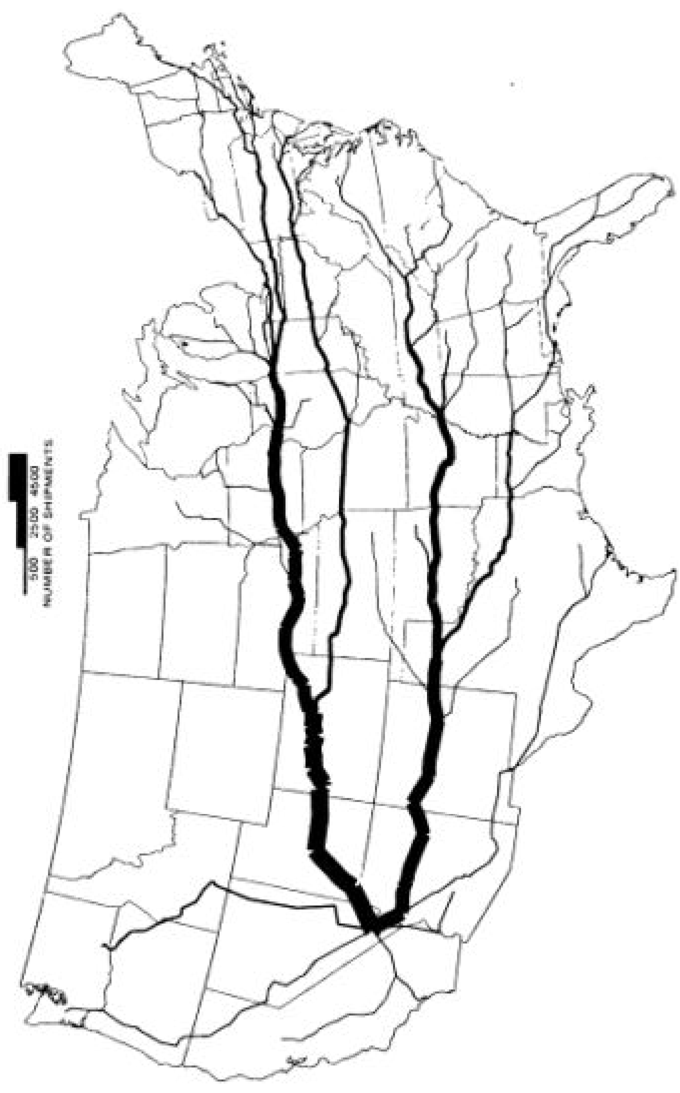


Figure 3.6 Projected annual spent-fuel shipments to a western storage site in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

Figure 3.7 Projected annual spent-fuel shipments to a Gulf Coast storage site in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

Figure 3.8 Projected annual spent-fuel shipments to a southeastern storage site in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

become a source of public concern in communities along the waste funnel. Comparison of transport options for routing to a single destination is also instructive, for it reveals a significant reduction in routing complexity for the truck-only system. Significantly fewer routes would cross the states on the way to the center of the waste funnel, and the total number of locations where shipments would cross state borders also drops about 25-50 percent (Table 3.8).

In a single repository system, nuclear-energy-related effects would be distributed well beyond those associated with power production. Attention should be given to whether the denser transport flows increase the vulnerability of the repository system to public concern-related problems, labor strikes, disrupting weather, or highway shutdowns.

Accidents of a radioactive and nonradioactive nature will happen in all the systems reviewed here and have the potential of eliciting considerable media attention. Here again, the transport mode will be relevant: a truck-dominated system would have the greater number of accidents and total fatalities, but rail accidents have the potential for greater loss of life and economic cost for a single event (Norton 1981).* Given the level of public concern, the movement of waste through communities could be a source of anxiety to local citizens and could lead to demands for greater local and state influence over nuclear waste transportation policy.

In a regional repository system, the areas that would bear the burden of long-term waste isolation would be located closer to the plants that generate the waste. In this way, regional siting would build upon the approach currently being developed for the management of low-level waste. It would also reduce adverse social effects from transport through the substantial reduction in shipping

* McSweeney and Peterson (1984, p. 14) estimate that an all-truck transportation system would increase total transport-related fatalities by a factor of 5 but decrease latent cancer fatalities by a factor of 2. It is also important to note, for perspective, that the projected loss of life is approximately one per year, a minor fraction of the total lives lost per annum from truck accidents (over 2000 fatalities/year) and train accidents associated with the movement of freight (over 1000 fatalities/year).

distances and the fewer states and communities involved in waste transport.

These potential advantages need to be assessed at length and placed in a broader context. A regional system requires finding individual sites within different regions. This would more visibly demonstrate that all parts of the country would share in radioactive waste risks and burdens, thereby offering the opportunity to lessen social conflict. On the other hand, disputes could occur more frequently in the search for multiple sites as opposed to a single national facility. These trade-offs are highly uncertain and worthy of further investigation.

The institutional effects of facility location and transport should be carefully appraised by DOE in formulating its Mission Plan. State and local regulatory, monitoring, and emergency response capabilities and responsibilities, in particular, will need to be considered (Church and Norton 1981, Norton 1981).

The extent of these probable institutional impacts is difficult to discern. Railroads have a traditional legal history of independence from local and state regulation. Yet the duration of rail stops appears to have a large impact on both cost and risk (McSweeney and Peterson 1983) and could lead to substantial local concern at semiurban marshalling yards. A predominantly truck system would be less complex in its routing than a mixed-mode system, but the increased number of shipments could provoke more state and local monitoring. How adequately these different costs can be met by normal inspection and emergency planning should be the subject of further analysis.

Some states would be quite differently affected than others. New Hampshire, for example, recently disbanded the radiological division in its public health department as a cost-cutting measure, and the state might have difficulty resuming this activity. The Midwest would be confronted with greater monitoring and regulatory costs regardless of the transport mode used, given a western site (Windham 1981). In a decentralized, regional system, the number of states affected drops significantly, and those affected are already likely to have nuclear reactors. These states are already required to respond to emergencies at nuclear plants and have a head start putting in place appropriate plans and institutions. All states, of course, must deal with broader hazardous waste transport issues.

Overall, the panel finds a number of socioeconomic and institutional effects associated with a single or centralized repository system and the waste funnel such a system would create. Prominent among these effects would be greater regional inequity, higher shipping cost, and larger potential regulatory and emergency response burdens along the transport corridor. The panel considers regional equity, with its potential for co-location of costs, risks, and benefits (whatever they are and however they may be defined), as an important and possibly necessary ingredient in achieving social consensus on a nuclear waste management program. The number and location of facilities may affect levels of public concern. Finally, the transport corridor considerations affecting cost, socioeconomic effects, and institutional burdens have received relatively little attention and should be addressed more fully in the siting program.

TEMPORARY STORAGE PRIOR TO PERMANENT ISOLATION

Temporary storage and the possibility of reprocessing have not been explicitly considered in our assessment of facility location and transportation. One proposed radioactive waste strategy involves interim storage of spent fuel at away-from-reactor (AFR) facilities prior to permanent isolation. Handling of spent fuel in the AFR option would involve two major steps: first, transfer of spent fuel from reactors to one or more above-ground away-from-reactor storage facilities; second, transfer of spent fuel from both AFRs and reactors when repositories are able to accept shipments. Reprocessing could add further complexity. In the AFR case, temporary storage would relieve reactor operators of the need to expand existing pool storage capacity, ship to other fuel pools, re-rack fuel to accommodate more fuel in existing pools, transfer to dry storage in on-site, air-cooled facilities, or, if none of these are possible, shut down the reactor.

In the event that a waste repository were opened in the early 1990s and dry storage is not possible, some limited amount of spent fuel might be handled in a single, small AFR. This has been provided for in the Nuclear Waste Policy Act of 1982. With such a facility serving roughly 10 to 15 reactors, transportation requirements would be only moderately higher than in either the single or multiple repository systems. The AFR system could become substantial, however, if repositories could not receive fuel until the early twenty-first century or long-term on-site storage capacity is not developed or both.

With several small regional AFRs, there would be fewer transportation requirements initially than for a single national repository, but once a repository (or more than one) opens, these rates will be significantly higher than in either of the direct reactor-repository transport systems. If fuel arrives at repositories more quickly than it can be loaded into the repository, at-repository above-ground storage capacity may be needed. If it is possible to defer the AFR decision through expanded on-site storage capacity until potential repository locations become clearer, transportation costs and risks might be reduced through co-location of interim storage and final disposal.

Costs

Costs involved in the interim storage option would probably be distributed quite differently from costs for alternatives involving direct shipment to either regional or national repositories. The capital costs of an AFR storage facility for a large number of reactors might well be less than for equivalent pool storage at the reactors (Ghovanlou et al. 1980), although this may not apply to dry-storage techniques, and these costs would be increased when unpacking of AFRs begins and the extra handling and transportation costs are added to those incurred for direct reactor-repository transport.

Institutional Effects

Temporary storage of spent fuel has the potential for both reducing or increasing institutional problems. Temporary storage of spent fuel prior to permanent isolation could add to long-term regulatory burdens on state governments because of increased transport levels in a reactor-AFR-repository system. It could, if located away from reactors, relieve utilities of procedural and logistical difficulties in expanding on-site storage capacity. At the same time it might also allow for additional time for planning and siting repositories. AFRs could prove quite difficult to site, just as any nuclear facility is, but also because of the probable need to ensure that they will not become de-facto permanent repositories.

A further consideration involves the adequacy of financial resources needed for more complex spent-fuel management systems. DOE's National Plan estimates the cost of a fully operational radioactive waste system at $30 billion (1980-2000) in 1980 dollars; with different assumptions, the Congressional Office of Technology Assessment has estimated these costs in the tens of billions of dollars. There is also the possibility that these costs may be significantly underestimated, and, in that context, there will be a temptation to postpone commitments of resources needed for a full-scale program. AFR storage could add to that uncertainty. The Nuclear Waste Policy Act provides little guidance to the DOE on criteria for accepting fuel into a federally operated AFR or for scheduling shipments from reactors and AFRs to permanent repositories. The logistical and institutional issues involved therein require careful attention and should be studied by DOE in its preparation of a Mission Plan.

TRANSPORT MODE

Earlier in this chapter it was noted that DOE planning assumed that as much as 90 percent of spent fuel would be moved by rail rather than truck (DOE/EIS-0046F 1980, Chapter 4.5). The panel, however, raises a number of questions concerning this assumption.

Rail transport of spent fuel has several advantages over truck transport, primarily those associated with economies of scale. Current rail casks carry ten times as much spent fuel in a single car as a truck cask, and a new generation of truck and rail casks sized and designed for aged spent fuel will likely preserve this relative advantage. Handling costs for loading spent fuel at reactors and unloading at repositories (or AFRs) are substantially less per kilogram for rail than for trucks. The physical economies of rail transport also mean fewer border crossings, less overall health and safety risk, and associated institutional burdens than would be true if the same fuel were shipped by truck.

Other potential advantages of rail transport, however, may not translate into financial savings. The economics of rail and truck shipment is very sensitive to average transport speed. For normal freight, average truck speeds favor truck over rail by a factor of nearly 6 (35 mph versus 6 mph, although hazardous cargo is carried more quickly by both). (For rail speeds, see Wilmot et al. 1983 and Anderson 1978.) These speeds are currently the basis for DOE planning and are imbedded in the ORNL model used for the logistical calculations given in this report. At the speeds given above, there is little difference in average shipping costs for rail and truck.

Based on experience with hazardous cargo, expedited service can move freight as quickly as 12 mph. This would not reduce carrier costs but would cut cask-leasing costs. For shipments longer than 1000 miles, this might translate into a 30 percent savings for rail. Special trains are a further option, but because of their high cost would boost shipping costs beyond even transcontinental truck shipment.*

State and local monitoring of shipments and development of emergency response capability are considerations for both rail and truck. The two modes require different oversight systems. Traditionally, state and local governments have had little role in regulating rail shipments of any commodity, but one recent court found that the local community in that case had some jurisdiction over hazardous material routing. In that case, truck shipments were affected, but such jurisdiction could conceivably be extended to the rail system as well (Church and Norton 1981).

Institutional difficulties associated with rail transport appear to be more formidable than those of truck transport (see Chapter 5). Command and control systems for hazardous material transport are developed, to some extent, for truck shipments, less so for rail. Moreover, several trucking companies now offer spent-fuel transportation service, and costs appear to be lower than those used in our calculations. Spent-fuel casks are also available for truck shipments. It is unclear how quickly they can be made available for rail service. In addition, the Association of American Railroads has informally

* One means for reducing this differential, however, would be to utilize a larger number of casks in a single shipment. For example, 10 casks in one train would reduce by 70 percent the unit cost associated with shipping a single cask by special train (private communication from Jon Cashwell, Transportation Technology Center, Sandia National Laboratories).

indicated that its members would prefer not to handle spent-fuel shipments as normal or expedited freight. The primary concerns of the railroads, as described recently by Sandia Laboratories (Klassen 1982) are three: (1) as long as there are any conceivable accident situations that could lead to cask failure, the casks are not safe enough to be transported by ordinary trains; (2) in the event of an accident, the Price-Anderson Act and existing insurance might not provide an adequate amount of liability insurance protection; and (3) an accident might lead to a prolonged shutdown of all transport operations because of delay by nuclear regulatory authorities in reopening the track. The use of special trains might resolve their concerns, although at high cost. A recent Interstate Commerce Commission ruling, upheld by the courts, has disallowed railroad attempts to require special tariffs and status for spent-fuel and radioactive waste shipment, so railroads may lack the institutional capability to prevent such shipments. Nevertheless, the railroad industry lacks a strong financial incentive to become heavily involved in spent-fuel transportation, and, in the face of that, the extent to which an incentive to manufacture or use rail casks exists in the United States is unclear.

In general, it appears to the panel that the lack of rail access to a number of reactors, unresolved institutional difficulties, and the reluctance of the railroad industry to transport spent fuel makes the achievement of DOE's 90 percent rail/10 percent truck planning hypothesis questionable. We have not found a basis for recommending a particular alternative mix, but the strong possibility of much greater truck transportation certainly exists, along with its particular set of risks and institutional impacts, and deserves further attention by DOE.

FINDINGS

In its identification of the socioeconomic and institutional issues associated with the deployment of a network of waste facilities and transport links, the panel made use of rough estimates of the scale and timing of spent fuel discharges from power reactors and of transport routing and costs. Only one level of potential nuclear power production, involving 113 reactor units, was examined. The estimates did not include the handling of wastes from military programs, nor did they include a system involving reprocessing of spent fuel. Further analysis is needed to consider how these aspects of a nuclear waste storage system increase the effects identified here.

On the basis of its analysis, the panel concluded the following:

1. A substantial disparity exists between the amount of research effort expended on technical aspects of underground nuclear waste storage and the limited efforts expended on the above-ground design of the waste system. Specifically, the socioeconomic and institutional issues associated with facility location and transport modes, routes, distances, and scheduling require greater attention than they have received to date. While the panel believes that the logistical and institutional challenges can be met, it finds substantial tasks ahead that merit attention in a formulation and implementation of a national radioactive waste management strategy. The panel also emphasizes that the kinds of problems involved are not readily amenable to technical solutions; they must be considered in the overall system design and in institutional policies that include socioeconomic as well as technical criteria.
2. The socioeconomic and institutional effects associated with the network of nuclear waste facilities and transportation are quite sensitive to the number and location of repositories. These effects, as suggested by the panel's analysis, include transport-system complexity, shipping costs, public concern and conflict, vulnerability to possible transport-system bottlenecks, and institutional burdens on states and localities. One problem—interregional inequity—viewed as particularly important by the panel, could be minimized through regional siting. The relationships between these factors and effects have received only limited research attention and require further explicit analysis. They will also need to be weighed against geologic criteria and overall waste management system costs.
3. The socioeconomic effects of establishing temporary away-from-reactor facilities for interim storage depend on specific assumptions and scenarios chosen and are at present not well understood. Whether such storage facilities are co-located with repositories, located at reactors, or located away from both repositories and reactors appears to affect significantly total system transport costs, regulatory and emergency response

burdens on state and local governments, and public concern along transport routes. At-reactor storage, in particular, may have potential for reducing these effects. At the same time, the panel recognizes the potential usefulness of the limited away-from-reactor storage provided for in the Nuclear Waste Policy Act of 1982.

4. Current DOE plans assume that the transportation of waste will be primarily by rail. The panel has identified a variety of obstacles to a predominantly rail transportation system. The rail industry appears to have few economic incentives and a stated reluctance to take on radioactive waste transport. Rail also does not appear to have a decisive economic advantage over truck transport, and the rail system is less responsive to possible demands for routing changes. These obstacles should receive further review from DOE. If these problems lead to greater use of truck transport, differing socioeconomic and institutional effects will need to be anticipated.

REFERENCES FOR CHAPTER 3

Anderson, R. T. 1978. Studies and Research Concerning BNFP Light Water Reactor Spent Fuel Transportation Systems. Prepared for the Department of Energy. Barnwell, So. Carolina: Allied-General Nuclear Services .

Andrews, W. B. 1980. An Assessment of the Risk of Transporting Liquid Chlorine by Rail. PNL-3376. Richland, Wash.: Pacific Northwest Laboratory, March.

Behnke, W. D. 1980. Speech given at the McGraw-Hill Conference on Nuclear Commerce in the '80's, St. Charles, Illinois, April 28.

Church, A. M., and R. D. Norton. 1981. Issues in emergency preparedness for radiological transportation accidents. Natural Resources Journal 21:757-772.

Diedrich, R. 1983. Estimates of Future U.S. Nuclear Power Growth. Pre-publication draft. Washington, D.C.: U.S. Department of Energy.

Geffen, C. A. 1980. An Assessment of the Risk of Transporting Propane by Truck and Train. PNL-3308. Richland, Wash.: Pacific Northwest Laboratory, March.

Ghovanlou, A., L. Ettlinger, A. De Agazio, and N. Lord. 1980. Analysis of Nuclear Waste Disposal Technologies and Strategies for Technology Deployment. Draft. McLean, Va.: Mitre Corporation, April.

Kasperson, R. E., ed. 1983. Equity Issues in Radioactive Waste Management. Cambridge, Mass.: OGH Publishers.

Kirby, K. D., W. J. Elgin, W. Mitchell III, S. E. Turner. 1979. Evaluation of the regional repository concept for nuclear waste disposal. Pp. 183-186 in Proceedings of the National Waste Terminal Storage Program Information Meeting. ONWI-62. Columbus, Ohio: Battelle Memorial Institute.

Klassen, D. 1982. Transportation of Radioactive Material by Rail: Special Train Issue. Sandia Report SAND-81-1447. TIC-0226. Albuquerque, N. Mex.: Sandia National Laboratories.

McSweeney, T. I., and R. W. Peterson. 1984. Assessing the Estimated Cost and Risk of Nuclear Waste Transportation to Potential Commercial Nuclear Repository Sites. Paper #IAEA-CN-43/243 Presented at IAEA International Conference on Radioactive Waste Management, Seattle, Wash., May 16-20, 1983. To be published in Proceedings of that Conference (in preparation).

Norton, R. D. 1981. Policy issues in the routing of radioactive materials shipments. Natural Resources Journal 21:735-756.

Rhoads, R. 1978. An Assessment of the Risk of Transporting Gasoline by Truck. PNL-2133. Richland, Wash.: Pacific Northwest Laboratory, November.

U.S. Department of Energy. 1979. Technology for Commercial Radioactive Waste Management. DOE/ET-0028, Vol. 1. Washington, D.C.

Wilmot, E. L., M. M. Madsen, J. W. Cashwell, D. S. Joy. 1983. Preliminary Analysis of the Cost and Risk of Transporting Nuclear Wastes to Potential Candidate Commercial Sites. Sandia Report SAND-83-0867. Albuquerque, N. Mex.: Sandia National Laboratories, June.

Windham, P. 1981. State government views on the transportation of nuclear spent fuel and associated institutional impacts. Draft. Prepared for the Panel on Social and Economic Aspects of Radioactive Waste Management, Board on Radioactive Waste Management, National Research Council. Washington, D.C.

4

The Waste Repository Site: Characteristics and Socioeconomic Considerations

There are a number of reasons for concern with the socioeconomic impacts of a waste repository. Social justice considerations, for example, would argue that we attempt to restore the status quo in locales that are subject to an imposed change. Distributive justice concerns would dictate that we try to avoid impact to communities already suffering some relative inequity (low-income populations, for example) or an uncompen-satable effect. Economics demands that we anticipate the costs of new facilities (planning and actual utilization) so as not to produce a "boom and bust" phenomenon. Finally, practical politics would argue that we should be sensitive to the needs of local areas, particularly if there is some likelihood that impacts (or potential impacts) will generate rancor and ill will.

Recognizing the importance of socioeconomic impacts at repository sites does not mean that we can identify what the impacts are or know how we should deal with them (through mitigation, compensation, or override, for example). However, previous research indicates several steps that can be taken. First, we can summarize what we know and do not know about the effects of large-scale industrial facilities. This does not necessarily provide site-specific data, nor does it identify which impacts may be perceived as most important for a given locale. Second, we can involve local potentially impacted populations in the identification and mitigation process. This form of iterative planning is increasingly common for public facilities, and nuclear facilities in particular (NUREG/CR-2750). It is premised on increased awareness of the unique perspective of local citizens in defining key community characteristics (and, therefore, those characteristics that, if affected, will alter community life) and in establishing the costs or other mitigating structures that will satisfy the need to maintain community integrity. Indeed, some have argued that the planning of facilities should be an opportunity to improve the quality of life for communities rather than simply to "make them whole" again (Seley 1983). The third, and final, step is to compare the results of several community-specific impact assessment procedures. Depending on the particular consideration (social justice, distributive justice, economic, political) applied, it is then necessary to choose a site based on explicit reference to the consideration and the identified impacts. For example, it would be ideal to be able to devise an index of socioeconomic impact criteria for each potential host site and then compare these across sites in terms of social justice and other considerations. The resulting matrix (impact on one dimension, social or distributive justice criteria on another) would yield a least-cost approach from both sponsor and community perspective.

Unfortunately, the state of the art of impact assessment is not sufficiently advanced to provide such a matrix. Thus, we are left with a research and policy void that must be filled to make socioeconomic impact assessment both possible and relevant. Nonetheless, we can identify a list of impacts to look for and review some of what is known about their measurement and identification to guide further research. The rest of this chapter is devoted to this review.

It will be seen that the U.S. Department of Energy (DOE) and others have already initiated research relevant to effect identification. It is the first step of the three-step process outlined here. We recommend that the integration of socioeconomic criteria into the site-selection process for a high-level waste repository focus additional attention on the other two steps in the outline—design of an iterative assessment and mitigation process and identification and comparison of criteria for selection—before impact assessments are devised or utilized. In particular, we recommend study of the U.S. Army Corps of Engineers' program of citizen participation (Hanchey 1975, Ragan 1975) and a review of ongoing siting efforts in regard to hazardous chemical waste repositories that employ local boards of various types to elicit local attitudes and integrate local concerns (the laws in Massachusetts and Wisconsin merit particular attention).

Repository sites for the long-term isolation of high-level radioactive wastes will be primarily in rural areas, and the planning, construction, and operation of the repositories will result in significant socioeconomic effects.* These effects will be of two kinds: those that occur when any large-scale industrial facility is located in a rural community (hereafter conventional effects) and those that arise as a result of the special characteristics of a repository for radioactive wastes (hereinafter special effects). Assessing either type of effect is difficult for a number of reasons (Finsterbusch and Wolf 1977, Peelle 1979, Finsterbusch 1980).

In addition to the uncertainties inherent in predicting social attitudes and behavior, many reactions occur during actual construction and operation (Cluett et al. 1980). Hence, findings from surveys of opinion about anticipated projects are only loosely correlated with findings from later surveys conducted during construction and operation. The manner in which a facility is planned and introduced can have a significant influence on public perception of, and response to, its effects. In addition, a single accident at the site or along the transport corridor may generate psychological stress that will alter the scope and magnitude of some (or possibly all) other effects. Even a harmless accident incorrectly reported as potentially dangerous can result in stress and behavioral response owing to the volatility of the nuclear issue (see Chapter 2). The 1982 Court of Appeals ruling (People Against Nuclear Energy v. NRC, U.S. Court of Appeals, District of Columbia Circuit, Intervenors #81-1131, May 14, 1982), despite its having subsequently been overturned by the U.S. Supreme Court, underscores the significance of psychological factors in the aftermath of accidents.

Adding to the difficulty is the lack of a common standard by which to compare effects once they are

* Within social science and government, it has become common to use the term "impact" to refer to the effect (positive or negative) that a project or program has on people or environments. We produce environmental impact statements, social impact assessments (SIAs) and measurements of socioeconomic impact in what has been an expanding field of study. To avoid jargon and because it seems more neutral, the panel uses the word "effect" wherever possible in this report. Some may prefer to read in the work "impact" where we have used effect, which should not change the intended meaning.

defined. How should social change be weighed against economic change? How should social change in one locale be compared with social change in another if the nature of the change is different? The panel cannot provide answers for these thorny questions, nor can it provide assurance that answers will be provided by others; it does, however, identify them as major socioeconomic considerations in the repository decision-making process.

While there are important impediments to any attempt to weigh and compare socioeconomic effects, enough knowledge does exist to categorize them. In this chapter the panel provides a description of a repository site and explores the nature and magnitude of the effects that are likely to occur and the adequacy of our knowledge about them.

THE REPOSITORY SITE: A DESCRIPTION

The DOE's standard design for a repository includes surface facilities for receiving and handling radioactive wastes and a subsurface area of approximately 2000 acres for waste emplacement. The surface facilities will consist of a fenced area of about 400 acres and include unloading areas, water and sewage treatment plants, and a number of buildings (Figure 4.1). After the 30-40 years postulated for repository operation, only a small monitoring building is expected to be required at the site (Office of Nuclear Waste Isolation 1981).

The size of the repository will vary according to the degree of centralisation of the waste management system, the total amount of waste involved, temperature considerations, and the size of the buffer zone. Spent fuel will arrive in shipping casks by rail, truck, or possibly barge, in amounts dependent on the waste system design.

Once at the site, the shipping casks will be removed from the carrier by crane and moved to shielded transfer cells. The remainder of the above-ground operation consists of moving the canisters to a shaft through which they will be lowered into the repository.

Construction of the repository, the shafts, and the surface facilities will take an estimated 7 years after the site has been selected and will require an estimated 1700 construction workers if the repository is located in salt and an estimated 4200 workers if the repository is located in hard rock. Maintenance workers—those who would be needed for the 30-40-year operation phase—are

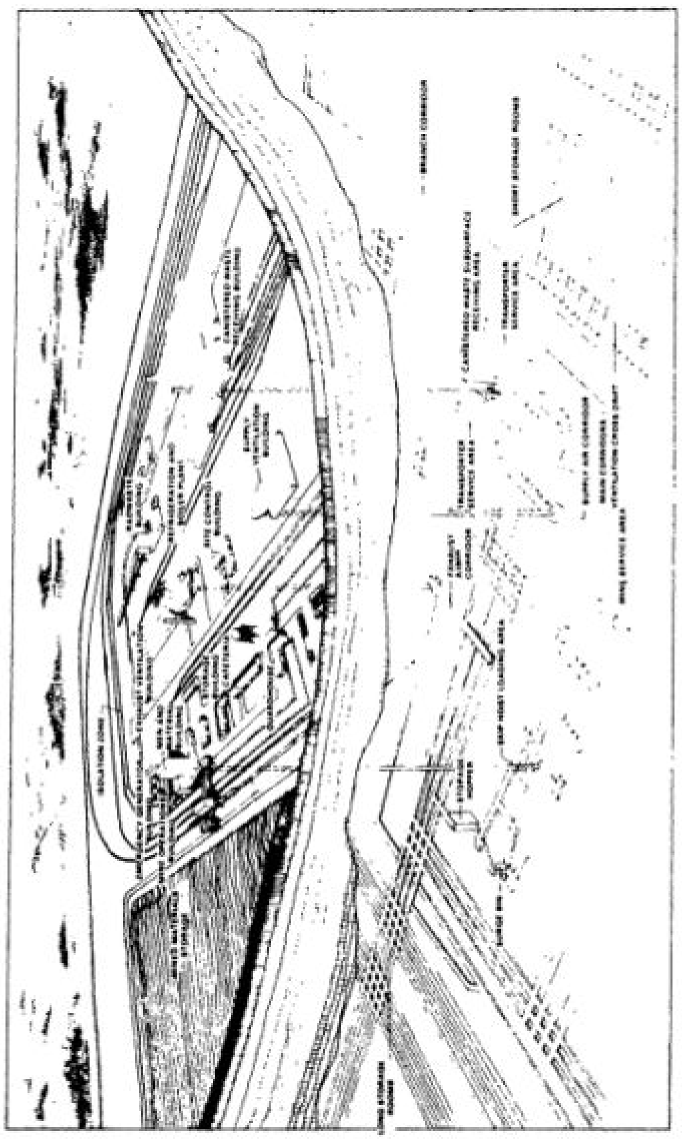


Figure 4.1 Artist's concept of a geologic repository and its support facilities. Source: U.S. Department of Energy, Management of Commercially Generated Radioactive Waste, DOE/EIS-0046F, Volume 1 (1980), p. 5.33.

projected to number between 870 and 1100 (Office of Nuclear Waste Isolation 1981). The site will also likely require monitoring for a lengthy (50-100 years) period of time.

DOE's socioeconomic characterization of repository sites in southeastern, midwestern, and southwestern locations provides general descriptions of population, employment, education, and housing at the sites (Table 4.1). While such data can be useful, particularly in determining economic effects, they are inadequate indicators of the range of a repository's socioeconomic effects. The following section discusses a number of economic and noneconomic effects that depend on more than the size of the in-migrant worker population.

CONVENTIONAL EFFECTS

The magnitude and distribution of the conventional effects of a large industrial facility in a rural area are a function of three primary variables: the characteristics of the project; the characteristics of the site area and population; and the characteristics of workers, their families, and others attracted to the area by the project (Leistritz and Murdock 1979, 1981; Thomas et al. 1982b). The major conventional effects to be expected are shown in Table 4.2.

Economic Effects

Construction and operation of a radioactive waste repository will have direct and indirect effects, including changes in employment patterns, property values, the costs of goods and services, and the level of economic activity, that can be expressed in marketplace terms. Many of these effects can be projected on the basis of the expected number and characteristics of new workers or the requirements for building and maintaining the repository (Greene and Hunter 1978). The rates of change, however, are more difficult to anticipate but are perhaps even of greater importance to the host community. Some economic effects would be the result of voluntary reactions (e.g., growth, speculation in land prices, and new investment patterns) to the local economy.

The U.S. Department of Energy (1981) has estimated the sizes of in-migrant populations for repositories in different geological media. In general, the smaller the community and the more remote the site, the larger the anticipated effects (Cole and Smith 1979). The availability of a construction labor force, the distance to the nearest metropolitan center, and the degree of advance site planning all affect the ability of a host community to absorb new economic activity with minimal disruption.

Economists estimate that population growth in excess of 10 to 15 percent annually creates serious problems for a given locale (Gilmore 1976, Greene and Hunter 1978). Smaller growth rates can induce less serious. but long-term effects; Peelle et al. (1979) conclude that a 5 percent increase plus or minus 2 to 2-1/2 percent in the population of Cherokee County, South Carolina, as a result of the construction of the Cherokee Nuclear Station, "will be sufficient to have a continuing impact" (p. 63). Mountain West Research has analyzed the total direct population influx for each 100 incoming construction workers for 14 energy-related construction projects. The average was 228 per 100, but the range was large—from 145 to 288 (Mountain West Research 1978). In-migrant population levels are highly dependent on the marital and family status of workers and on whether they decide to bring their families (Dixon 1978).

In general, spending by construction and operations personnel and their families in the community near a repository benefits retail, commercial, and service businesses. A recent review of socioeconomic impacts at 12 nuclear power stations, however, found few economic benefits to localities (Chalmers et al. 1982). The initiation of most large-scale construction projects in small communities also is followed by rising prices, particularly for housing and retail goods and services (Susskind and O'Hare 1977, Dixon 1978). Local industrial and professional employers are often forced to compete for skilled workers and must heed demands from their employees for increased pay to keep pace with that of the in-migrants (Leistritz and Murdock 1979). Pressure to expand or compete may, however, force small businesses with inadequate capital into bankruptcy (Howard et al., as cited in Finsterbusch 1980).

The Site Selection program outlined in the Nuclear Waste Policy Act of 1982 calls for identification of five candidate repository sites before a final selection is made. This procedure can be expected to have long-term effects on some local economies. During the decision-

TABLE 4.1 Selected Data Characteristics of Three Reference Sites, Socioeconomic Impact Analysisa

	Southwest Site		Midwest Site		Southeast Site	
Characteristic	County	Region	County	Region	County	Region
Population						
Estimated total population 1975	42,000	142,000	47,000	2,154,000	17,000	487,000
% Change 1965-1970	-8.5	-8.6	15.0	11.1	-1.4	4.2
% Change 1970-1975	3.2	5.8	24.9	3.8	11.9	2.6
Unemployed construction labor force, 1980	---	390	---	10,660	---	2,420
Net migration rate 1965-1970	-14.9	-14.6	7.4	3.0	-6.6	-2.4
Net migration rate 1970-1975	-0.9	0.5	18.4	-0.7	6.1	-2.2
% Urban 1970	76.9	78.9	8.4	85.1	40.9	50.1
Density 1970 (persons per sq mi)	9.9	9.2	57.8	246.8	31.1	60.1
% Nonwhite 1970	2.9	5.0	0.3	2.4	41.3	38.3
% Families with children under 18, 1970	56.8	59.3	59.4	59.7	57.6	57.6
Median age 1970	27.2	26.3	25.6	25.6	24.9	24.5
Employment						
Nonworker-to-worker ratio	1.7	1.7	1.6	1.3	1.4	1.5
% Employed in farming	5.7	5.8	13.6	2.2	8.5	4.9
% Employed in construction	7.7	5.6	6.0	3.7	5.2	5.8
% Unemployed	5.1	5.1	4.5	3.3	4.6	4.3
% Below poverty level	17.8	16.6	10.8	5.5	24.6	22.3
Median family income	7,870	7,965	8,936	11,242	6,997	7,166

	Southwest Site		Midwest Site		Southeast Site	
Characteristic	County	Region	County	Region	County	Region
Education						
Median years school completed	11.9	12.0	12.1	12.3	9.8	10.6
% High school graduates	49.3	51.3	56.0	64.5	29.8	37.0
Housing						
% Housing units renter occupied	25.9	25.7	15.8	31.5	33.4	33.2
% Units vacant	16.1	18.2	6.4	3.4	9.4	8.3
Trailers as % of housing units	2.5	3.3	6.5	1.8	7.2	5.8
% Units lacking plumbing	5.0	3.6	8.7	4.0	29.3	19.7
% Units built 1939 or earlier	19.2	17.6	53.3	41.1	36.8	30.6
% Units with 1+ persons per room	11.7	11.6	9.5	6.9	15.1	13.1
% Units using public sewer service	77.8	82.1	39.3	82.7	45.8	46.3

SOURCE: U.S. Department of Energy, Management of Commercially Generated Radioactive Waste, U.S. DOE/EIS-0046F, Volume II (1980), p. G.3.

[a] These data were developed from standard sources, but since sites are generic, no identifying information is given.

TABLE 4.2 Conventional Site Effects of a Large Industrial Facility

1.0 Economic Effects
1.1 Change in property value
1.2 Change in rental costs
1.3 Change in cost of goods and services
1.4 Higher property taxes
1.5 Change in employment
1.6 Change in provision of jobs
1.7 Change in travel costs
1.8 Change in market areas and competitive position of economic activities
2.0 Environmental and Health Effects
2.1 Noise
2.2 Air pollution
2.3 Damage to soil quality
2.4 Water drainage damage
2.5 Vibration
2.6 Congestion and access
2.7 Accidents
2.8 Aesthetic changes
3.0 Social Change Effects
3.1 Social Pathologies (alcoholism, drug abuse, mental illness, divorce, juvenile delinquency)
3.2 Crime
3.3 Personality adjustment
3.4 Affectual relations
3.5 Use of community facilities
3.6 Intergroup conflict
3.7 Quality of public services
3.8 Sense of community (includes sense of attachment, support networks)
4.0 Location Transfer Costs and New Location Effects
4.1 Searching
4.2 Moving
4.3 Capital Financing Costs
4.4 Start-up and operating costs (businesses)
4.5 Personality adjustment
5.0 Institutional Adaptations
5.1 Land-use functions
5.2 Development planning
5.3 Negotiations with contractors, government agencies
5.4 Conflict resolution
5 5 Jurisdictional issues
5.6 Public service bureaucracies; direct-service agencies
5.7 Division of responsibilities

making period, residents in the vicinity of the candidate sites are likely to place less emphasis on property maintenance (Miller 1971), properties will be hard to sell (Corrigan 1976), and economic development is often hampered. The effects of uncertainty will be felt most strongly by residents with fixed incomes. There may be a significant trade-off, however, between the economic costs of a large number of potential sites and the political costs of a small number of sites (Ghovanlou et al. 1980). As noted in the previous chapter, while multiple repositories would generate adverse socioeconomic effects at more sites, they have potential for reducing overall regional inequities, transport system costs, and state emergency response burdens.

Several conclusions can be drawn about the likely economic effects of a radioactive waste repository:

1. The effects are potentially large, involve uncertain rates of change, and are sufficiently complex that they cannot be projected from population increases alone.
2. Some effects will not be apparent until the construction process actually begins, thereby implying that some means of monitoring and responding to effects at site are needed (Wolf 1974, Cluett et al. 1980).
3. The site-selection procedure mandated in the Nuclear Waste Policy Act of 1982 will impose adverse effects (e.g., community conflict, speculation) on the candidate host sites as well as on the site finally selected. A decentralized waste system could well add to these site effects, although compensating with advantages in overall socioeconomic and institutional effects.

Environmental and Health Effects

Nonradiological environmental and health effects arising from the construction and operation of a repository should be no more severe than those of most large construction projects. This appears also to be true for nuclear power plants (Chalmers et al. 1982).

The measurement of environmental and health effects requires two kinds of standards: (1) professionally established norms for such effects as noise and air pollution and (2) standards established by the community on how much noise and pollution residents are willing to tolerate. Professional standards are useful in providing outer boundaries for changes that do not produce measurable harm; community standards represent tolerance levels. People are sometimes willing to tolerate far greater levels of "nuisance" (such as noise in New York City or rock music) than professional standards would specify as healthy. People in rural areas and small communities may be more sensitive to artificial environmental changes and less tolerant of environmental damage than people in urban areas. This implies that community standards may often be more important than professional standards (Saarinen 1976).

Community standards for individual pollutants or overall environmental impact are most commonly estimated by using changes in property values as an indicator of personal sentiments, although the application of this measure is not definitive. In general, application of this standard suggests a correlation between actual and perceived levels of pollutions (Pearce 1978a). As suggested in Chapter 2, public concerns over radioactive wastes indicate that perceptions will be important. Should high community standards override all other standards where the community is especially sensitive, or should a lower professional standard prevail across all communities? This type of question has, of course arisen in other contexts—such as the search for a generally applicable legal definition of obscenity—but has been difficult to resolve.

Professional standards are not much easier to develop and apply than community standards. Noise and air pollution, for example, have been studied extensively in an attempt to establish professional standards. Researchers have attempted to model the effects of such pollutants, placing a monetary value on the magnitude and scope of the pollution. But as Pearce (1978a) points out, such efforts deny the variability of impact. Units of noise, for example, cannot be assessed at the same price regardless of how much is "consumed" by an individual. We know that certain levels of noise will cause stress, loss of sleep, and other social, psychological, or economic effects (U.S. Environmental Protection Agency 1973), but noise is experienced differently by various segments of the population. In addition, the volume, pitch, and duration of individual noises can cause specific reactions.

Similarly, air pollution involves estimation and assessment difficulties. Obvious physical damage can result from air pollution—corrosion, paint damage, soiling of laundry, and soiling of windows or building interiors are all measurable indicators with measurable costs. Respiratory and other diseases have been linked directly to air pollution, although the time scales involved make causality difficult to determine precisely in some instances. But despite the fact that some of the consequences of air pollution can be identified, the measurement technique used in any study can have a significant effect on its results and conclusions (Pearce 1978b).

Efforts have been made to link professional and community standards through attempts to regulate levels of environmental and health pollution. For example, the Environmental Protection Agency published noise standards in 1974 that set an L_{dn} (day-night average sound level)* of 45 dBA indoors and 55 dBA outdoors for residential areas, hospitals, and schools (U.S. Environmental Protection Agency 1974). The National Research Council has estimated that at 55 L_{dn} a community will generally not react to noise exposure, while at 75 L_{dn} and higher a community can be expected to react strongly (National Research Council 1977). Almost all heavy trucks and construction equipment exceed that noise level at a distance of 50 feet or less (U.S. Environmental Protection Agency 1972). The construction equipment at a

* An EPA Aircraft/Airport Noise Study Task Group has assessed the impact of cumulative noise exposure on annoyance (U.S. Environmental Protection Agency 1973). Their conclusion was that the "energy" equivalent, or average, A-weighted sound level, taken over a 24-hour period, with a 10-decibel penalty applied to nighttime sound levels, is the simplest noise measure that provides high correlation with annoyance, complaint behavior, and overt community reaction (Von Gierke 1973). This measure was named "day-night average sound level," or L_{dn}.

Sound-level meters typically contain three different response weighting networks: The A, B, and C networks, with the A used most commonly. When using the meter on the A weighting, the quantity obtained is the A-weighted sound level. Its unit is the decibel (dB) most popularly referred to as dBA (U.S. Environmental Protection Agency 1973). The 10-dBA nighttime penalty applies to sounds measured between 10 p.m. and 7 a.m. Thus, a 40-dBA sound after 10 p.m. is counted as a 50-dBA sound (Finsterbusch 1980).

radioactive waste repository would probably not be near enough to any town to cause annoyance, but community residents, businesses, and schools at nodes in the waste funnel may be expected to react to increased noise levels from truck and car traffic. On-site monitoring would be necessary to verify noise levels and citizen reactions. There are a variety of ways to abate noise, such as barriers, sound insulation, and time restraints. But such strategies often themselves engender a negative reaction from people who desire no aesthetic changes in their environment.

To conclude, although environmental and health effects can be anticipated and measured in many instances, different community standards, the problems of determining causality, and the compounding of reactions by anxiety complicate the prediction of actual consequences. Physical measurement would therefore have to be combined with careful surveys and behavioral indicators. Contradictions in the applicability and relevance of standards in individual cases are likely to require resolution before priorities can be established.

Locational Costs and Effects

Since a radioactive waste repository does not require a large amount of surface land, it is unlikely that many people would be required to relocate. However, searching for, moving to, and financing a new home or business can be costly, especially in times of rapidly increasing home prices and high mortgage interest rates. In circumstances where government compensation is appropriate, bureaucratic delays cause cash-flow problems, especially for those of moderate income and for small businesses. Indeed, the possibilities of relocating a small business are often severely limited. Such businesses generally have a localized clientele that is lost when the business is moved. The growth in the number of steady customers needed to ensure its survival at a new location is often slow.

Residents and business owners being forced to move often experience psychological hardship. Finsterbusch (1980) suggests that the approach taken by government authorities to displacement and relocation can strongly affect its success. He recommends that the government keep the public well informed, that it seriously consider a full range of alternatives (including the no-build alternative), that it allow sufficient time for reloca tion, and that it be prompt and generous in relocation payments. In general, officials should demonstrate that they are helpful and concerned.

Social Change

Some of the most complex but most important effects of siting can be grouped under "social change." Fragile social networks in rural towns, for example, are damaged by large-scale energy developments nearby (Freudenberg et al. 1977, Freudenberg 1978, Susskind and O'Hare 1977, Cortese and Jones 1977). Assessing social change, however, requires agreement on the meaning of such concepts as social stability, social cohesion, and "community," i.e., what it is that is subject to change. Despite the acknowledged importance of a "sense of community," strong local attachments are usually revealed only when an area or group is threatened (Burkhardt 1971, Erikson 1976). At that point it is difficult to determine whether opposition is a generalized feeling, a specific response to a decision, or the strong but possibly not representative feelings of a small but vocal group. The elderly and those with low or fixed incomes are particularly vulnerable to social change and to inequities in the siting process.

In the 1960s planners learned that communities previously believed to be disordered and unsupportive can provide their residents with social support networks (Michelson 1970). The lengthy history of conflict over large-scale construction projects is dotted with examples of inaccurate assessments of community attachment in low and moderate income areas (Altshuler 1965, Keyes 1969, Simmie 1974, Fagence 1977, Gold 1979). To determine which types of areas are the least susceptible to damage to social cohesion, or how it can be minimized if inevitable, is a formidable problem. Lacking any agreed-upon measures of social change, researchers have devised a series of indicators.

It is often assumed that length of residence and home ownership are appropriate indicators for community attachment and serve as convenient predictors of negative reaction to a facility or project. Yet there is no clear correlation between community attachment and length of residence. In some cases the high cost of moving to another home is more distressing to a family than changes in the locality. On the other hand, certain groups have exhibited clear signs of despair when forced to relocate (Marris 1974).

Certain pathological changes occur in a community because of unwanted construction or an influx of new workers (Coates 1975). Higher rates of alcoholism, drug abuse, mental illness, juvenile deliquency, and divorce among residents are all indicative of social change (Freudenberg et al. 1977, Susskind and O'Hare 1977, Kohrs 1974). Increased crime rates will cause greater fear and fear-related reactions among residents (Freudenberg et al. 1977, Greene and Hunter 1978). Measures of social interaction include such factors as rates of church attendance and organizational membership (Stanley and Rattray 1978). Neighborhood interaction scales have been combined with surveys of satisfaction, participation, identification, and the desire to stay in the neighborhood to determine community stability (Burkhardt 1971).

Neither observations nor surveys, however, are entirely reliable. Preferences themselves do vary. Some may like a particular locale because they do not have to interact much. Or behavior and expressed preference are contradictory (Hoinville 1971, Clemente et al. 1977). Respondents may find it difficult to recognize their emotional ties to a locale or to predict their future behavior. There is some evidence that residents favor large public projects before they are built but change their minds once construction begins (Little and Lovejoy 1977, Freudenberg 1978, Peelle 1979). In any case, indicators of social interaction do not in themselves tell us how to plan.

Patterns of use of community facilities, such as recreation areas, historic sites, museums, taverns, or movie theatres, are affected by an influx of new residents. Newcomers replace oldtimers at such places, but such behavior is hard to predict. Intergroup conflict arises among local residents or between local residents and newcomers, particularly in regard to life styles, economic interests, political philosophies, and moral values (Shields 1977, Finsterbusch 1980). Increases in the numbers of individuals seeking public services often result in changes in service quality or a scarcity of services relative to demand. New workers frequently exhibit health problems unique to a locale (Greene and Hunter 1978).

Social changes, more than other changes, are difficult to anticipate and require carefully developed assessment procedures. And again, the rates of such changes will likely be as important as the types and eventual magnitudes. Social change can be critical to the character of a locale (particularly a small town), is often the type of change of the greatest concern to residents, and should be monitored during both the planning and construction stages of a facility (Cluett et al. 1980). Local authorities and the federal government need to be prepared to respond flexibly and in timely fashion to changes (Greene and Hunter 1978).

Local Institutional Effects

Local government and community agencies have a variety of functions that will change both qualitatively and quantitatively as a radioactive waste repository is planned, constructed, operated, and monitored. During the siting process local governments often find themselves in a reactive posture that is inconsistent with the historic patterns of leadership, community structure, community interaction, and autonomy generally characterizing small communities (Cortese and Jones 1977). There will be new needs for funds to support increased services and new requirements for planning and land use control to ensure that the influx of new workers and economic growth is orderly. Hence, the local governments could find themselves negotiating with the project developer for financial help (Stenehjem and Allen 1978) and seeking a greater share of tax revenues from government agencies at the state and federal levels. It may have to apply for grants or loans or impose new taxes (Greene and Hunter 1978). All of these activities require greater expertise, resulting in a change in the size and professionalism of the local government. This development has been noted in communities hosting nuclear power plants (Chalmers et al. 1982). Small towns, accustomed to more informal modes of governance (Shields et al. 1978), frequently resent the requirement to conduct their affairs in a more complex and time-consuming manner.

The need to redesign service agencies to meet increased or changed demands usually strain small local governments. New agencies may be required to deal with heavily affected groups. Small businesses will need advice or assistance to cope with new demands. Local courts may find it difficult to deal with a new array of criminal and jurisdictional issues. Hospitals are likely to have to deal with an increased number of patients.

Institutions at the local level, in short, almost certainly will face a number of challenges to their traditional patterns of operation.

SPECIAL EFFECTS

Effects associated with the radiological characteristics of the repository have received relatively little attention and are not well understood. The factors pertinent to this special class of impacts include (1) public concerns; (2) equity across regions and across generations; (3) the national debate over nuclear power; and (4) institutional issues—credibility of institutions, long-term security of site, waste transportation, and roles in decision making.

Public concern will be found not only at the waste repository site but in the surrounding region and within communities along the "waste funnel" leading to the repository. Psychological stress felt by many people in the vicinity of the repository and along transportation routes is a possible social effect that should be anticipated and evaluated.

Equity issues may also become important (Kasperson and Rubin 1983). Many residents are likely to find it difficult to accept the fact that their area has assumed a burden for the benefit of distant areas, particularly if the repository is the only one for all commercial high-level wastes. This leads residents both to identify more adverse effects and to see them as more unacceptable. Concern must also be expected in the host region over even de minimis adverse effects on the health of today's children and succeeding generations.

The existence of the national debate over nuclear power impinges on arguments over the siting of a repository. A prospective site, whatever the local sentiments, will likely become a battleground for contending groups. Local residents might well be drawn into the battle on various sides, thus polarizing the community. Indeed, it is possible that the major adverse social effect will be community conflict during the site selection and planning stage rather than more conventional effects during the construction and operation of a repository.

Finally, there are local institutional concerns. The degree of public concern about the long-term security of the site depends in part on the extent to which local residents believe that stable institutions are ready and able to protect the community. The handling of the accidents that would inevitably occur will do much to determine local confidence in the responsible institutions (and the degree of behavioral reactions to stress). If institutional credibility is found wanting, then demands for intervention by local institutions are likely. The way in which spent-fuel casks are transported, for example, could well affect public acceptance, particularly if the flow of waste at and near the repository site becomes particularly heavy. Finally, the host locality will undoubtedly be affected by the adequacy of its participation in decision making.

These special effects may prove to be resistant to formal assessment and particularly to quantitative measurement and expression. It must be recognized, however, that they could well exceed the more conventional effects of a repository and also prove resistant to mitigation or elimination. Methods for assessing these effects, which note both advantages and disadvantages, have recently been carefully appraised (Thomas et al. 1982a). Further, recognition is needed that system design choices will interact with site effects, in ways sometimes predictable and sometimes not.

INFLUENCE OF TIME AND DISTANCE ON WASTE MANAGEMENT ACTIVITIES

Different effects will occur at different stages in the siting and development of a repository. The first rumors of planning for such a facility will cause changes in property values, depending on site location and existing land use. Values will change again after construction is finished if the effects, or perceptions of the effects, are different from those anticipated. Since the selection of a particular site may not occur until after the site has been acquired (and "qualified"), rumors will sometimes coincide with planning. Psychological, health, and social changes, on the other hand, will become evident only after the facility has been operating for a number of years.

Effects are also related to distance from a facility, but this relationship is not always unilinear. Some people in the immediate vicinity of a repository may not be perturbed and choose to remain where they are, whereas others further away may leave the area. The extent of most effects will depend on the shape and slope of their distance-decay curves (Massam 1975). Health effects, for example, will likely be highly sensitive to proximity to the facility—the closer one's home to the site, the greater the effects of noise and air pollution. Economic effects, on the other hand, are generally more evenly spread over a wider area. Disturbances resulting from in-migration will tend to be unevenly distributed. If all effects were equal in weight or uniformly diffused, their measurement would be relatively simple, and choosing one site instead of another would alter equities in predictable ways. Unfortunately, the situation is more complex.

LOCAL EFFECTS ALONG TRANSPORT CORRIDORS

As indicated in Chapter 3, a substantial amount of truck or rail traffic can be anticipated in the delivery to away-from-reactor storage facilities (if built) a repository (or repositories) or both. Special problems may occur for locales located at nodes along transport corridors. Truck stops will be created, and certain roads or intersections will experience unusually heavy traffic. Depending on the size of the locale and the number of trucks traveling through, some of the same effects—increased stress or greater anxiety for local populations, reduced property values, pressures on the local economy, and disruptions of social fabric—that would occur at a site during repository operation should be anticipated.

Whether these problems will assume sufficient magnitude to require governmental intervention is uncertain and depends, in part, on overall waste system design. But the study and mitigation of socioeconomic effects should certainly include increased attention to these potential problems. The panel recognizes that the assessment and mitigation of transport corridor effects could present planning and organizational problems. To what extent (if any) should adverse socioeconomic effects in the many communities along transport corridors be included in impact mitigation programs? The panel notes that adverse effect mitigation is generally not undertaken for the movement of other energy resources (such as coal). Sufficient information and analysis does not exist at this time for the panel to take a position on this question. What is essential is that such prospective problems at nodes along transport corridors be anticipated, that means be instituted to identify and assess such effects, and that the possibility that mitigation of effects may be required be included as part of the waste management program.

MITIGATION AND COMPENSATION

The potential adverse effects to a community hosting a radioactive waste repository should be avoided where it is feasible to do so and, for those adverse effects that cannot be avoided, mitigated to the fullest extent reasonably achievable. A sound program to this end does not now exist. The Council on Environmental Quality's regulations to federal agencies for implementation of the National Environmental Protection Act require environmental impact statements to include provisions for mitigating adverse impacts (Peelle 1979). The panel's view is that a sound program for anticipating and responding to the socioeconomic effects of siting a radioactive waste repository would comprise the following:

1. Analysis of socioeconomic effects, with participation by the residents;
2. Development of plans and policies to avoid and to mitigate adverse effects, with participation by the residents;
3. Capital, provided by the beneficiaries of nuclear power, to fund the mitigation of expected adverse conventional effects;
4. Compensation for adverse effects, conventional and special, that cannot reasonably be avoided or further mitigated; and
5. Means of redress for effects resulting directly from the siting of a radioactive waste repository or from overall changes in the radioactive waste program that alter site characteristics.

Although the occurrence of specific effects is difficult to predict, a substantial number of conventional adverse effects that will occur can be avoided or mitigated through advance planning and effective management. The process by which planning and management can be successfully implemented calls for interaction between residents of the community and representatives of state and federal agencies. The involvement of local residents in identifying and assessing local effects, in evaluating planning alternatives, and in contributing to the definition and evaluation of management options can increase the effectiveness of the siting process.

The panel's review of the Nuclear Waste Policy Act of 1982 and the siting programs of DOE suggest that an appropriate mechanism or process for assuring the active involvement of local residents in assessing site effects and in monitoring mitigation and compensation programs does not now exist. There is need, therefore, for prompt attention to redressing this deficiency in institutional arrangements for site selection and development. Consideration should be given to the appropriate role and powers of such a mechanism, budgetary needs, and capacity for independent technical review. One useful model at the state level may be the Environmental Evaluation Group, which has advised the governor of New Mexico on the Waste Isolation Pilot Plant project.

A number of federal programs exist that are aimed at mitigating the conventional impacts that stem from the location of energy or other industrial facilities. The applicability and timeliness of each, however, are limited. The Education Act of 1950, for example, provides federal financial assistance to school districts experiencing financial burdens as a result of federal project development, but there are serious time lags in the flow of assistance funds. Small communities that need technical planning expertise can obtain help through the U.S. Department of Housing and Urban Development's Comprehensive Planning Assistance Program, but there are numerous eligibility restrictions and a cumbersome application process. The Community Facilities Loan and Grant Program of Federal Housing Administration is another source of assistance for fire-fighting and transportation needs, but inflexible funding formulas have hampered its application (Leistritz and Murdock 1979, pp. 322-324). The recently passed Energy Impact Assistance Act may improve the situation, although administrative complexities, fragmented sources of aid, and the "prohibition of delay" stipulation (Section 608) may reduce its potential effectiveness (Peelle 1980, pp. 120-121).

Even prompt and ambitious mitigation of adverse socioeconomic effects will not always suffice to provide adequate protection for the host community and host region. Past experience suggests that many adverse effects will be underestimated, will not be quantifiable, or will not become apparent until the siting process actually begins. Other effects, such as those described above as comprising social change, will be essentially irreversible and not subject to mitigation. The community is also vulnerable to policy or program changes that could alter expected benefits or add new (and perhaps unforeseen) effects. The conversion of a demonstration facility to a permanent repository, for example, would introduce a new array of beneficial and adverse effects. Meanwhile, the research base to support mitigation efforts is limited and uneven: studies of impact mitigation have been largely limited to a few selected types of management processes or only a few cases relevant to a given process (Halstead and Leistritz 1982). As a result, an adequate conceptual basis for designing mitigation programs does not now exist (but see Murdock et al. 1982, Chapters 10-12 for a noteworthy effort to fill this void).

To prevent the community from bearing unfair burdens and harm, an ambitious program of technical and financial support for the mitigation of adverse effects at the site will be needed. The Nuclear Waste Policy Act of 1982 recognizes this need in providing for funds to be used for impact mitigation (see Section 116). Grants may be made to states to develop a request for impact assistance which must be submitted to the Secretary following the site characterization activities and before the recommendation of a repository site by the Secretary to the President. Since no limit to such mitigation funds is specified, the scale of the program is potentially adequate. There are, however, several potential problems which will need to be addressed by DOE in implementation. First, the goals and levels of funds are set in a binding agreement following the granting of construction authorization. But, as the panel has noted, many adverse impacts cannot be identified at this time and will become apparent only as the site is developed and undertakes operation. Second, the agreement is between the federal government and the state, with no assurance that the state will adequately assess the needs of the host locality or allocate the funds delivered in an effective manner.

FINDINGS

From its analysis of likely socioeconomic effects at the waste disposal site, the panel finds the following:

1. The research base that exists to support the selection of sites for a nuclear waste repository and the formulation of programs for impact mitigation is limited and uneven. The underdeveloped state of theory in social

impact assessment theory and methodology and the cursory efforts thus far in comparative analysis of impact mitigation are particularly problematic. The limited research program sponsored by the DOE has not sufficed to fill this void. As a result, no authoritative statements can be made at this time about the magnitude, types, or rates of adverse socioeconomic effects to be expected at a repository site nor criteria that should be formulated for site suitability or appropriate program of impact mitigation.

2. Adverse socioeconomic effects will likely be strongly site-specific and will be related in particular to the population size and rural qualities of the host region as well as to the overall waste system design. These effects will be difficult to predict on the basis of experience with other types of facilities at other sites. These effects have the potential, however, for substantial harm to the host community and region and should, therefore, receive more thorough assessment than has been accomplished to date.
3. The special effects associated with the radiological mission of the repository will interact with, and may well exceed, the more conventional effects resulting from the location of large industrial facilities in rural communities.
4. A number of significant effects will not become evident until the siting process begins. Accordingly, careful monitoring of socioeconomic effects at the site and a program for timely and flexible provision of resources to reduce or mitigate adverse impacts are required. The panel finds that an appropriate mechanism for assuring the active involvement of local residents in assessing site effects and in monitoring mitigation and compensation programs does not now exist and should receive attention by the DOE.
5. A sound program to anticipate and respond to the effects of siting a radioactive waste repository should, in the panel's view, comprise (a) analysis of socioeconomic effects, with participation by the residents; (b) development of plans and policies to avoid and to mitigate adverse effects, with participation by the residents; (c) capital, provided by the beneficiaries of nuclear power, to fund mitigation of expected adverse conventional effects; (d) compensation for adverse effects, conventional and special, that cannot reasonably be avoided or further mitigated; and (e) means of redress for effects resulting directly from the siting of a repository or

from overall changes in the radioactive waste program that alter site characteristics.

6. An ambitious program of technical and financial support to mitigate adverse effects at repository sites will be needed. While the Nuclear Waste Policy Act of 1982 provides for this need, problems may be expected in implementation. The goals and levels of funds for impact mitigation, for example, are set at an early stage in site development, yet many effects cannot be anticipated and will become apparent with the development of the site and the beginning of operations. Also, no assurance exists that the states will adequately assess the needs of this host locality and allocate funds in an effective manner.

REFERENCES FOR CHAPTER 4

Altshuler, A. 1965. The City Planning Process. Ithaca, N.Y.: Cornell University Press.

Burkhardt, J. 1971. Impact of Highways on Urban Neighborhoods: A Model of Social Change. No. 356. Highway Research Board.

Chalmers, J., D. Pijawka, K. Branch, P. Bergmann, J. Flynn, and C. Flynn. 1982. Socioeconomic Impacts of Nuclear Generating Stations. Summary Report. NUREG/CR-2750. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Clemente, F., J. Cole, E. Kloman, J. McCabe, P. Sawicke, J. Schumaker, and J. Spencer. 1977. Public Participation in Energy Related Decision-making: Six Case Studies. M76-53. McLean, Va.: The Mitre Corporation and National Academy of Public Administration, December.

Cluett, C., M. Greene, and L. Radford. 1980. Individual and Community Response to Energy Facility Siting: An Annotated Bibliography. No. P-493. Montacello, Il: Vance Bibliographies, May.

Coates, V. 1975. Community Level Impacts of Expanded Underground Coal Mining. Readings in Technology Assessment. Washington, D.C.: George Washington University Program of Policy Studies in Science and Technology, June.

Cole, R., and T. Smith. 1979. Compensation for the Adverse Impacts of Nuclear Waste Management Facilities: Application of an Analytical Framework to Consideration of Eleven Potential Impacts. Summary

Report. Seattle, Wash.: Battelle Human Affairs Research Centers, September.

Corrigan, R. 1976. The western boom towns - "going crazy," going it alone. National Journal August:1150-1152.

Cortese, C. F., and B. Jones. 1977. The sociological analysis of boom towns. Western Sociological Review 8:76-90.

Dixon, M. 1978. What Happened to Fairbanks? Boulder, Colo.: Westview Press.

Erikson, K. 1976. Everything in its Path. New York: Simon and Schuster.

Fagence, M. 1977. Citizen Participation in Planning. Oxford, England: Pergamon Press.

Finsterbusch, K., and C. P. Wolf, eds. 1977. Methodology of Social Impact Assessment. Stroudsburg, Pa.: Dowden, Hutchinson & Ross.

Finsterbusch, K. 1980. Understanding Social Impacts. No. 110. Beverly Hills, Calif.: Sage Library of Social Research.

Freudenberg, W., L. Bacigalupi, A. Clay, C. Landoll, and K. N. Deeds. 1977. Subjective responses to an energy boomtown situation: a preliminary report on research in progress in four western Colorado towns . Presented at Annual Meetings, American Sociological Association, Chicago, September.

Freudenberg, W. 1978. Toward ending the inattention: a report on the social consequences of energy boomtown developments. Paper presented at the 144th National Meeting, AAAS, Washington, D.C.

Ghovanlou, A., L. Ettlinger, A. De Agazio, and N. Lord. 1980. Analysis of Nuclear Waste Disposal Technologies and Strategies for Technology Deployment. Draft. McLean, Va.: The Mitre Corporation, April.

Gilmore, J. S. 1976. Boom towns may hinder energy resource development. Science 191:535-540.

Gold, R. L. 1979. On local control of western energy development. The Social Science Journal 16:121-127.

Greene, M., and T. Hunter. 1978. The Management of Social and Economic Impacts Anticipated with a Nuclear Waste Repository: A Preliminary Discussion. Draft. Seattle, Wash.: Battelle Memorial Institute, May.

Halstead, J. M., and F. L. Leistritz. 1982. Resolving problems in repository siting: a review of issues and mitigation measures. Pp. 179-199 in Nuclear Waste: Socioeconomic Dimensions of Long-Term Storages, H. Murdock, F. L. Leistritz, and R. R. Hamm, eds. Boulder, Colo.: Westview Press.

Hanchey, J. R. 1975. Public Involvement in the Corps of Engineers Planning Process. IWR Research Report 75-R4. Fort Belvoir, Va.: U.S. Army Engineer Institute for Water Resources.

Hoinville, G. 1971. Evaluating community preferences. Environment and Planning 3:33-50.

Kasperson, R., and B. Rubin. 1983. Siting a radioactive waste repository: what role for equity? Pp. 118-136 in Equity Issues in Radioactive Waste Management, R. Kasperson, ed. Cambridge, Mass.: UGH Publishers.

Keyes, L. 1969. The Rehabilitation Planning Game. Cambridge, Mass.: MIT Press.

Kohrs, E. 1974. Social consequences of boom growth in Wyoming. Paper given at the Rocky Mountain AAAS, Laramie, Wyoming, July.

Leistritz, L., and S. Murdock. 1979. Economic and Social Impacts of Energy Development in the Western United States: Research Findings and Future Research Needs. Texas A&M, College Station, Tex., June.

Leistritz, L., and S. Murdock. 1981. Socioeconomic Impact of Resource Development: Methods for Assessment. Boulder, Colo.: Westview Press.

Little, R. L., and S. B. Lovejoy. 1977. Employment Benefits from Rural Industrializaton. Lake Powell Research Project, Los Angeles.

Marris, P. 1974. Loss and Change. New York: Pantheon Books.

Massam, B. 1975. Location and Space in Social Administration. New York: John Wiley & Sons.

Michelson, W. 1970. Man and His Urban Environment. Reading, Mass.: Addison-Wesley.

Miller, Jr., S. F. 1971. Effects of Proposed Highway Improvements on Property Values. Report No. 114. National Cooperative Highway Research Program, Washington, D.C.

Mountain West Research. 1978. Construction Worker Profile: Final Report for the Old West Regional Commission. Washington, D.C., December.

Murdock, S. H., F. L. Leistritz, and R. R. Hamm, eds. 1982. Nuclear Waste: Socioeconomic Dimensions of Long-Term Storage. Boulder, Colo.: Westview Press.

National Research Council. 1977. Guidelines for Preparing Environmental Impact Statements on Noise. Report of the Committee on Hearing, Bioacoustics and Biomechanics Working Group 69. Washington, D.C.: National Academy of Sciences.

Office of Nuclear Waste Isolation. 1981. Framework for Community Planning Associated with Nuclear Waste Repository Siting. Draft. Columbus, Ohio: Battelle Memorial Institute, October.

Pearce, D. W. 1978a. Noise nuisance. In The Valuation of Social Cost, D. W. Pearce, ed. London: George Allen & Unwin.

Pearce, D. W. 1978b. Air pollution. In The Valuation of Social Cost, D. W. Pearce, ed. London: George Allen & Unwin.

Peelle, E. 1979. Community impacts of energy production. Prepared for the Sociopolitical Resource Group of the Risk/Impact Panel, Committee on Nuclear and Alternative Energy Systems, National Research Council, Washington, D.C., December.

Peelle, E. 1980. Social Impact Mitigation and Nuclear Waste Repository Siting. Statement to Subcommittee on Rural Development, Senate Committee on Agriculture, Nutrition and Forestry, August 26.

Peelle, E., M. Schweitzer, P. Scharre, and B. Pressman. 1979. A Study of the Cherokee Nuclear Station: Projected Impacts, Monitoring Plan, and Mitigation Options for Cherokee County, South Carolina. Oak Ridge, Tenn.: Oak Ridge National Laboratory, July.

Ragan, J. F., Jr. 1975. Public Participation in Water Resources Planning: An Evaluation of the Programs of 15 Corps of Engineers Districts. IWR Contract Report 75-6. Fort Belvoir, Va.: U.S. Army Engineer Institute for Water Resources.

Saarinen, T. F. 1976. Environmental Planning: Perception and Behavior. Boston: Houghton Mifflin Co.

Seley, J. E. 1983. Politics of Public Facility Planning. Lexington, Mass: Lexington Books.

Shields, M. 1977. Grounded theory construction in social impact assessment. Pp. 64-73 in Methodology of Social Impact Assessment, K. Finsterbusch and C.P. Wolf, eds. Stroudsburg, Pa.: Dowden, Hutchinson & Ross.

Shields, M., J. Cowan, and D. Bjornstad. 1978. Socio-Economic Impacts of Nuclear Power Plants. Oak Ridge, Tenn.: Oak Ridge National Laboratory, July.

Simmie, J.M. 1974. Citizens in Conflict. London: Hutchinson and Co.

Stanley, J., and A. Rattray. 1978. Social severance. Pp. 140-163 in The Valuation of Social Cost, D.W. Pearce, ed. London: George Allen & Unwin.

Stenehjem, E., and E. J. Allen. 1978. Constraints to Energy Development. American Behavioral Scientist 22:92-213.

Susskind, L., and M. O'Hare. 1977. Managing the Social and Economic Impacts of Energy Development. Summary Report. Phase I of the MIT Energy Impacts Project. Cambridge, Mass.: MIT Press.

Thomas, J. K., D. E. Albrecht, and S. H. Murdock. 1982a. Assessing the social effects of repository siting. Pp. 157-176 in Nuclear Waste: Socioeconomic Dimensions of Long-Term Storage, S. H. Murdock, F. L. Leistritz, and R. R. Hamm, eds. Boulder, Colo.: Westview Press.

Thomas, J. K., R. R. Hamm, and S. H. Murdock. 1982b. The socioeconomic impacts of repositories. Pp. 103-117 in Nuclear Waste: Socioeconomic Dimensions of Long-Term Storage, S. H. Murdock, F. L. Leistritz, and R. R. Hamm, eds. Boulder, Colo.: Westview Press.

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

U.S. Environmental Protection Agency. 1972. Report to the President and Congress on Noise. Washington, D.C.: U.S. Government Printing Office.

U.S. Environmental Protection Agency. 1973. Public Health and Welfare Criteria for Noise. No. 550/9-73-002. Office of Noise Abatement and Control. Washington, D.C.: U.S. Government Printing Office, July.

Von Gierke, H. E. 1973. Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure. NTID 73.4. Prepared for US EPA, July.

Wolf, C. P. 1974. Social impact assessment: the state of the art. In Social Impact Assessment (ERDA-5), C. P. Wolf, ed. Milwaukee, Wisc.: Environmental Design Research, Inc.

5

Institutional Means

The preceding chapters have indicated that siting, constructing, and operating high-level radioactive waste repositories involve emotional issues of public concern, potentially significant effects associated with the overall facility and transport network, and potentially important socioeconomic effects localized at the repository site and along waste transport corridors. Solving these problems requires well-developed capabilities and effective response by institutions, and hence relevant institutional considerations should be examined.

At the end of 1982 Congress passed the Nuclear Waste Policy Act of 1982 (NWPA), creating a new framework for the management of high-level radioactive waste. The Low-Level Radioactive Waste Management Act of 1980 had earlier outlined institutional arrangements for handling low-level waste. The emergence of these major policies from the Legislative Branch, after extensive debate in three consecutive Congresses, defines a comprehensive national approach to the final disposition of radioactive materials.

This chapter has three objectives:

1. To appraise the principal elements set forth in NWPA in terms of their potential for addressing the socioeconomic considerations integral to successful siting and operation of a radioactive waste disposal system based on geologic repositories;
2. To assess the adequacy of current approaches to fostering public participation in repository site search and selection; and
3. To analyze the current regulatory framework for the transportation of radioactive wastes.

INSTITUTIONAL THEMES IN THE NUCLEAR WASTE POLICY ACT OF 1982

The Act is a complex piece of legislation. It charts a course that will last more than a decade, culminating in the opening of a high-level waste repository toward the end of the twentieth century. The NWPA has been summarized elsewhere (see, e.g., Nuclear Waste News 1982). In its review of institutional issues, the panel examined the following principal themes embodied in the Act:

1. States are accorded a substantial role in the repository siting process. The Act requires the Secretary of Energy to follow a policy of "consultation and cooperation" in dealing with states and Indian tribes [Sec. 117(b)]. States and tribes containing a candidate site are eligible for grants from the Department of Energy (DOE); these grants are intended to fund independent reviews, monitoring, and provision of information to the public [Sec. 116(c) (1) (B)]. Once the Nuclear Regulatory Commission grants a construction authorization for a repository, DOE and the state are to conclude a written agreement for impact mitigation payments to the state [Sec. 116(c) (2)]. Perhaps most important, the Act gives the states and tribes hosting repositories the right to disapprove the designated site; a vote of both houses of Congress is required to override the disapproval [Sec. 116 (b) (2), 118(a), and 115].
2. The federal government is to bear the risks of repository development on a tight schedule. Following the enactment of NWPA but no later than January 1, 1990, the federal government is authorized to enter into contracts with electric utilities to transfer title to spent nuclear fuel to the federal government. This contractual commitment is intended to provide planning certainty to the utilities in exchange for payments into the Interim Storage Fund (Sec. 136). The Act provides for limited federal capacity to store spent nuclear fuel, together with a program to provide monitored retrievable storage, that is, long-term storage in near-surface facilities. If schedules for geologic repositories slip, this may provide flexibility. The fund will be administered by the Treasury of the United States, and fund payment levels will be set by the Secretary of the DOE. The schedule for repository development stretches over a time of at least 15 years, yet its intermediate mileposts demand both speed and flexibility by DOE and its contractors.

State/Local Institutional Structure

The NWPA relies on the classic federalist division of authority to define the opposing interests in repository development. The federal government is the advocate of the national interest in safe, efficient disposition of spent fuel and radioactive wastes; states, through their governors or legislatures, are presumed to speak for locally affected populations concerned about risk, protection of property rights, due process, and other burdens borne by those living near a proposed site.

Social research on other controversial facilities reinforces the panel's judgment that a major institutional gap exists in the framework defined in the NWPA. There is no institutionalized process for relating the concerns of locally affected populations to the actions of state governors or legislatures; indeed, constitutional principle dictates that state governments be responsive to population centers whose interests are typically different from those of rural areas likely to host repositories. Social scientists have suggested institutional designs for bridging such gaps in other policy areas; this stock of design principles is sufficiently well tested, in the panel's view, that it can be used by state governments as a basis for addressing the institutional problems pointed out below. Ignoring this gap increases the likelihood that conflict will spill over into tangentially related arenas that are accessible to local populations; such spillovers threaten to disrupt the federal programs' tight schedule.

As noted in the previous chapter, the NWPA contemplates substantial funding to mitigate "any economic, social, public health and safety, and environmental impacts that are likely as a result of the development of a repository" [Sec. 116(c) (2) (B)]. In Sec. 116(c)(3), the federal government undertakes to provide payments in lieu of taxes to compensate state and local governments for lost revenues. The Act thus makes an important statement of principle: the burdens borne by those living near the site should be mitigated and paid for by beneficiaries.

The history of other federal construction programs, such as interstate highway construction, indicates, however, that mitigation or anticipated economic benefit is not always sufficient to eliminate conflict (Seley 1983). Moreover, highway planners have been repeatedly surprised by the scope and magnitude of local communities' resistance (Lupo et al. 1971).

Congress chose not to prescribe institutional means to link local populations to state governments. Whatever the merits of so respecting the customs of federalism, the need for such linkage is real and, in the panel's judgment, of potentially critical importance to the national program. The long experience of grants-in-aid, categorical programs (including those great society programs, particularly the Community Action Program bypassing state and local government control), revenue-sharing, block grants, and other elements of fiscal federalism underscores the persistent tension between state and local governments in the sharing of federal money (Marris and Rein 1973, Glickman 1980). Experience at the Western New York Nuclear Service Center (West Valley) suggests the extent to which a state may seek facility development at the expense of the locality (Kates and Braine 1983). As noted in Chapter 4, there is no guarantee that federal assistance to states will be used to help local communities in ways they deem useful; the Act does permit the Secretary of Energy to negotiate an agreement for funding with the states, and this could in principle be used to provide indirect representation of local community interests. In addition, localities or states could place economic interest above technical scrutiny, to the disadvantage of both local communities and the long-range national interest.

Although Congress has determined that federal prescription is inappropriate in designing institutional relations between states and affected local governments, the void threatens a sound institutional arrangement for repository siting. The panel observes that relationships of this kind have been developed, with notable successes (Brock 1982) and failures (Bacow and Milkey 1983). State laws, such as those for selecting hazardous waste facility sites in Wisconsin, Massachusetts, and Michigan, illustrate a range of possibilities for institutionalizing local interests. (It should be noted, however, that radioactive waste repositories pose a national problem, whereas hazardous waste storage facilities address needs found within many states' economies. Analogies between the two kinds of facilities should be drawn with caution.

Failure to take local concerns into account can lead to intensified conflict, although the dynamics of intensification are understood only qualitatively (Cobb and Elder 1976, Nader and Todd 1978). A mark of escalation is the attempt to place issues in dispute onto the agendas of institutions charged with related responsibilities.

This general principle points to the likelihood that litigation over elements of the federal program may be used to air conflicts between local communities and states. That DOE would be a largely innocent bystander in such a process would do little to ameliorate the harm done to the national siting program. Such a possibility underscores the responsibility of state governments to address the issue of state-local relations constructively.

Management for Operations

The NWPA creates a long-term operational mission for DOE—the planning, construction, and operation of at least two high-level waste repositories (Section 114). Although major elements of the technological design are already in hand, this mission includes the responsibility to conduct an ambitious research and development program, while simultaneously creating a sizable capability to locate, license, and build repositories and to transport, package, store, and dispose of wastes.

DOE and its predecessor agencies have established a strong technical research and development capability. The NWPA presents an important institutional challenge, however, in requiring DOE to create the capacity for operational planning and later for operations. This capacity must include an innovative and largely unprecedented ability to detect and correct organizational error (Landau 1969, LaPorte 1975). Both the transition from a research and development to an operational form of organization and the institutional capacity to learn from mistakes are difficult challenges of organization and management.

The Act recognizes the need for imaginative organizational design in its requirement for a Mission Plan in Section 303. The Mission Plan, called for in Section 301, will need to consider organizational ideas developed in the National Aeronautics and Space Administration and particularly the crucial role of learning from mistakes. Especially in new, industrial-scale ventures such as repository development, an inability to profit from errors dooms an organization to inadequate performance (Hirschman 1970). Similarly, strong attention to identifying potential failures, technical, institutional, or programmatic, is required in order that contingency planning can proceed. These issues need to be addressed at length in DOE's Mission Plan. Despite the explicit recognition of need for public information and participation, the NWPA also commits the federal government to a schedule that is difficult to meet or to sustain over a long period of time. In particular, the tight time schedule seems likely to force DOE to choose between an open, consultative approach and one that risks conflict and involuntary disruption by attempting to heed congressionally mandated deadlines. DOE has informally acknowledged the difficulty of meeting the schedule for site guidelines and preliminary site identification. This may indicate a tendency to favor openness rather than speed.

Perhaps more worrisome, the study of alternative management structures for the long term has been slow in getting started. Required by the NWPA, this study is needed to evaluate institutional possibilities, including a public corporation, for managing the construction and operation of civilian radioactive waste facilities. There is an adequate social scientific base in organizational sociology, industrial economics, business administration, and the study of public enterprise to support this management study. It is essential, in the panel's view, that a judicious appraisal of management alternatives that taps a broad range of social sciences expertise be undertaken without further delay.

Dispute Handling

Selecting two high-level waste repositories under the NWPA is likely to be a contentious process. The Act recognizes this reality in many of its provisions, most notably the right of the selected host state to disapprove DOE's recommendation that a particular site be chosen.

In its deliberations before the NWPA was passed, the panel discussed at length the institutional arrangements appropriate to the settlement of the disputes likely to arise in repository siting. A majority of the panel agreed that a process modeled on a trial court, with the role of judge played by the Nuclear Regulatory Commission (NRC) or a newly created independent commission, was a promising alternative for site selection. Choices made by such a body could combine knowledgeable technical review with an open, fair, reasoned process that could win broad public confidence and withstand judicial review.

The process chosen by Congress in the NWPA is considerably different. Reliance is placed on administra tive decision making by DOE, subject to a variety of checks: the consultation process with states and tribes; Presidential selection of sites to be characterized and of the first sites to be used for repositories; veto power for designation vested in states and tribes; congressional authority to override such a veto; limited judicial review; and technical review by the NRC. This array of limitations on the federal energy bureaucracy has a common denominator: all the checks and balances, and the administrative procedure they constrain, are formal processes. The panel's early deliberation on the decision process together with its study of recent literature on dispute settlement, leads the panel to question elements of the existing formal process and to suggest that a constructive role may be played by more informal methods, including public participation.

The NWPA assigns principal responsibility to DOE for repository site selection. The administrative discretion exercised by DOE is expanded by explicit exceptions to existing law, in particular the National Environmental Policy Act. On the other hand, states and Indian tribes are accorded substantial authority to participate—with federal funding—in the planning process. Under the Act, the President selects a site for the first repository; if the host state or Indian tribe disapproves this selection, its disapproval must be overriden by a veto of both houses of Congress.

While judicial review is limited, it is not eliminated. Indeed, in its language excluding part of the site selection process from the established body of environmental law, the NWPA calls for the preparation of "environmental assessments" subject to judicial review. Because such assessments are apparently not the same, legally, as environmental assessments under the National Environmental Policy Act, litigation to clarify differences is likely, in one or more of the five candidate sites to be identified by DOE, with consequences in case law that are impossible to foresee.

More generally, the Act's approach of relying on administrative decision making puts the incentive to use judicial means of dispute settlement near the start of the site-selection process. The panel's earlier discussions focused on putting the incentive to litigate at the end of the selection process rather than at the beginning. This would have been accomplished by a trial-type selection process, whose results would have been subject to judicial review after technical and socioeconomic evidence had been marshaled.

Litigation early in a complex and technical process often strains the judicial process. In developing evidence, fashioning remedies, and monitoring their implementation, courts face substantial difficulties in these cases (Horowitz 1976). Moreover, an adversarial procedure can hamper the evaluation of an already difficult set of facts, technical uncertainties, and socioeconomic considerations (Harter 1982).

Adjudication contributes to environmental dispute resolution in critical ways, however, by providing access to the governmental arena for aggrieved parties, by bringing in an impartial but legitimate decision maker (Sax 1971), and by putting the power of government behind the settlements arrived at. The question of institutional design, therefore, is how to make use of adjudicatory authority, given the likelihood of serious conflict.

Since the institutional structure is now established in law, the panel points out the useful role that can be played by informal processes that can supplement official administrative and judicial actions. The emergence, since 1974, of a quasi-professional practice of environmental dispute resolution (Bellman et al. 1980, Lee 1981, Harter 1982, Susskind and Weinstein 1981, U.S. Environmental Protection Agency 1982) suggests the possibility that complex disputes involving many parties can be settled by informal negotiation more effectively and more fairly than through exclusive reliance on formal procedures. The matters at stake are issues of public policy, of course, so they must be adopted by the relevant government institutions. These informal methods are accordingly complementary to governmental processes rather than substitutes for them.

Since the primary responsibility for repository development is assigned to DOE in the law, authority, expertise, and resources are highly centralized. State governors and legislatures are given the responsibility to represent local populations, a role that is almost certain to create strains within potential host states. Under these conditions the most important informal process to employ is local public participation and the related design approach of iterative planning.

PUBLIC PARTICIPATION

As reviewed in Chapter 4, substantial attention is required both to the potential effect of a waste reposi tory on local public groups and to the role of such groups in siting decisions. Recent history indicates that local public groups often perceive public facilities to be a threat to their existing land uses, property values, and quality of life. Although there is little definitive research on the effect of public participation on the acceptance of facilities, it is clear that a broad range of individual techniques is available (U.S. Department of Transportation 1976). While there is no generally preferred generic form of public participation, there is evidence that communities react very strongly when they believe that they have been excluded from the planning process. Local populations in Utah and Nevada, for example, were persuaded to reverse their support for the land-based MX mobile missile system as a result of the perceived insensitivity of the Air Force and a suspicion that they were being seen as expendable (Albrecht 1983). There is also evidence that group homes for the mentally retarded have achieved a higher rate of acceptance in communities where participatory techniques of planning were applied during the siting process (Lubin et al. 1982).

There is also the more general argument, stemming from the pluralistic conception of our society, that citizens have a right to participate in decisions that affect their lives even though their ultimate desire to accept or reject a project may not be granted.

A final argument is that planners can learn different or new facts and more about community values and hidden effects by involving citizens instead of merely relying on predictive modeling. Neither current methods of observation nor available predictive models of social conditions are sufficient to preempt local involvement. Planning can, then, be a powerful means for discovering local needs and desires. An approach that includes citizen involvement and anticipatory assessment in planning the siting of a waste repository has significant advantages for understanding and responding to community integrity over an approach limited to adversarial or reactive processes.

Throughout its deliberations the panel sought to define the various public groups and the interests that each represented. A highly visible issue like the siting of the first geologic repository is likely to spark political mobilization at both the site and national levels. As a result, the less-well-organized and -funded groups especially concerned the panel, because they have, with respect to some aspects of the overall waste management problem, a large stake in the outcomes. They reside in areas near proposed sites or along transportation corridors or are members of the larger and less directly affected public that has a inchoate, less-well-defined concern about outcomes affecting the future course of the development of nuclear power.

The panel notes the NWPA's objective that "state and public participation in the planning and development of repositories is essential in order to promote public confidence in safety of disposal of such waste and spent fuel" (Section 111). Realization of this goal will require objectives and detailed procedures for each stage of the siting process. Such involvement will also need to consider a broad range of participation means since past research has indicated the limitations of public hearing as a form of participation (Checkoway 1981). The creation of an independent technical capacity for citizens in affected locales has, in past experience, been at the core of an effective program of public participation. The panel notes, however, that technical expertise for independent review is already in short supply, a situation that may complicate the attempt by local citizens and program officials to obtain a credible second opinion on repository work.

Past research on public participation has also emphasized the importance of two-way communication between agencies and members of the public (Hanchey 1975). Yet DOE's current objectives for public participation constitute in large measure a one-way flow of information from the agency to the public. In this respect the panel notes (but did not independently validate) a recent critical assessment of DOE's program for public participation that concluded that it "exemplifies co-optation strategy; the responsibility for power is to be shared, but little of the power itself. Indeed, the purposes of participation, as DOE defines them, may be more to 'educate' the public into sharing programmatic objectives and opinions than to grant any real independent authority" (Rochlin 1981, p. 12).

The timing of participation has also been a particularly crucial issue in the past. Past research on public participation speaks strongly to the importance of early involvement of citizens, when plans are still tentative and options remain open (Ingram and Ullery 1977). The NWPA outlines in only a general way the structure and timing of public participation to be used in site search ing and selection. Therefore DOE's plan for public participation appears still relevant as to the details of the process. The major activity described in the draft National Plan is the opportunity to review and comment on major federal actions needed to comply with NEPA, but that comes quite late in the decision-making process. These procedures apply also to the promulgation of EPA's environmental radiation standards, NRC's licensing procedures, and DOT's routing requirements for transporting radioactive materials.

The review and comment process, however, is limited as a means of ensuring full and timely public participation. The agency's proposed repository plans are the result of substantial investigation and analysis. By the time the tentative plan is published for public comment, the agency is likely to be strongly committed to it. Under the NWPA, the Secretary of Energy will hold public hearings in the vicinity of each repository site under consideration, but an environmental impact assessment is required only at the time of site recommendation to the President (Section 114). By this time, DOE is likely to be heavily committed to its sites, and it may be difficult to judge impartially whether comments from the public warrant changes in the proposed activity. This process is particularly subject to public criticism if the research and development programs on which the agency bases its plans are perceived to be inadequate or inappropriate.

The record of effective public participation programs suggest, then, the importance of early and broad involvement of the general public, the creation of an independent technical review capability among local citizens, and a role for citizens early and in all subsequent stages of site searching and selection. Since past research on public participation, though quite extensive, does not permit specification of preferred modes of involvement and institutional vehicles, the treatment of the participation program as a major research effort, with thorough peer review and employment of a broad range of techniques and principles followed by careful monitoring and evaluation seems particularly advantageous. In this regard, the efforts of the U.S. Army Corps of Engineers in employing a broad range of participation programs, followed by careful evaluation, over the past decade may provide a useful model (Ragan 1975).

In this context, the NWPA shifts the ground rules of citizen involvement in several important respects. While the DOE is subject to a wide range of institutional con straints, all of these checks and balances take the form of formal procedures. It is left to the state governments to decide how strong a role self-appointed representatives of the public and nongovernmental groups will play. These are conditions in which serious political tensions can develop and, in particular, where the interest of those most directly affected (i.e., the local populations near the repository sites) may be poorly represented. The Act does, however, allow the states considerable latitude for citizen involvement: the panel finds that the experience of citizen participation programs, iterative planning, and environmental dispute resolution is applicable to the design of informal processes in the repository siting program.

REGULATION OF TRANSPORTATION

Chapter 3 emphasized the importance of waste transport in the total radioactive waste management task. Over the next few decades, interstate highways may be extensively used for conveyance of radioactive wastes to away-from-reactor (AFR) storage, reprocessing plants, or final repositories. This use of common traffic arteries could intensify public concern about the safety of waste transport. The Transportation Research Board of the National Research Council (1983) has recently noted the extent of these concerns.

The panel has examined the regulatory structure for such a transportation system and believes it inadequate in several respects. First, a sufficiently broad-based and uniform regulatory regime to assure the safe transport of radioactive wastes may not exist; second, redundancies and incompleteness seem to exist in the current NRC/DOT regulations; and, third, the role of the states in ensuring the safe transport of wastes within their territories needs to be addressed further.

Transportation of spent fuel and high-level wastes is currently regulated primarily by NRC, DOT, and DOE. Regulations promulgated by NRC and DOT cover transport to and from commercial reactors. DOE oversees transport to and from federal research, development, and defense facilities. The Interstate Commerce Commission and the Federal Emergency Management Agency have more minor roles. The Atomic Energy Act, the Hazardous Materials Transportation Act, the Dangerous Cargo Act, the Price-Anderson Act, the Railroad Safety Act of 1970, state and local laws and regulations, and laws governing Indian tribes make up the complex statutory framework applicable to waste and spentfuel transportation.

Most of the transportation of commercial spent fuel is handled by common or contract carrier. Four trucking companies in the United States handle most of the shipments of commercial radioactive material. Under NRC regulation, common and contract carriers are exempt from the licensing requirement; however, NRC reactor licensees' casks are not exempt. Both shippers and carriers must comply with packaging and other NRC and DOT safety regulations for transporting waste and spent fuel.

To prevent conflicts in their regulations governing the transportation of radioactive materials, NRC and DOT subscribed to a memorandum of understanding (MOU) in 1979, updating the earlier DOT/AEC MOU of 1973. The memorandum delegates to NRC the authority to certify the casks in which spent fuel is shipped by NRC licensees. It also charges DOT to develop regulations for the packaging and transportation of radioactive materials as a part of its overall body of regulations for the packaging and transportation of all hazardous materials. It further confirms that DOT obtain NRC approval of specification package designs for shipment of radioactive materials. The memorandum gives to NRC the authority to certify Type B and fissile packaging designs to be used by its licensees. The NRC has adopted DOT's regulations applicable to shippers. These involve proper packaging requirements, package and vehicle radiation levels, markings and security seals.

More is required by an NRC interim rule to prevent sabotage or theft of spent fuel in transit. In July 1980, the NRC published for the second time its interim regulations aimed at preventing sabotage and theft of spent fuel shipments. According to a report by Sandia Laboratories (1978), with whom the government had contracted for cask development, the damages from successful sabotage of a shipment in a densely populated area could rise to $2 billion to $3 billion. The somewhat stiffer regulations of the interim rule require any reactor licensee who transports spent fuel or delivers spent fuel to a carrier for transport to notify the NRC in advance of each shipment so that the NRC can approve the route, make appropriate arrangements with law-enforcement agencies along the route, avoid (where practical) heavily populated areas, schedule shipments, and provide trained escorts. The licensee must also make arrangements relating to drivers and escorts, communications, and vehicle immobilization. Similar requirements apply to shipments by rail.

Congress enacted legislation in 1980 requiring NRC licensees to notify state governments when certain types of shipments of radioactive materials, including spent fuel and high-level wastes, would be moving through their states. In December 1980, the NRC issued a notice of proposed rulemaking, by which the licensee would have to notify, and provide information to, the governor of a state through which a shipment would pass at least 4 days prior to arrival at the state boundary.

Concern over the expected increase in shipments of radioactive materials has prompted many state and local jurisdictions to enact laws and regulations for safe shipment. One such regulation has caused a legal conflict between state and local interests and the nuclear power industry. An amendment to the New York City Health Code banned most commercial shipments of radioactive materials through New York City. Pursuant to the amendment, some spent-fuel truck shipments from Brookhaven National Laboratories' Long Island facility were interrupted in 1976. The NRC, Energy Research and Development Administration (now DOE), and Associated Universities, Inc., which manages Brookhaven National Laboratory for the DOE, challenged the constitutionality of the ordinance in federal district court [U.S. v. City of NY, No. 76 Civ 273 (SDNY, filed Jan. 15, 1976)]. The plaintiffs requested a preliminary and permanent injunction to prohibit enforcement of the ordinance, but the court denied the motion for failure to show immediate irreparable injury.

After the ruling of the district court, Associated Universities asked DOT whether the New York ban was preempted under the Hazardous Materials Transportation Act. That Act states that local and state regulation of hazardous materials transportation is preempted if it is "inconsistent" with the Act or regulations thereunder. Preemption may be waived by DOT if, on the application of an appropriate state agency, the Secretary determines that state regulation affords an equal or greater level of protection to the public and does not unreasonably burden commerce. In response to the request, DOT issued a ruling in 1978 holding that the ban was not preempted by the Act, because highway routing of radioactive materials had not yet been exercised under it. Immediately thereafter, state and local routing requirements for the transport of radioactive materials proliferated.

As a direct result, DOT in 1981 published guidelines to become effective in February 1982 that would have the effect of preempting certain state and local laws. The regulation, "HM-164," addresses only highway shipment of radioactive materials. It designates the entire interstate highway system as the approved transportation route for "large quantity" packages of radioactive materials. The rule declares "inconsistent" state and local regulations that require prenotification or escort personnel or escort requirements, deferring consideration of promulgating a national prenotification rule pending an outcome of NRC's rulemaking on this topic. It also declares "inconsistent" states' prohibiting the use of an interstate highway without designating an equivalent alternate highway, bans on travel during certain times of day, or constraints on travel in urban vehicular tunnels. It requires shipments of spent fuel and waste to follow interstate or equivalent highways and to use beltways where available around cities. The rule also requires the carrier to prepare a written route plan for the driver and shipper. The plan must identify origin and destination points, the route selected, planned stops, approximate departure and arrival times, and telephone numbers for emergency assistance in each state along the selected route. The driver must have received training concerning other DOT requirements for the materials being transported.

HM-164 has been criticized by states because of its attempt to delineate by regulation restrictions on state and local police power actions. Moreover, HM-164 assigns to the states key responsibility for emergency planning and enforcement of regulations. States would like the federal government to assume these responsibilities and implement them by providing technical assistance, guidance, and financial support. On March 25, 1981, the City of New York filed suit in the federal district court for New York's Southern District against the DOT for relief from enforcement of HM-164. The State of New York later joined with New York City as a co-plaintiff. The complaint alleges, among other things, that the Secretary of Transportation has no legal authority under the Hazardous Materials Transportation Act to declare that DOT regulations preempt state or local regulations. On July 9, 1981, a similar suit against DOT was filed by the State of Ohio. Ohio's challenge is designed to protect (1) the state's existing prenotification requirement for the transportation of large quantities of nuclear materials through the state and (2) the Ohio constitution's direct grant of police powers to municipalities. Clearly the stage is set for a judicial test of the federal government's authority to preempt local and state regulation of radioactive waste and spent-fuel shipments.

The regulatory framework just described possesses several interesting properties. First, the focus of regulation is on the licensee's role in supervising the transportation of radioactive wastes. While carriers and drivers are subject to some direct regulation by the agencies, it is the licensee who bears the heaviest burden in vouching for safe transport. While HM-164 and the NRC sabotage regulations do give some attention to truck and driver safety and conditions on the open road, the focus of the former is relief from state and local requirements, while the focus of the latter is espionage and sabotage not conventional (and more likely) accident safety for the highway-using public and surrounding communities. The current regulatory framework for radioactive waste and spent fuel can be analogized to air traffic control, where air freight customers, not air traffic controllers, have been made primarily responsible for the safe air transport of hazardous materials. As "traffic" increases, such a situation will not likely be allowed to continue.

Second, the regulatory framework places the maximum emphasis on cask integrity. Certainly, cask integrity is essential to a successful radioactive waste transportation scheme. Casks must be able to withstand the tremendous stresses to which they may be exposed in the complex array of accidents that, sooner or later, are likely to occur. A measure of additional protection through special regulatory requirements applicable to trucks, drivers, and their routes seems appropriate to the risks posed by such accidents.

In sum, the panel majority found that an underdeveloped regulatory framework currently exists for the transportation of spent fuel and high-level wastes. The federal governmental agencies involved defer to each other, with primary responsibility essentially delegated to NRC's reactor licensees. The states are fighting preemption, but mainly in order to secure the right to ban or restrict waste shipments. A situation in which no level of government or private utility has a strong incentive to act decisively is not conducive to vigorous and broad-based safety regulation.

To prevent future accidents as the frequency of shipment grows and to forestall the adoption of a hastily conceived and costly federal regulatory regime in the wake of accidents, reform of the federal regulatory structure, within the ample statutory authority for reasonable regulatory requirements that already exists, may be required. Thus, the panel recommends a careful evaluation of existing federal regulation of highway transport to assure that (a) a sufficiently broad and uniform regulatory regime exists for the safe transport of radioactive wastes, (b) any redundancies and incompleteness in the existing NRC-DOT regulations have been eliminated, and (c) the needs of states to control safety on their highways are met. If the federal government itself transports the wastes, a similar reassessment of safeguard adequacy must be implemented.

FINDINGS

As a result of its analyses, the panel found that

1. A major institutional gap exists in the framework defined in the Nuclear Waste Policy Act of 1982. There is no institutionalized process for relating the concerns of locally affected populations to the actions of state governors or legislatures. Institutional designs for bridging this gap have been utilized in other policy areas and may provide possible means to fill this void.
2. The site-selection timetable outlined in the Nuclear Waste Policy Act (NWPA) is likely to force the Department of Energy to choose between an open, consultative approach to planning that fails to meet deadlines and a closed, executive approach that meets schedules. A decision to adhere to the tight schedule of the NWPA could contribute to insufficient attention to local concerns and participatory opportunities or result in inappropriate compromises.
3. Informal processes of planning and conflict resolution can provide valuable supplements to the official administrative and judicial processes outlined in the Nuclear Waste Policy Act. Environmental mediation is one such process that deserves further exploration.
4. An ambitious program of public participation is needed to meet the challenges posed by high levels of public concern and the complexity of issues surrounding the siting of nuclear waste repositories. Previous

research and experience suggests that an effective participation program will include:

(a) the direct involvement of affected public groups in impact assessment;
(b) early and broad public involvement in both site searching and site selection, within the context of technical criteria;
(c) the development of an independent technical review capability, similar to that created using DOE funds by the State of New Mexico for the Waste Isolation Pilot Plant, among citizens of the communities hosting the repositories or those exposed to extraordinary waste transportation flow at major points along the waste funnel;
(d) a variety of techniques and mechanisms of public participation, since the state of social science theory does not indicate a preferred mode of public participation. The participation program may be designed as a major research effort, with participation of citizens, peer review, and careful monitoring and evaluation.

5. Transportation of radioactive wastes by truck could be carried out either by a federally owned and operated fleet or by private trucking companies subject to federal and state regulation. Whether private companies or the federal government transport the wastes, a sound federal regulatory system requires

(a) a sufficiently broad-based and uniform regulatory regime;
(b) the elimination of redundancies and incompleteness in the existing NRC-DOT regulations for transportation; and
(c) addressing the desire of states to deal with safety on their own highways.

REFERENCES FOR CHAPTER 5

Albrecht, S. L. 1983. Community response to large-scale federal projects: the cast of the MX. Pp. 233-250 in Nuclear Waste: Socioeconomic Dimensions of Long-Term Storage, S. H. Murdock, F. L. Leistritz, R. R. Hamm, eds. Boulder, Colo.: Westview Press.

Bacow, L. S., and J. R. Milkey. 1983. Responding to local opposition to hazardous waste facilities: the Massachusetts approach. Resolve, Winter/Spring, pp. 1 and 4-8.

Bellman, H. S., C. Sampson, and G. W. Cormick. 1982. Using Mediation When Siting Hazardous Waste Management Facilities. Report Prepared for the Office of Solid Waste and Emergency Response. Washington, D.C.: U.S. EPA.

Brock, J. 1982. Bargaining Beyond Impasse. Cambridge, Mass.: Auburn House.

Checkoway, B. 1981. The politics of public hearings. Journal of Applied Behavioral Science 17 (4):566-582.

Cobb, R., and C. Elder. 1976. Participation in American Policy. Baltimore, Md.: Johns Hopkins University Press.

Glickman, N., ed. 1980. The Urban Impacts of Federal Policies. Baltimore, Md.: The John Hopkins University Press.

Hanchey, J. R. 1975. Public Involvement in the Corps of Engineers Planning Process. IWR Research Report 75-R4. Fort Belvoir, Va.: U.S. Army Engineer Institute for Water Resources.

Harter, P. J. 1982. Negotiating regulations: a cure for malaise. Georgetown Law Journal 71:1-118.

Hirschman, A. O. 1970. Exit, voice and Loyalty. Cambridge, Mass.: Harvard University Press.

Horowitz, D. 1976. The Courts and Social Policy. Washington, D.C.: Brookings Institution.

Ingram, H. M., and S. J. Ullery. 1977. Public participation in environmental decision-making: substance or illusion. Pp. 123-139 in Public Participation in Planning, W. R. D. Semell and J. T. Coppock, eds. New York: John Wiley & Sons.

Kates, R. W., and B. Braine. 1983. Locus, equity, and the West Valley nuclear wastes. Pp. 94-117 in Equity Issues in Radioactive Waste Management, R. E. Kasperson, ed. Cambridge, Mass.: OGH Publishers.

Landau, M. 1969. Redundancy, rationality and the problem of duplication and overlap . Public Administration Review 29:346-358.

LaPorte, T. R. 1975. Complexity and uncertainty: challenge to action. Pp. 332-356 in Organized Social Complexity, T. R. LaPorte, ed. Princeton, N.J.: Princeton University Press.

Lee, K. N. 1982. Defining success in environmental dispute resolution. Resolve, Spring, pp. 1 and 3-6.

Lubin, R. A., A. A. Schwartz, W. B. Zigman, and M. P. Janicki. 1982. Community acceptance of residential programs for developmentally disabled persons. Applied Research in Mental Retardation 3:191-200.

Lupo, A., F. Colcord, and P. Fowler. 1971. Rites of Way: The Politics of Transportation in Boston and the U.S. City. Boston: Little, Brown & Company.

Marris, P., and M. Rein. 1973. Dilemmas of Social Reform. 2nd ed. Chicago: Aldine.

Nader, L., and H. F. Todd, eds. 1978. The Disputing Process In Ten Societies. New York: Columbia University Press.

National Research Council. 1983. Transportation of Hazardous Materials: Toward a National Strategy. Transportation Research Board. Washington, D.C.: National Academy of Sciences.

Nuclear Waste News. 1982. Summary of nuclear waste policy act of 1982. Nuclear Waste News, Dec. 30, pp. 204-207.

Ragan, J. F., Jr. 1975. Public Participation in Water Resources Planning: An Evaluation of the Programs of 15 Corps of Engineers Districts. IWR Contract Report 75-6. Fort Belvoir, Va.: U.S. Army Engineer Institute for Water Resources.

Rochlin, G. I. 1981. The Role of Participatory Impact Assessment in Radioactive Waste Management Program Activities. Columbus, Ohio: Office of Nuclear Waste Isolation, Battelle Memorial Institute.

Sandia National Laboratories. 1978. Transport of Radionuclides In Urban Environs: A Working Draft Assessment. Albuquerque, N. Mex.

Sax, J. L. 1971. Defending the Environment: A Strategy for Citizen Action. New York: Knopf.

Seley, J. E. 1983. The Politics of Public Facility Planning. Lexington, Mass.: D.C. Heath and Company.

Susskind, L., and A. J. Weinstein. 1980. Toward a theory of environmental mediation. Environmental Affairs 9:310-357.

U.S. Department of Transportation. 1976. Effective Citizen Participation in Transportation Planning. Volume 2. Washington, D.C.

Appendix A:

Spent-Fuel Transportation Analysis for the National Academy of Sciences

S. C. Mc Guire, P. E. Johnson, S. M. Gibson, and D. S. Joy
Oak Ridge National Laboratories
April 1981

Oak Ridge and Sandia National Laboratories, as contractors for the Department of Energy, in support of the work of the panel provided this analysis at the panel's direction and do not necessarily endorse its conclusions.

The ORNL Spent Fuel Logistics Model (SFLM) has been used to make a number of logistics calculations for this analysis. These calculations show the projected movement of spent-fuel assemblies from operating and planned nuclear reactor sites both to illustrative permanent repositories and away-from-reactor (AFR) storage facilities (Figures A.1 through A.12). In addition, the number of annual spent-fuel shipments, the transportation distances, the costs in 1981 dollars, and the cask fleet requirements were itemized for transporting the spent fuel from the reactors to the storage facilities. The results covered the period 1986 through 2004. Information used as input to the SFLM was supplied by the Savannah River Laboratory (SRL) and their subcontractor, the S. M. Stoller Corporation. This information is based on utility responses to the 1980 DOE spent-fuel survey (Ref: DOE/SR-0007, Spent Fuel Storage Requirements and Update of DOE/NE-0002, March 1981).

Two general types of source-to-destination configurations have been considered. First, it was assumed that spent fuel would be shipped from the reactor sites to a single storage facility located in either the southeastern, Gulf Coast, or western part of the United States. For each of these locations, it was further assumed that the spent fuel would be moved in two ways. The first employed both rail and truck casks; the second used only truck casks. In all cases where both rail and truck casks are utilized, it was assumed that those reactors that have direct rail access to their fuel storage pool

Figure A.1 Projected annual spent-fuel shipments to a southeastern storage site in 2004. Basis: reactors with truck service only (for demonstration purposes only).

Figure A.2 Projected annual spent-fuel shipments to a southeastern storage site in 2004. Basis: reactors with rail service (for demonstration purposes only).

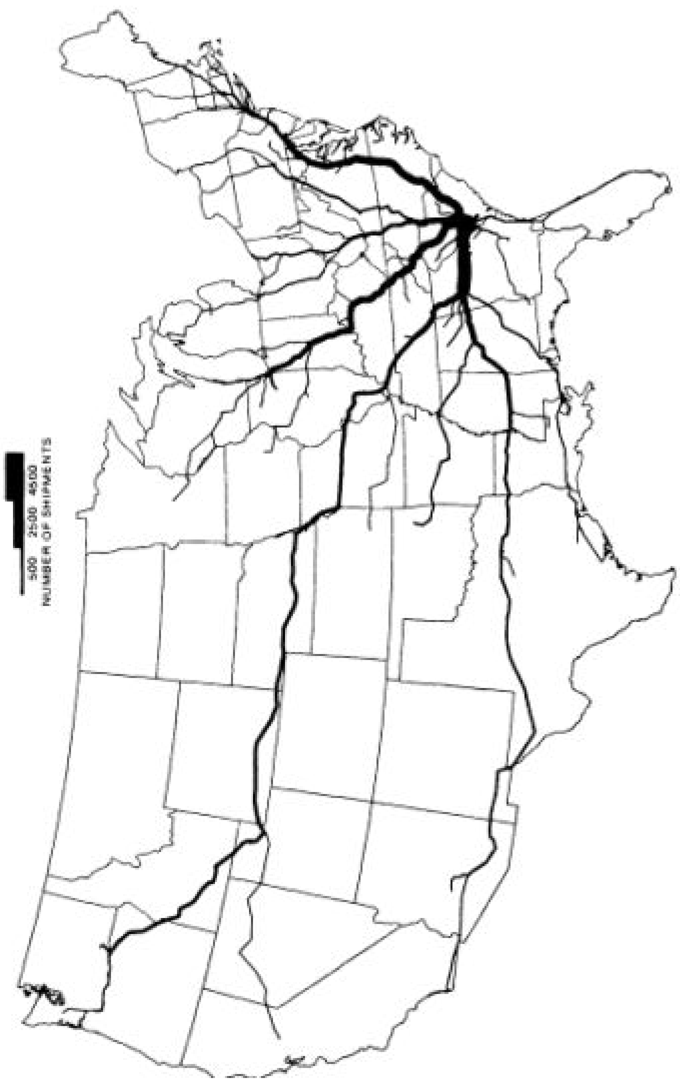


Figure A.3 Projected annual spent-fuel shipments to a southeastern storage site in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

Figure A.4 Projected annual spent-fuel shipments to a Gulf Coast storage site in 2004. Basis: reactors with truck service only (for demonstration purposes only).

Figure A.5 Projected annual spent-fuel shipments to a Gulf Coast storage site in 2004. Basis: reactors with rail service (for demonstration purposes only).

Figure A.6 Projected annual spent-fuel shipments to a Gulf Coast storage site in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

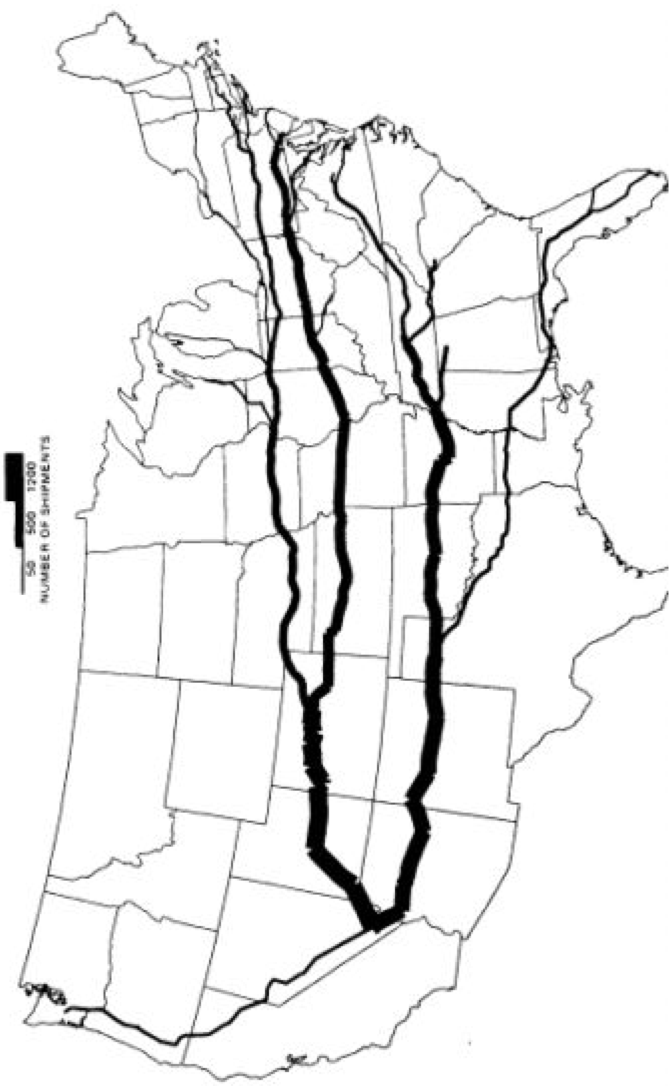


Figure A.7 Projected annual spent-fuel shipments to a western storage site in 2004. Basis: reactors with truck service only (for demonstration purposes only).

Figure A.8 Projected annual spent-fuel shipments to a western storage site in 2004. Basis: reactors with rail service (for demonstration purposes only).

Figure A.9 Projected annual spent-fuel shipments to a western storage site in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

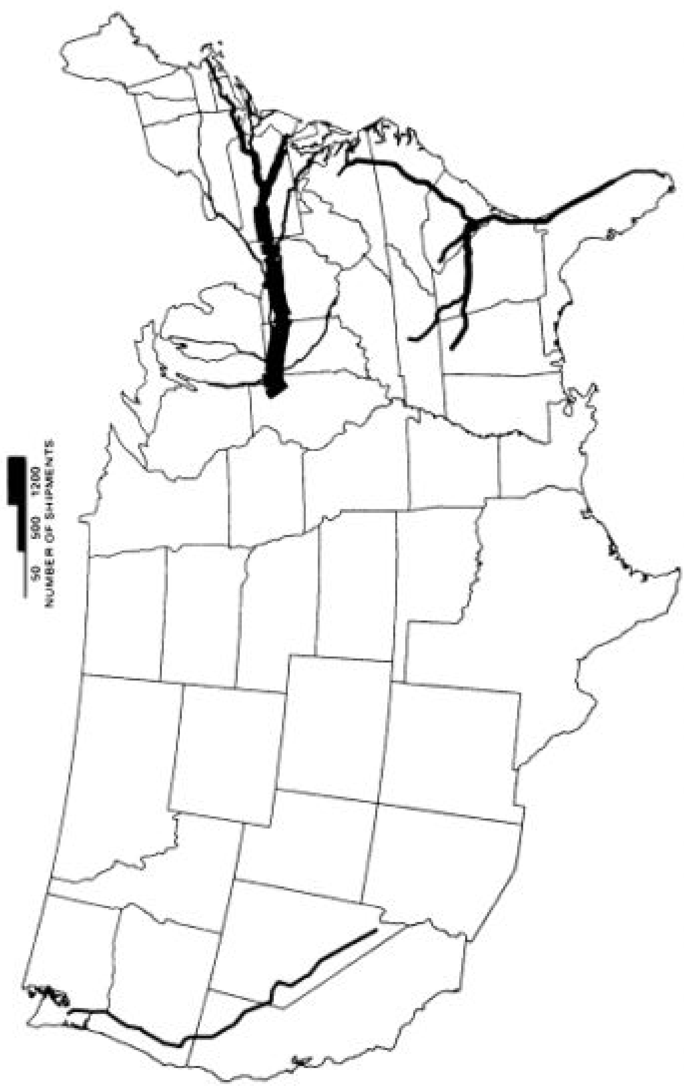


Figure A.10 Projected annual spent-fuel shipments to regional storage sites in 2004. Basis: reactors with truck service only (for demonstration purposes only).

Figure A.11 Projected annual spent-fuel shipments to regional storage sites in 2004. Basis: reactors with rail service (for demonstration purposes only).

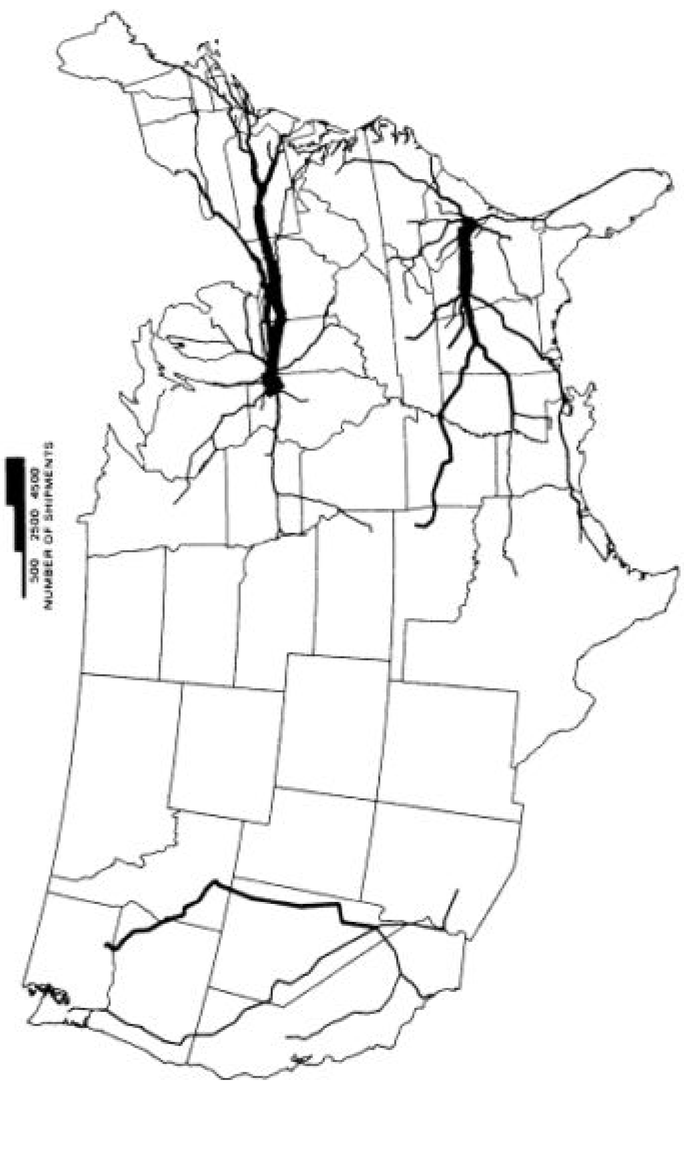


Figure A.12 Projected annual spent-fuel shipments to regional storage sites in 2004. Basis: truck shipments from all reactors (for demonstration purposes only).

would ship by rail and those without this feature would ship by truck.

Other calculations assumed that all spent fuel would be shipped from the reactor sites to one of three regional storage facilities that are open simultaneously to receive fuel. The three storage facilities were located in the southeastern, midwestern, and western regions of the United States. For the runs involving the regional facilities, the country was divided into three regions, and all fuel shipped from a reactor was sent to its respective storage facility. The western region was defined to include all reactors in the states of Washington, Oregon, California, and Arizona. The storage facility for this region was assumed to be located in the vicinity of Las Vegas, Nevada. The southeastern region includes reactors in the following states: Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, Tennessee, South Carolina, North Carolina, and Virginia. The storage facility for this region was assumed to be located at Barnwell, South Carolina. The midwestern region includes all other reactors, and the storage facility would be located at Morris, Illinois. As with the single storage facility runs, the fuel was assumed to be moved by rail or truck in one case and only by truck in another.

The tables in this appendix summarize the results of these logistics calculations. They include the following:

1. Listing of the number of spent-fuel assemblies that will be shipped annually from each reactor during the period 1985 through 2004 (Table A.1). Only those 113 reactors that are projected to make a shipment are listed. The entries in this table take into account the capacity of the cask in which the shipment will be made.
2. The number of spent-fuel assemblies that would be moved annually to a single storage facility (Table A.2) and to the three regional facilities (Table A.3) between the years 1986 and 2004 and includes a breakdown by reactor type, i.e., PWR or BWR. The source data indicate that no shipments would be required prior to 1986 and are based on the following assumptions:

(a) Full core reserve would be maintained at each reactor
(b) The utilities would expand their on-site storage capacity to its maximum extent by 1984; and
(c) Firmly planned transshipments would take place.

TABLE A.1 Number of Spent-Fuel Assemblies Shipped from Reactors to a Storage Facility

REACTOR	TYPE	NUMBER OF ASSEMBLIES SHIPPED										NUMBER OF ASSEMBLIES SHIPPED									
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALVERT CLIFFS-1	PWR	0	0	0	0	0	0	0	0	67	72	144	72	72	144	72	72	144	72	72	144
PILGRIM-1	BWR	0	0	0	0	74	0	176	174	0	176	174	0	176	174	0	176	0	174	176	0
PILGRIM-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	72	72	72	72	72
CONNECTICUT YANKEE	PWR	0	0	0	0	0	0	0	0	0	0	0	0	50	0	52	52	52	0	52	52
INDIAN POINT-2	PWR	0	0	0	0	0	0	0	0	61	72	0	72	72	0	72	72	0	72	72	0
INDIAN POINT-3	PWR	0	0	0	25	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
BEAVER VALLEY-1	PWR	0	0	0	0	0	0	0	0	60	50	50	50	50	60	50	50	50	50	60	50
BEAVER VALLEY-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	50	50	50
OYSTER CREEK-1	BWR	0	0	44	132	132	0	132	132	132	0	132	132	132	0	132	132	132	0	132	132
SHOREHAM	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	134	136
MAINE YANKEE	PWR	0	0	40	70	0	70	80	70	70	0	70	80	70	70	0	80	70	70	80	0
THREE MILE ISLAND-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	60	50	50
NINE MILE POINT-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	168	0	216	0	192	0	192	0
NINE MILE POINT-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	192	168
JAMES A. FITZPATRICK	BWR	0	0	0	0	48	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
MILLSTONE-1	BWR	0	0	0	0	72	0	192	168	0	168	192	0	168	168	0	192	168	0	168	192
MILLSTONE-2	PWR	0	0	0	0	0	0	0	60	70	0	70	70	70	0	80	70	70	0	70	70
SUSQUEHANNA-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	192	360	360	336	360	360	336	360
PEACH BOTTOM-2	BWR	0	0	272	0	286	286	0	286	286	0	286	286	0	286	286	0	286	286	0	286
PEACH BOTTOM-3	BWR	0	0	90	286	0	286	286	0	286	286	0	286	286	0	286	286	0	286	286	0
LIMERICK-1	BWR	0	0	0	0	0	0	0	0	0	0	0	216	288	0	288	288	0	288	288	0
LIMERICK-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	216	288	0	288	288	0	288
SEABROOK-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	30	70	60	70	60	70	60
SEABROOK-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	70	60	70	60
SALEM-1	PWR	0	0	0	0	0	0	0	0	0	9	63	63	63	63	63	63	63	63	63	63
SALEM-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	43	60	60	60	60	60	60
HOPE CREEK-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	0	248
HOPE CREEK-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62
ROBERT E. GINNA	PWR	0	0	0	6	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31

REACTOR	TYPE	NUMBER OF ASSEMBLIES SHIPPED												NUMBER OF ASSEMBLIES SHIPPED							
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
VERMONT YANKEE	BWR	0	0	0	96	96	72	96	96	96	96	96	72	96	96	96	96	96	72	96	96
YANKEE	PWR	0	0	0	0	0	0	0	0	0	0	0	0	38	38	0	38	38	38	0	38
ZIMMER-1	BWR	0	0	0	0	0	0	0	0	0	0	0	14	140	140	140	140	140	140	140	140
PERRY-1	BWR	0	0	0	0	0	0	0	0	264	288	576	288	312	576	288	312	576	288	288	600
DRESDEN-1	BWR	0	72	72	48	72	72	48	72	72	48	72	72	72	48	72	72	48	72	72	72
DRESDEN-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	192	0	192	192	0
DRESDEN-3	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	168	192	0	192	192
LASALLE-1	BWR	0	0	0	0	0	0	0	0	96	264	504	240	264	504	240	264	504	240	264	504
ZION-1	PWR	0	0	0	0	0	0	0	30	120	120	120	120	120	120	120	120	120	120	120	120
BYRON-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	40	110	120	110	120	110	110	120
BRAIDWOOD-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	110	120	110	120	110
QUAD-CITIES-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	192	192
BIG ROCK POINT	BWR	0	0	0	0	0	0	0	0	0	0	0	0	20	22	22	22	22	22	22	22
PALISADES	PWR	0	23	69	0	69	69	0	69	69	0	69	69	0	69	69	0	69	69	0	69
MIDLAND-2	PWR	0	0	0	0	0	0	0	0	0	20	110	60	60	120	120	120	60	50	120	120
LA CROSSE BWR	BWR	0	0	0	0	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
FERMI-2	BWR	0	0	0	0	0	0	0	96	0	288	0	264	264	0	288	0	264	264	0	288
CLINTON-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	144	144	144
DONALD C. COOK-1	PWR	0	0	0	0	0	0	0	0	0	0	0	120	140	60	150	150	60	140	150	60
DUANE ARNOLD	BWR	0	0	0	0	0	0	0	0	0	0	0	24	72	96	72	96	72	96	72	96
WOLF CREEK	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	60	70
COOPER	BWR	0	0	0	0	0	0	0	0	96	120	96	120	96	120	96	120	96	120	96	120
MONTICELLO	BWR	0	0	0	0	144	144	0	144	144	0	120	144	0	144	144	144	0	144	120	0
PRAIRIE ISLAND-1	PWR	0	0	0	0	0	0	0	0	70	80	80	80	80	80	80	80	80	80	40	80
FORT CALHOUN-1	PWR	0	0	0	0	0	0	0	0	30	0	40	50	0	40	50	0	40	40	0	50
MARBLE HILL-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	130	120	130	130	120
DAVIS-BESSE-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	10	70	0	70	70	0	70
POINT BEACH-1	PWR	0	0	0	0	0	0	0	0	0	0	0	39	72	72	72	72	72	72	72	72
KEWAUNEE	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	36	36	36	36	36
JOSEPH M. FARLEY-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	50	60	50	50

REACTOR	TYPE	NUMBER OF ASSEMBLIES SHIPPED												NUMBER OF ASSEMBLIES SHIPPED							
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
JOSEPH M. FARLEY-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	50
NUCLEAR ONE-1	PWR	0	0	0	0	0	0	0	0	10	80	0	70	70	0	80	70	0	70	80	0
NUCLEAR ONE-2	PWR	0	0	0	0	0	0	0	0	0	0	0	10	60	50	50	50	50	60	50	50
BRUNSWICK-1	BWR	0	96	0	168	192	0	168	192	0	168	192	0	168	192	0	168	168	0	192	168
BRUNSWICK-2	BWR	0	0	0	96	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
ROBINSON-2	PWR	0	40	60	50	50	50	60	50	50	60	50	50	60	50	50	50	60	50	50	60
OCONEE-1	PWR	0	0	93	0	144	144	0	144	144	0	144	144	0	144	144	0	144	144	0	144
OCONEE-3	PWR	0	0	0	0	65	0	72	72	0	72	72	0	72	72	0	72	72	0	72	72
MCGUIRE-1	PWR	0	0	0	0	0	0	0	0	0	0	0	60	60	60	70	60	60	60	60	60
MCGUIRE-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	60	70	60	60	60
TURKEY POINT-3	PWR	0	0	0	0	33	50	0	50	50	0	50	0	50	50	0	50	50	0	50	50
TURKEY POINT-4	PWR	0	0	0	48	63	0	63	63	0	63	0	63	63	0	63	63	0	63	0	63
ST. LUCIE-1	PWR	0	57	88	0	88	88	0	88	88	0	88	88	0	88	88	0	88	88	0	88
ST. LUCIE-2	PWR	0	0	0	0	0	0	46	84	0	84	84	84	0	84	84	0	84	84	84	0
CRYSTAL RIVER-3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	70	70	0	70
EDWIN I. HATCH-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	24	288	288	264	288	288	264
VOGTLE-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120	130	120	130
RIVER BEND-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	144	168
WATERFORD-3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	70	70	70	80
GRAND GULF-1	BWR	0	0	0	0	0	0	0	0	192	216	216	240	216	216	240	216	216	216	240	216
GRAND GULF-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	240
VIRGIL C. SUMMER-1	PWR	0	0	0	0	0	0	0	50	50	60	50	50	50	50	60	50	50	50	50	60
BROWNS FERRY-1	BWR	0	0	0	0	0	0	0	0	0	0	0	258	524	262	262	524	262	262	524	262
BROWNS FERRY-3	BWR	0	0	0	0	0	0	0	0	0	0	54	264	0	262	264	0	262	264	0	262
SEQUOYAH-1	PWR	0	0	0	0	0	0	0	0	50	110	110	110	110	100	110	110	110	110	100	110
WATTS BAR-1	PWR	0	0	0	0	0	0	0	0	0	70	110	110	110	110	100	110	110	110	110	100
BELLEFONTE-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	60	70	70	70	70
BELLEFONTE-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	60	70	70	70
HARTSVILLE-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	176	176	176
HARTSVILLE-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	176	176

REACTOR	TYPE	NUMBER OF ASSEMBLIES SHIPPED												NUMBER OF ASSEMBLIES SHIPPED							
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
PHIPPS BEND-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	168
SURRY-1	PWR	0	108	122	0	122	122	0	122	122	0	122	122	0	122	122	0	122	122	0	122
NORTH ANNA-1	PWR	0	0	0	0	135	69	69	138	69	69	138	69	69	138	69	69	138	69	69	138
PALO VERDE-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	70	80	80	70	80	80	70
PALO VERDE-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	80	80	70	80	80
PALO VERDE-3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	80	70	80
ALLENS CREEK-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	192	216	192	216	192	216
SOUTH TEXAS PROJECT-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	60	70	60	60	60
SOUTH TEXAS PROJECT-2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	60	70	60
BLACK FOX-1	BWR	0	0	0	0	0	0	0	0	0	0	24	288	0	288	288	0	288	288	0	288
BLACK FOX-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	288	288	0	288	288
COMANCHE PEAK-1	PWR	0	0	0	0	0	0	0	0	0	0	0	80	140	130	130	140	130	140	130	130
TROJAN	PWR	0	0	0	0	0	0	0	0	50	60	50	60	50	60	60	50	60	50	60	60
SKAGIT-1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	216	216	216
SKAGIT-2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	216
RANCHO SECO	PWR	0	0	0	0	0	0	0	0	0	0	20	50	60	60	0	50	60	50	60	0
SAN ONOFRE-1	PWR	0	0	0	0	40	50	0	50	60	0	50	50	0	50	50	0	60	50	0	50
SAN ONOFRE-2	PWR	0	0	0	0	0	30	80	70	0	70	70	70	80	70	70	0	70	70	80	70
SAN ONOFRE-3	PWR	0	0	0	0	0	0	30	80	0	70	70	70	70	80	70	0	70	70	70	80
WNP-2	BWR	0	0	0	0	0	0	0	0	0	0	144	168	168	168	168	168	168	168	168	168
WNP-1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	60	70	70	70	70
WNP-3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	69	79	79	79	79	79	79
WNP-4	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	60	70	70	70
WNP-5	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	79	79	79	79	79

TABLE A.2 Number of Spent-Fuel Assemblies Shipped Annually to a Single Storage Facility

	Shipped	
Year	PWR	BWR
1986	228	168
1987	472	478
1988	199	826
1989	897	1260
1990	830	1148
1991	588	1386
1992	1378	1648
1993	1448	1952
1994	1379	2406
1995	2182	3166
1996	2443	3664
1997	2259	4110
1998	3034	4674
1999	3634	5376
2000	3427	5192
2001	4620	6158
2002	4540	6224
2003	4160	6950
2004	4689	8118
TOTAL	42,407	64,904

A good approximation of the amount of heavy metal (MTU) in these shipments can be obtained by using the following conversion factors:

PWR = 0.4614 MTU/assembly,

and

BWR = 0.18335 MTU/assembly.

3. The number of shipments needed to transport the number of assemblies to a single storage facility and to regional facilities. Two cases are shown here: one in which rail and truck casks are used (Tables A.4 and A.5)

TABLE A.3 Number of Spent-Fuel Assemblies Shipped Annually to Regional Storage Facilities

	Western		Southeastern		Midwestern	
Year	PWR	BWR	PWR	BWR	PWR	BWR
1986	0	0	205	96	23	72
1987	0	0	263	0	109	478
1988	0	0	98	264	101	562
1989	40	0	700	312	157	948
1990	80	0	523	120	227	1,028
1991	110	0	310	288	168	1,098
1992	200	0	861	312	317	1,336
1993	110	0	633	312	705	1,640
1994	200	0	668	504	511	1,902
1995	260	144	1,018	606	904	2,416
1996	300	168	1,110	1,170	1,033	2,326
1997	260	168	914	1,028	1,085	2,914
1998	459	168	1,308	1,388	1,267	3,118
1999	568	168	1,450	1,654	1,616	3,554
2000	498	168	1,144	1,820	1,785	3,204
2001	798	264	1,898	2,146	1,924	3,748
2002	818	384	1,870	1,988	1,852	3,852
2003	798	480	1,495	2,508	1,887	3,962
2004	788	600	1,947	3,012	1,954	4,506
TOTAL	6347	2712	18,515	19,528	17,697	42,712

and one in which only truck casks are used (Table A.4 and A.6).

TABLE A.4 Annual Spent-Fuel Shipments to a Single Storage Facility

	Mixed Mode		Truck Only
Year	Rail	Truck	
1986	11	188	312
1987	13	575	711
1988	29	288	612
1989	41	1053	1527
1990	44	916	1404
1991	58	635	1281
1992	90	1214	2202
1993	121	1110	2424
1994	166	760	2582
1995	217	1385	3765
1996	248	1593	4275
1997	273	1348	4314
1998	322	1857	5371
1999	396	2030	6322
2000	402	1677	6023
2001	514	2145	7699
2002	502	2262	7652
2003	532	1903	7655
2004	575	2480	8748

Information was provided on the relative amount (weight percent) of fuel shipped by rail to a single storage facility (Table A.7) and to regional facilities (Table A.8). The variations in these figures are a function of the particular reactors making shipments in the various years and also the transportation mode, i.e., rail and/or truck, available at the individual reactors. All rail shipments were assumed to be made in a cask capable of transporting 10 PWR assemblies or 24 BWR assemblies. The truck cask was assumed to transport a single PWR assembly or 2 BWR assemblies. Actual spent-fuel casks exist with these capabilities.

4. The cask fleet requirements for both the rail/truck mix (Table A.9) and truck only (Table A.10) between 1986 and 2004 to make all shipments to a single storage facility located in either the southeastern, Gulf Coast, or

TABLE A.5 Number of Spent-Fuel Shipments to Regional Storage Facilities

	Western		Southeastern		Midwestern		Total	
Year	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck
1986	0	0	8	165	3	23	11	188
1987	0	0	6	303	7	272	13	575
1988	0	0	16	48	13	240	29	288
1989	4	0	18	650	19	403	41	1053
1990	8	0	10	473	26	443	44	916
1991	11	0	18	250	29	385	58	635
1992	20	0	23	761	47	453	90	1214
1993	11	0	29	473	81	637	121	1110
1994	20	0	59	288	87	472	166	760
1995	32	0	55	725	130	660	217	1385
1996	37	0	81	831	130	762	248	1593
1997	33	0	87	516	153	832	273	1348
1998	46	69	97	960	179	828	322	1857
1999	49	148	135	833	212	1049	396	2030
2000	41	158	143	516	218	1003	402	1677
2001	75	158	184	1003	255	984	514	2145
2002	82	158	180	964	240	1140	502	2262
2003	84	158	190	713	258	1032	532	1903
2004	88	158	216	1115	271	1207	575	2480

western region of the United States and then shipments to regional facilities (Table A.11 and A.12). In addition to the cask capacities discussed above, the information is based on the following assumptions:

TABLE A.6 Number of Spent-Fuel Shipments to Regional Storage Facilities Using Truck Casks Only

Year	Western Facility	Southeastern Facility	Midwestern Facility	Total
1986	0	253	59	312
1987	0	363	348	711
1988	0	230	382	612
1989	40	856	631	1527
1990	80	583	741	1404
1991	110	454	717	1281
1992	200	1017	985	2202
1993	110	789	1525	2424
1994	200	920	1462	2582
1995	332	1321	2112	3765
1996	384	1695	2196	4275
1997	344	1428	2542	4314
1998	543	2002	2826	5371
1999	652	2277	3393	6322
2000	582	2054	3387	6023
2001	930	2971	3798	7699
2002	1010	2864	3778	7652
2003	1038	2749	3868	7655
2004	1088	3453	4207	8748

(a) Average transport speed: rail = 6 mph; truck = 34 mph;
(b) Total time at point of departure and destination to unload casks: rail = 5 days; truck = 3 days; and
(c) All casks are available 300 days/year.

Capital cost for the casks is estimated to be approximately $5,000,000 for a rail cask and $500,000 for a truck cask.

5. The effect of the location of a single storage facility and regional facilities on the required transportation distances for rail and trucks (Tables A.13, A.14, and A.15). The transportation distance is round-trip distance, i.e., includes shipment of empty

TABLE A.7 Relative Amount of Fuel Shipped by Rail to a Single Storage Facility

Year	Amount (wt %)
1986	36.2
1987	19.4
1988	53.5
1989	28.3
1990	33.4
1991	49.6
1992	43.3
1993	53.3
1994	69.5
1995	61.7
1996	62.4
1997	68.7
1998	64.4
1999	67.3
2000	71.8
2001	71.4
2002	70.4
2003	75.2
2004	71.1

TABLE A.8 Relative Amount of Spent Fuel Shipped by Rail to Regional Storage Facilities

	Amount (wt %)		
Year	Western	Southeastern	Midwestern
1986	---	32.1	55.4
1987	---	16.5	23.0
1988	100.0	76.3	39.2
1989	100.0	21.1	34.0
1990	100.0	17.1	39.5
1991	100.0	41.1	46.4
1992	100.0	22.7	53.7
1993	100.0	37.5	58.4
1994	100.0	66.8	66.5
1995	100.0	42.8	67.8
1996	100.0	50.6	64.8
1997	100.0	65.1	66.4
1998	86.9	51.3	69.5
1999	76.7	63.0	68.3
2000	72.0	75.2	69.7
2001	82.5	65.8	72.9
2002	83.7	66.8	69.3
2003	84.0	75.0	72.8
2004	84.6	67.4	70.6

TABLE A.9 Cask Fleet Requirements for Shipping Spent Fuel to a Single Storage Facility Using Both Rail and Truck Casks

	Southeastern Facility (No. of Casks)		Gulf Coast Facility (No. of Casks)		Western Facility (No. of Casks)	
Year	Rail	Truck	Rail	Truck	Rail	Truck
1986	1	3	1	4	2	6
1987	1	9	1	10	2	17
1988	2	5	3	6	5	9
1989	3	15	3	18	6	31
1990	4	14	4	16	6	27
1991	5	10	5	12	8	19
1992	8	18	8	21	11	36
1993	9	17	9	20	15	33
1994	12	12	11	14	20	23
1995	17	20	16	24	25	40
1996	19	23	18	27	28	45
1997	20	21	19	23	32	39
1998	24	28	23	32	37	52
1999	28	33	27	37	46	56
2000	27	29	27	32	47	47
2001	37	35	36	38	59	59
2002	36	37	35	41	57	63
2003	38	32	37	35	61	52
2004	41	40	39	44	65	69

cask to reactor and shipment of loaded cask to receiving facility.

6. Estimated transportation costs for rail/truck (Table A.16) and trucks only (Table A.17) including both the carrier cost and a charge for leasing the shipping cask, in 1981 dollars. Most cost data are based on information that is approximately 3-4 years old (see D. S. Joy, D. J. Hudson, and M. W. Anthonly, Logistics Characterization for Regional Spent Fuel Repository Concepts, ONWI-124, August 1980); the calculated cost was increased by 40 percent to account for inflation. Lease charges, after adjusting for inflation, were assumed to be $5040/day for a rail cask and $910/day for a truck cask.

TABLE A.10 Cask Fleet Requirements for Shipping Spent Fuel to a Single Storage Facility Using Truck Casks Only

Year	Southeastern Facility (No. of Casks)	Gulf Coast Facility (No. of Casks)	Western Facility (No. of Casks)
1986	5	6	9
1987	11	12	21
1988	10	12	19
1989	23	27	43
1990	23	26	39
1991	21	25	37
1992	36	40	61
1993	40	43	66
1994	43	46	69
1995	63	68	100
1996	72	75	110
1997	73	77	113
1998	92	95	138
1999	108	112	162
2000	104	107	154
2001	133	137	195
2002	133	136	192
2003	135	137	191
2004	151	154	220

When shipping to multiple facilities, the average shipping distances are much smaller. This results in a considerable reduction in the cask fleet requirements and costs when compared with the case where a single storage facility is used (Table A.18). Shipping casks were assumed not to cross any regional boundary in the

TABLE A.11 Cask Fleet Requirements for Shipping Spent Fuel to Regional Facilities Using Rail and Truck Casks

	Western		Southeastern		Midwestern		Total	
Year	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck
1986	0	0	1	3	1	1	2	4
1987	0	0	1	4	1	4	2	8
1988	0	0	1	1	1	4	2	5
1989	1	0	1	9	1	7	3	16
1990	1	0	1	7	2	7	4	14
1991	1	0	1	4	2	7	4	11
1992	1	0	1	10	3	8	5	18
1993	1	0	2	7	4	10	7	17
1994	1	0	3	4	4	8	8	12
1995	2	0	2	10	6	11	10	21
1996	2	0	4	11	6	12	12	23
1997	2	0	4	7	7	14	13	21
1998	3	2	5	13	8	13	16	28
1999	3	3	7	11	9	17	19	31
2000	3	4	7	7	9	16	19	27
2001	5	4	9	14	11	16	25	34
2002	5	4	9	13	10	18	24	35
2003	5	4	9	10	11	17	25	31
2004	6	4	10	15	11	19	27	38

TABLE A.12 Cask Fleet Requirements for Shipping Spent Fuel to Regional Facilities Using Truck Casks Only

Year	Western Facility (No. of Casks)	Southeastern Facility (No. of Casks)	Midwestern Facility (No. of Casks)	Total
1986	0	4	1	5
1987	0	5	6	11
1988	0	3	7	10
1989	1	11	10	22
1990	1	8	12	21
1991	2	6	12	20
1992	3	13	16	32
1993	2	11	23	36
1994	3	13	21	37
1995	5	18	31	54
1996	6	24	32	62
1997	6	20	37	63
1998	9	28	40	77
1999	11	32	49	92
2000	10	30	48	88
2001	15	42	53	110
2002	16	41	53	110
2003	17	39	55	111
2004	18	49	59	126

TABLE A.13 Transportation Distances Associated with Shipping Spent Fuel to a Single Storage Facility Using Both Truck and Rail Casks

	Southeastern Facility Distance (mile × 10^6)		Gulf Coast Facility Distance (mile × 10^6)		Western Facility Distance (mile × 10^6)	
Year	Rail	Truck	Rail	Truck	Rail	Truck
1986	0.01	0.19	0.02	0.32	0.06	0.90
1987	0.02	0.59	0.03	0.97	0.07	2.66
1988	0.04	0.38	0.07	0.60	0.17	1.43
1989	0.08	1.10	0.10	1.82	0.20	4.98
1990	0.12	0.98	0.13	1.60	0.19	4.30
1991	0.15	0.79	0.17	1.26	0.27	3.13
1992	0.25	1.29	0.25	2.12	0.39	5.79
1993	0.28	1.24	0.28	2.04	0.54	5.28
1994	0.37	0.94	0.35	1.50	0.71	3.75
1995	0.54	1.49	0.51	2.46	0.91	6.59
1996	0.62	1.73	0.57	2.59	1.01	7.26
1997	0.64	1.69	0.62	2.38	1.18	6.19
1998	0.78	2.36	0.74	3.28	1.33	8.26
1999	0.90	3.07	0.87	4.02	1.67	8.96
2000	0.87	2.93	0.86	3.64	1.73	7.40
2001	1.19	3.17	1.15	4.15	2.16	9.37
2002	1.19	3.44	1.13	4.43	2.06	9.93
2003	1.26	3.12	1.20	3.88	2.22	8.29
2004	1.34	3.59	1.25	4.75	2.39	10.91
TOTAL	10.65	34.09	10.30	47.81	19.26	115.38

TABLE A.14 Transportation Distance Associated with Shipping Spent Fuel to a Single Storage Facility Using Truck Casks Only

Year	Southeastern Facility Distance (mile × 10^6)	Gulf Coast Facility Distance (mile × 10^6)	Western Facility Distance (mile × 10^6)
1986	0.28	0.50	1.44
1987	0.76	1.23	3.29
1988	0.75	1.24	3.03
1989	1.85	2.80	6.95
1990	2.03	2.80	6.21
1991	2.04	2.84	5.86
1992	3.38	4.52	9.65
1993	3.74	4.70	10.51
1994	4.20	4.90	10.79
1995	6.27	7.43	15.69
1996	7.32	8.00	16.85
1997	7.40	8.33	17.58
1998	9.40	10.39	21.11
1999	11.20	12.19	24.75
2000	10.93	11.71	23.54
2001	13.92	14.88	29.70
2002	14.22	14.87	28.96
2003	14.64	15.13	28.75
2004	15.91	16.59	33.28
TOTAL	130.24	145.05	297.94

multiple-facility runs. That is, a cask used to make shipments to the western storage facility would not be used to make any shipment to other facilities. If there is no further demand for this cask, it would stand idle. The large variation in transportation requirements for the various receiving facilities is a function of the particular set of reactors making shipments to that facility.

TABLE A.15 Transportation Distances and Costs of Shipping Spent Fuel to Regional Facilities Using Rail and Truck Casks

	Distance (mile × 10^6)		
Year	Rail	Truck	Cost ($ × 10^6)
1986	0.01	0.15	1.8
1987	0.01	0.54	5.3
1988	0.03	0.43	5.2
1989	0.03	1.05	11.1
1990	0.05	0.93	10.8
1991	0.07	0.84	10.9
1992	0.09	1.26	16.8
1993	0.13	1.26	19.2
1994	0.15	1.01	19.5
1995	0.22	1.53	28.3
1996	0.29	1.70	33.8
1997	0.32	1.65	35.0
1998	0.36	1.98	41.9
1999	0.46	2.43	51.4
2000	0.48	2.29	50.3
2001	0.61	2.45	62.4
2002	0.60	2.72	63.0
2003	0.65	2.49	63.9
2004	0.68	2.94	70.9
TOTAL	5.24	29.65	601.5

Note on Cost Sensitivity: The most critical parameter in the cost equations is the average rail speed. The value used in these calculations for rail transport was 6 mph.

TABLE A.16 Transportation Costs of Shipping Spent Fuel to a Single Storage Facility Using Both Rail and Truck Modes

Year	Southeastern Facility Cost ($ × 10^6)	Gulf Coast Facility Cost ($ × 10^6)	Western Facility Cost ($ × 10^6)
1986	2.2	3.2	7.2
1987	5.8	7.8	16.5
1988	5.4	7.6	15.0
1989	13.3	17.0	34.1
1990	14.1	16.9	30.8
1991	14.0	16.7	28.9
1992	23.6	27.3	47.9
1993	25.5	28.8	53.1
1994	28.4	29.8	54.6
1995	41.8	44.9	79.2
1996	48.4	49.7	87.8
1997	48.8	51.2	90.7
1998	61.3	63.8	109.5
1999	72.8	75.5	130.3
2000	69.7	72.4	125.6
2001	90.1	92.6	157.7
2002	91.1	92.9	156.0
2003	92.7	93.5	155.9
2004	101.7	102.9	177.4
TOTAL	850.7	894.5	1558.2

TABLE A.17 Transportation Costs of Shipping Spent Fuel to a Single Storage Facility Using Truck Casks Only

Year	Southeastern Facility Cost ($ × 10^6)	Gulf Coast Facility Cost ($ × 10^6)	Western Facility Cost ($ × 10^6)
1986	2.3	3.2	7.1
1987	5.7	7.6	16.1
1988	5.3	7.3	14.6
1989	13.1	17.0	34.0
1990	13.4	16.6	30.5
1991	13.0	16.3	28.7
1992	21.8	26.5	47.5
1993	24.2	28.1	51.9
1994	26.6	29.5	54.6
1995	39.4	44.1	77.9
1996	45.5	48.3	84.6
1997	46.0	49.8	87.7
1998	58.0	62.1	106.0
1999	68.9	72.9	124.4
2000	66.6	69.9	118.3
2001	85.0	88.9	149.6
2002	86.1	88.7	146.4
2003	87.8	89.8	145.6
2004	97.0	99.8	168.1
TOTAL	805.7	866.4	1493.6

TABLE A.18 Transportation Distances and Costs of Shipping Spent Fuel to Regional Facilities Using Truck Casks Only

Year	Distance (mile × 10^6)	Cost ($ × 10^6)
1986	0.19	1.9
1987	0.65	5.2
1988	0.75	5.3
1989	1.43	11.4
1990	1.43	10.9
1991	1.55	11.0
1992	2.21	17.0
1993	2.52	19.1
1994	2.51	19.7
1995	3.61	28.5
1996	4.40	33.6
1997	4.65	34.7
1998	5.41	41.7
1999	6.77	50.7
2000	6.68	49.3
2001	8.07	61.1
2002	8.16	61.2
2003	8.41	62.3
2004	9.26	69.7
TOTAL	78.66	594.3

A change of a few miles per hour would have a major impact on rail transportation time and, hence, the number of casks required. Changing the average truck speed by about 5 mph, however, would only have a small impact on the number of truck casks required. With the data used for those calculations, truck transport is somewhat less expensive than rail transport. If the average rail speed was increased by 1 mph, the relative economics of truck and rail shipments would be narrowly reversed. At 7 mph, rail transport would be less expensive, especially for shipments over 300 miles, and therefore cask leasing costs would decline.

Appendix B:

Supplementary Comments Chapter 5

Frederick R. Anderson
September 23, 1983

I am taking the opportunity to file these supplementary remarks because in adopting the final version of Chapter 5 on Institutional Issues the panel decided not to analyze critically the Nuclear Waste Policy Act of 1982 (NWPA). The final report instead proposes that the Department of Energy adopt administrative implementation strategies for NWPA that rely primarily on informal mediation procedures. Yet to my mind the NWPA itself deserves a brief appraisal because it merely cements into place the decision-making process for waste management that was set in motion by the Carter Administration. When the panel last met, in the fall of 1981, its draft report was critical of the then basic federal approach. The same problems remain today with the new law.

The pivotal phase of the NWPA process involves compiling the inventory or list of final candidate sites. Because of the millenia of risk to future generations and the environment that waste "isolation" unavoidably will create, the inventory process should include an exacting comparison, based on numerous technical and social criteria, of a score of sites nationwide. This comparative benefit-risk analysis should be able to withstand the most withering public technical review. Yet the NWPA creates an informal site inventory process with a built-in risk that technical considerations will yield to social and political ones. Further, it provides only minimal public participation in the site inventory process. A formal Nuclear Regulatory Commission (NRC) hearing and a licensing decision do follow the President's designation of a final site, but these address only the specific site itself. They cannot explore the potential comparative superiority of other sites discarded along the way. Thus the site inventory procedure may well not meet the cri teria that the panel originally set out for evaluating institutional arrangements: the insulation of programs from changes in political administrations, a high degree of public confidence, an uncompromised mission of protecting public safety, and effective public participation in decision making.

Does differing with the NWPA approach amount to quarreling with Congress over a policy difference that final enactment should have put to rest? I do not think so. If NWPA and its current implementation cannot satisfy the panel's institutional criteria, then our earlier deliberations deserve to be memorialized, because they may point the way both to better choices for implementing NWPA and to a sounder path for Congress to take if pressures mount in the coming years for a modification of the NWPA approach to site inventorying.

To my mind the criteria that must take precedence over all others in site selection are geologic and technical integrity. Few federal decisions must pass such a stark test of time; the repository must remain intact for thousands of years. How can the best site be selected? Congress has answered with a statute that heavily emphasizes agency expertise and discretion, with a nod to direct public participation and a bow to state interest—the federalism issue that so dominated the legislative history of the NWPA. The pre-NWPA process troubled the panel because it shielded the Department of Energy (DOE) and its predecessor agencies' site inventory from vigorous debate on the technical adequacy of agency studies. While enacted with improvements, the new Act still raises the same concerns, as does the manner in which the DOE has administered the Act in the immediate postenactment period. The pre- and post-Act experience leads me to conclude that the way to compile the best site inventory possible is to subject the inventory process to close public scrutiny in a more formal setting, which guarantees a meaningful opportunity to question federal data and conclusions.

The pre-NWPA process initiated by the Carter Administration produced (1) a decision to place the final site in a bedded salt formation and (2) selection of seven potential site locations for the repository. The way in which these decisions were accomplished pre-NWPA emphasized the model of informal decision making with primary reliance on agency expertise. In establishing criteria for selecting the seven sites, the DOE declined to adhere to the minimal public notice and comment requirements of the Administrative Procedure Act (APA), a statute that ordinarily must be satisfied before a federal agency can adopt binding guidelines on issues of public importance. Nor did it feel obliged to comply at all with the impact study, public comment, or alternative analysis requirements of the National Environmental Policy Act (NEPA).

Believing that the NWPA merely ratified the informal site inventory process of the Carter plan, the DOE has declined to reconsider both the choice of the seven initial sites and the criteria under which they were selected. The Act §§112 (a) and (b) requires the application of site-selection criteria that parallel the abandoned Carter approach but also impose material additional standards. Because the Act explicitly requires application of these criteria ("guidelines") for all site selections, one might conclude that the Act required the DOE to begin anew. (The Act simply fails to address the status of the Carter criteria and selections.) Instead, the current Departmental policy assumes that the new Act merely codifies selections made under the prior site inventory process, a policy that belies the claim that the Act adopts a new and comprehensive national plan for site selection.

The prospects for fuller public input in the next two steps, nomination of five sites and "characterization" (i.e., detailed physical study) of three final candidate sites, likewise seems limited, as the DOE seeks to follow what it believes to have been Congress' basic intent to trust to Departmental discretion to compile the best inventory possible in the shortest possible time. The guideline-writing requirements imposed by NWPA §112 for the nomination and characterization phases will also elude full APA and NEPA compliance under current policy. The Department apparently feels that the maximum procedural safeguards were spelled out in the Act by Congress, which did not intend for additional procedures to be imposed. NWPA does require public hearings and other salutary procedures, but they are minimal and must be read alongside other provisions that limit the scope of judicial review and of environmental assessment.

To the criterion of geologic suitability must be joined the criterion of conformance to widely shared institutional norms. In the United States it is not enough merely to reach the right decision; it must be reached by the right process as well. This quintessentially political issue preoccupied the panel throughout its existence, as well it should, since the panel was predominantly composed of social scientists and other students of the governmental process. The panel focused particularly on the issues of public participation in selecting a waste isolation strategy. The flavor of our deliberations still permeates the report. Yet the decision concurred in by my co-panelists to focus the concluding institutional chapter on nonadversarial means of enhancing public participation too strongly implies that NWPA has conclusively put to rest the basic institutional issues and that more formal adversarial procedures could not better accomplish the task.

I agree that every effort should be turned to making the new legislation work. But I also believe that the DOE has leeway within NWPA to strengthen the public role in the site inventory. Today, after the reformation of the administrative process that occurred in the 1970s, an acceptable decision-making procedure usually now means accommodation of interest groups as full participants, typically through more formal agency policy-making procedures. The Supreme Court has explicitly endorsed agency use of the latitude conferred by the APA to create additional procedures if they would foster sounder agency decisions [Vermont Yankee Nuclear Corp. v. Nuclear Regulatory Commission, 435 U.S. 519 (1978)]. Certainly, Congress still can strengthen public participation if support for the NWPA process weakens. Thus the reasons for the panel's earlier endorsement of a formal site-inventorying process deserve a few more words than the brief mention in our final report.

In its draft of final Chapter 5 (Institutional Issues), now discarded, the panel addressed how the American system of channeling interest groups should be applied to the divisive issue of nuclear energy development. The panel began with the premise that no problem that confronted the framers of the Constitution required more political insight than the problem of popular participation. In Federalist No. 10 James Madison argued that the conditions of liberty made inevitable the formation of "factions"—groups of citizens organized for the purpose of exerting pressure on the political system. Madison defended the constitutional plan for distributing authority to both federal and state governments on the ground that this separation of powers would permit freer play to the political activities of larger numbers of citizens.

The framers' concern extended to the actual structure of governmental bodies. The resulting system of checks and balances distributed power among the three branches of federal government as well as between the federal and state governments and provided different groups with different access to decision-making power on different kinds of issues. The elaboration of means of brokering the power of numerous "factions" became the greatest achievement of our political system in the ensuing 200 years. Sophisticated institutional mechanisms for interest group participation in modern federal agency decision-making processes are but the latest means to promote the Madisonian vision.

Madisonian goals seem to be well served by the NWPA so far as a federal-state conflict is concerned. The concern for state "consultation and concurrence" dominated the congressional debate on the Act. It produced, to name the salient features, a state veto, federal funding for intervention, the two-house override, final site selection by the President who can again take state interests into account, and federal construction impact mitigation payments.

The same, however, cannot be said for the way the Act handles the other factions in society that have organized on the issue of nuclear power but are not adequately represented by state governments. They are not ensured adequate formal participation in the site inventorying process. Formal participation at the subsequent NRC adjudicatory hearing, after the site has been selected, precludes public questioning of the relative merits of alternative sites in different parts of the nation. To most groups this is a key issue. I do not think Madison's insight will be well served in the 1980s by assuming that the states will represent affected interest groups adequately in the site-inventorying phase or that public groups will be content to help make the NWPA work through mediated informal participation.

The core of the problem is the NWPA itself. The Act vests the Department of Energy with considerable decision-making leeway regarding the geologic formations to be examined, the states and communities in which candidate sites are to be identified, the technical expertise on which the Department will draw, the weight to assign to the selection criteria (e.g., long-term geologic stability), the procedures to be followed in preliminary screening, the specificity of screening criteria, and a range of other managerial choices. Sometimes such flexibility is desirable, because it allows a fact-finding agency to proceed informally; to reschedule key steps in its decision process; to select quickly and freely among appropriate methodologies, experts, and data-collection techniques; and to turn to outside information sources as the agency requires them. Yet I believe that this broad discretion is incompatible with the social choices involved in selecting a site for a radioactive waste repository.

As the number of interested parties and the intensity to conflict mount in the federal system, Congress ordinarily specifies increasingly formal decision-making procedures, which, if they function properly, will increase the likelihood that fact-finding will be rigorously conducted, that relevant affected interests will become involved, and finally that better choices will be made. Compared with other major federal decision models available for repository site selection, the Act is deficient in such procedural safeguards.

The Act's procedures seem to be modeled on Congress' usual approach to federal agency decision making for the public lands. When the federal government manages land, it is in a sense operating a business, granting noncompetitive permissions, and dispensing federal largesse (e.g., grazing permits, timber contracts, military construction contracts). But in selecting a site for a radioactive waste repository, the federal government must umpire an intense dispute involving an array of interested partiesreflecting sensitive concerns about the state-federal balance, health and safety considerations, damage to environmental or aesthetic values, local social and economic dislocation (or benefits), and the moral and political implications of subjecting present and future populations to long-term risks.

In the past decade, through such generic legislation as the NEPA, the Federal Land Policy and Management Act (FLPMA), and the National Forest Management Act, Congress has attempted to check the wide discretion enjoyed by the federal resource management agencies. Some of these reforms are reflected to a limited extent in the NWPA, and others may indirectly influence how the Department conducts the inventory of repository sites. One cannot expect major change, however, because the NEPA impact statement process and the land-use planning process of FLPMA have not in general sufficed to ensure the development of adequate factual bases for potential adverse socioeconomic effects (these sections of impact statements on nuclear power plants are notoriously weak) nor, with licensing, to foster broad and effective public involvement. Evidence on this point is available in a recent study of the siting of the Seabrook Nuclear Power Plant (Stever 1980) and, more importantly, in the Council of Environmental Quality's 1976 retrospective analysis of impact statements in some 70 federal agencies.

During the 1970s, in response to congressional mandate, the federal regulatory agencies drastically expanded their use of what attorneys call informal rule making. In informal rule making a federal agency—usually a regulatory agency or independent regulatory commission—proposes a guideline, regulation, or standard (all "rules") in the Federal Register, thereby initiating a period of formal written public comment, at the end of which the rule, appropriately modified, is promulgated in final form. Ordinarily the commenters are limited, by their own resources and often the scope of the proceeding, in the extent to which they can probe the underlying assumptions and factual bases of the agency proposal. Yet even informal rule making would ensure more opportunity to probe the Department's site inventory decisions than is afforded under the NWPA.

A third major decision-making approach sometimes employed by Congress and the agencies provides a better alternative for the task of repository site selection. The formal rule-making process offers a clearer specification of the procedures, a written public record of decision, an opportunity for public examination of both the scientific data supporting the selection of candidate sites and the criteria guiding the assessment of socioeconomic effects at sites and along waste transportation corridors. Formal rule making is well suited to social problems characterized by conflict among interests, a need for maximum opportunity in probing the factual underpinning of decisions, and a requirement of visible agency accountability (i.e., an open decision openly reached). Somewhat eclipsed by informal notice-and-comment rule making in the early 1970s, the approach nevertheless has functioned reasonably well on the federal level for matters where Congress sought the advantages of greater formality (e.g., rate makings, initial licenses).

A majority of the panel members saw advantages to the adoption of such a formal approach. I sketch this approach more fully here, not to suggest that Congress should re-enter the thicket of nuclear waste disposal so soon but to show that a concrete and better alternative does exist and to remind the DOE that it has leeway under the statute to broaden direct public involvement in the inventorying process. The approach would entail the selection of an initial inventory of 6 to 10 technically qualified and finally certified sites, appropriately spread among the major regions of the country, through a formal hearing and decision process. (Lawyers may quibble about whether this process should be strictly formal or "hybrid" with informal elements and whether it should be labeled "adjudication" or "rule making." I prefer the latter because of the quasi-legislative policy decisions required.) Responsibility might be vested either in the NRC or in an entirely new ad hoc commission created by statute specifically to review the site inventory. The panel majority supporting this new approach had a slight preference for vesting this responsibility in the existing NRC, perhaps with a simplified and improved general mandate to conduct formal hearings. This would be consistent with NRC's overall mandate and would avoid the creation of a new institution. Some panel members, however, saw advantages to locating site-selection decisions outside of existing institutions, thereby affording greater protection against the intrusion of other issues into site selection.

The panel's majority proposal would have advanced NRC's involvement to the site inventory ("site banking") phase, with the objectives of converting perhaps the most controversial phase of implementing a national waste isolation program into a more searching inquiry, stimulating a wider and coordinated search for viable geologic formations and desirable social locations, and excusing the DOE from making the initial site-selection decision (it will still require an NRC license and Presidential approval).

The deciding body—NRC or a new commission—would provide a formal, written decision justifying its final list of six to ten regionally dispersed sites. The deliberations would require reopening the process of identifying candidate sites and for selecting sites from a complete candidate inventory. It would also involve detailed attention to the characteristics of the overall waste transport and isolation system as they impinge on the selection of particular sites. The goal of such a comprehensive approach would be to assure full comparability of sites and interregional equity.

Such a site-selection decision process would have the virtues of greater insulation from changing administrations in the selection and banking of certified sites, increased public confidence in the intrinsic fairness and due process of the proceeding, an absence of conflict of interest in the mission of protecting public safety in the selection of sites, a greater potential for sponsoring public participation, and a greater potential for producing enduring site-selection decisions.

The final report adopts a diffident on-the-one-hand, on-the-other-hand tone toward the adversarial process. Conciliatory and mediatory approaches are offered as an alternative. I rather suspect that the majority of the panel warmly approves of this approach and shares in the current society-wide lament that we are a contentious people and that we reflexively turn to the courts—flawed, expensive, and overloaded vessels though they be—to resolve our differences, no matter how large or small. Yet I want to make clear my preference for use of formal adversarial proceedings where strong held views divide public opinion, where factual issues permeate the issue to be resolved, where granting interest groups a legal right to direct participation would stimulate better agency documentation of its preferred course of action, and where legal institutions such as cross-examination may help to expose flawed technical studies or flush out political decisions masquerading as the product of the application of agency expertise.

Mediated informal dispute resolution offers bright prospects in some areas, e.g., local land-use conflicts and hazardous waste site cleanup under the federal Superfund. I am a warm advocate of mediation in such circumstances. Further, on a more general level, all who use our institutions for conflict resolution could promote comity by adopting a conciliatory attitude and a mutual willingness to reduce the field of conflict. But this is just common sense. [See, e.g., Roger Fisher and William Ury, Getting to Yes (Boston, Mass.: Houghton Mifflin, 1981)]. When the differences are sharp and the stakes high, more formal adversarial procedures must be employed. The site inventory deserves no less.

REFERENCE FOR APPENDIX B

Stever, D. M. 1980. Seabrook and the Nuclear Regulatory Commission: The Licensing of a Nuclear Power Plant. Hanover, N.H.: University Press of New England.