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# Nuclear Waste: The Problem Remains Unburied

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# NUCLEAR WASTE: THE PROBLEM REMAINS UNBURIED*

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## I. Introduction

Since the late 1950s, the Department of Energy (DOE) and its predecessor agencies have proposed to dispose of radioactive wastes by burying them underground.[1] After twenty years of research and development, however, DOE is unable to demonstrate that a geologic repository will protect the public from the hazards of radioactive nuclear waste. Two fundamental problems have plagued the effort. First, "federal officials . . . [have] failed to understand that they are dealing with problems that [are] not solely or even primarily technical in nature."[2] Second, the technologists have seriously underestimated the complexity and difficulty of the task of keeping wastes out of the biosphere.[3] Failure to confront adequately these issues has resulted in a history of delays, missteps, and radical changes of direction for the waste disposal program. This program's history is instructive because it illustrates how little the federal government has learned in its years of involvement with the waste disposal problem. The same issues confront DOE today as in the

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* This Article was adapted from a Position Statement and Cross-Statement file by the Natural Resources Defense Council, in the Waste Confidence Rulemaking Proceedings of the Nuclear Regulatory Commission. For a full discussion of the origin, nature and purposes of the proceeding, see Brown & Bergholz, *Nuclear Waste—The Case for Confidence in Disposal,* 32 S.C.L. REV. 851, 851-56 (1981).

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1. COMMITTEE ON WASTE DISPOSAL OF THE DIVISION OF EARTH SCIENCES, NATIONAL ACADEMY OF SCIENCES, THE DISPOSAL OF RADIOACTIVE WASTE ON LAND, (NAS-NRS Pub. 519, 1957).

2. R.G. HEWLETT, FEDERAL POLICY FOR THE DISPOSAL OF HIGHLY RADIOACTIVE WATES FROM COMMERCIAL NUCLEAR POWER PLANTS, AN HISTORICAL ANALYSIS, 3 (DOE, Mar. 9, 1978). Mr. Hewlett is the Chief Historian for the Department of Energy.

3. See note 6 *infra.*

1950s, and the same criticisms can be made of its present waste disposal program as have been made of its efforts during the last two decades.

After passage of the Atomic Energy Act of 1954, the Atomic Energy Commission (AEC)[4] and its advisers chose bedded-salt deposits as the most likely geological formation for the effective disposal of commercially produced, high-level wastes. In the early 1960s, the AEC altered its plans for federally regulated geologic waste disposal. It proposed instead to delegate responsibility for formulating a program for the indefinite storage of reprocessed, high-level liquid wastes in near-surface tanks initially to the nuclear industry and eventually to state governments. The plan called for repeated transfer of these wastes to new tanks as the old storage tanks wore out.[5]

Unfortunately, the perpetual, tank-storage plan was based upon inadequate study. For example, liquid wastes were placed in storage tanks at a facility near West Valley, New York, although methods had not been determined for removal of the wastes from the tanks when it came time to transfer them. Even today, no satisfactory removal method has been developed for the wastes in the tanks at West Valley, and additional special research is required.[6] The cost of solving the West Valley problem may be in excess of five hundred million dollars—more than fifteen times the original cost of the waste storage facility and more than one hundred times the amount of money set aside to deal with the wastes.[7]

In the late 1960s, after its disastrous experience with tank storage of liquid wastes, the government renewed its effort to

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4. In 1974, pursuant to § 104 of the Energy Reorganization Act (ERA), 42 U.S.C. § 814 (1974), the AEC was abolished and its functions split between the Energy Research and Development Administration (ERDA) and the NRC, *id.* §§ 5811, 5841. The ERDA was given responsibility for research and development programs related to nuclear activities. *Id.* § 5813 (1974). The NRC was given licensing responsibility for nuclear activities, including licensing of nuclear reactors, *id.* § 5841, and waste disposal facilities, *id.* § 5842. Pursuant to § 202 of the Department of Energy Organization Act, 42 U.S.C. § 7151 (1977), ERDA's nuclear waste management development and research functions were transferred to the Department of Energy.

5. DIVISION OF WASTE MANAGEMENT AND TRANSPORTATION, ATOMIC ENERGY COMMISSION, FEDERAL REPOSITORY PROGRESS REPORT 2 (June, 1972).

6. *See generally* U.S. GENERAL ACCOUNTING OFFICE, STATUS OF EFFORTS TO CLEAN UP THE SHUT-DOWN WESTERN N.Y. NUCLEAR SERVICE CENTER (EMD-8—69, June 6, 1980).

7. *Id.* at 16.

develop a geologic repository. An abandoned salt mine near Lyons, Kansas, was selected as the ideal location for a pilot facility.[8] Investigations following the initial testing of the mine disclosed, however, that water from adjacent mining operations might seep into the repository and dissolve the salt. Concern also developed over the potential intrusion of water into the mine from surrounding abandoned wells. Residents of Kansas increasingly became opposed to the project, and in early 1972 it was halted, in part because of this strong public sentiment. The Chief Historian of DOE, in his review of federal waste management policy through 1977, has said of this experience: "[T]he AEC learned a classic lesson in American politics: a federal agency disregards at its peril the potential power of state and local officials whose opinions reflect the consensus of their constituency on matters of health and safety."[9]

In May 1972, the AEC announced its plan to build a "retrievable surface storage facility," or "RSSF," to store wastes near the surface of the earth for an indeterminate period of time, while the prolonged search for an acceptable, safe geological site continued.[10] This stopgap approach to a waste disposal solution was judged to be unacceptable by many of the agencies and organizations concerned with the problem.[11] In 1975, the Energy Research and Development Administration (ERDA) withdrew its request for funding of the RSSF; however, the RSSF was retained purportedly as a back-up system in case other repository plans failed.[12]

In 1976, ERDA once again attempted to locate and construct a geologic repository. A potential site was found in northern Michigan. In June 1977, however, the federal government abandoned the effort after residents of the area voted overwhelmingly to prohibit the siting of a waste repository within

8. *See* McClain, *Status of AEC Project to Establish a Salt Mine Radioactive Waste Repository*, in 4TH INT'L SYMP. ON SALT, N. OHIO GEOLOGICAL SURVEY (1974).

9. R.G. HEWLETT, *supra* note 2, at 18.

10. *See* ATOMIC ENERGY COMMISSION, MANAGEMENT OF COMMERCIAL HIGH LEVEL AND TRANSURANIC CONTAMINATED WASTE (Envt'l Impact Statement, WASH-1539 (Sept., 1974).

11. T. ENGLISH, AN ANALYSIS OF THE BACK END OF THE NUCLEAR FUEL CYCLE WITH EMPHASIS ON HIGH-LEVEL MANAGEMENT (Jet Propulsion Laboratory Pub. No. 77-59, Aug. 12, 1977).

12. *Id.*

their state.[13]

The Chief Historian of DOE has made an observation that explains much of the AEC's repeated difficulty in deciding upon a system and siting for a waste disposal facility:

> [T]he [Atomic Energy] Commission did nothing to broaden staff capabilities beyond those of the scientists, engineers, and administrators who had been directing various aspects of the waste disposal program since 1947. No effort was made to study economic, political, and social factors that would well determine whether a specific waste disposal system could be installed at a given site. In this sense, the Commission learned little from fifteen years of frustration and disappointment in attempting to establish an acceptable waste disposal system.[14]

Since 1977, the debate within the scientific community concerning the ultimate feasibility of safe waste disposal has intensified greatly, and the federal agencies charged with responsibility for the development of a waste disposal system have issued a number of studies that highlight the continuing uncertainties.[15] In March 1979, a federal interagency review group prepared a comprehensive report for submission to the President. The report reviewed the nuclear waste disposal program and recommended changes. The *Report to the President by the Interagency Review Group on Nuclear Waste Management*[16] stated: "[T]he management of radioactive wastes for the past three decades can be characterized by inadequate integration of waste management R & D [research and development] efforts . . . caused in part by inadequate perceptions of the additional technological and scientific capabilities needed to develop an accept-

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13. *See* Abbots, *Radioactive Waste: A Technical Solution?*, 35 BULL. ATOM. Scientists 12, 12-18 (Oct. 1979).

14. R.G. HEWLETT, *supra* note 2, at 29.

15. *See, e.g.*, T. ENGLISH, AN ANALYSIS OF THE BACK END OF THE NUCLEAR FUEL CYCLE WITH EMPHASIS ON HIGH-LEVEL MANAGEMENT (Jet Propulsion Laboratory Pub. No. 77-59, viii, Aug. 12, 1977); J. BREDEHOEFT, A. ENGLAND, D. STEWART, N. TRASK, & I. WINOGRAD, GEOLOGIC DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE—EARTH-SCIENCE PERSPECTIVES, 3 (Geological Survey Circular 779, 1978); *Ad Hoc Panel of Earth Scientists, The State of Geological Knowledge Regarding Potential Transport of High-Level Radioactive Waste from Deep Continental Repositories*, 32 ENVIRONMENTAL PROTECTION AGENCY, (June, 1978) [hereinafter cited as *State of Geological Knowledge*].

16. INTERAGENCY REVIEW GROUP OR NUCLEAR WASTE MANAGEMENT, DEPARTMENT OF ENERGY, REPORT TO THE PRESIDENT (NTIS Report, TID-29442, Mar., 1979) [hereinafter cited as NTIS Report].

able disposal program."[17]

The federal government has renewed its search for a geological formation that can serve as a permanent waste repository. In addition to the unresolved technical problems, serious political and social resistance to the siting of a disposal facility continues to mount throughout the country. Against the backdrop of past mistakes, abandoned programs, and growing political opposition, there is substantial doubt concerning the federal government's ability to implement a safe method of the permanent disposal of radioactive wastes.

Confidence in DOE's program must be judged in light of its past efforts, for they are a measure of the agency's commitment to the task, as well as its organizational ability and its perception of the obstacles to implementation. The Department has made little real progress towards its goal of developing a safe, readily implemented waste disposal method. The issues facing the agency today are

> strikingly similar to those which the federal government ha[s] faced in managing nuclear wastes since 1955. The enduring nature of these wastes suggest[s] that solutions [will] not be found in short-term responses to technical problems or adjustments to political pressures. Rather, ultimate solutions seem likely to lie in a wise and penetrating analysis of the amalgam of economic, political, cultural and technical factors.[18]

As the former Chairman of the Council on Environmental Quality observed:

> [W]e have inherited a badly flawed federal program that provides a poor basis for getting to the right answer quickly and *no basis at all for public confidence.* The history of waste management in the U.S. provides ample warning of the risks of having policy formulation colored by past programs and nuclear promotional concerns. *It is a history of unbroken failure to produce an acceptable method of waste disposal.*[19]

This Article will focus primarily on DOE's failure to iden-

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17. *Id.*

18. R.G. HEWLETTE, *supra* note 2, at 1.

19. Address by G. Speth, Chairman of the Council on Environmental Quality, *Mandate for the Future: Nuclear Wastes and the Public Trust,* at 7, American Association for the Advancement of Science, Houston, Tex. (Jan. 5, 1979) (emphasis added).

tify and evaluate the social, political, and economic issues concerned in the implementation of a safe, reliable, and publicly acceptable waste disposal program. Initially, however, two other major deficiencies in the DOE effort to solve the waste disposal problem will be reviewed briefly.

The first of these deficiencies is DOE's failure to design a program that will meet the licensing requirements of the Nuclear Regulatory Commission (NRC). Unless Congress enacts legislation exempting waste disposal facilities from the provisions of the Atomic Energy Act, the NRC will be responsible for licensing waste repositories.[20] Licensing requires a determination by the NRC that the site chosen for the facility is suitable and that the facility can and will be constructed and operated at the site without endangering the health and safety of the public.[21] Such a determination must be based on evidence of the particular disposal activities to be licensed and their predicted environmental impacts as found on the record in the licensing proceedings.[22] Such a determination must also reflect findings by the Nuclear Regulatory Commission that the DOE waste disposal plan, including the site chosen for the location of the repository, meets NRC criteria for standards of performance. As presently constituted, the DOE plan does not fulfill even NRC's draft siting criteria and performance requirements.[23] DOE's approach to siting and performance[24] is dramatically different from that of the NRC and may result in a conflict which would bring the waste disposal program to a standstill.

Second, DOE continues to underestimate seriously the technological uncertainties and complexities inherent in the development of a disposal method that will isolate successfully radioactive wastes from the biosphere for thousands of years. In part, this underestimation is due to its failure to design and carry out a coordinated and comprehensive research effort. As the history of federal involvement in waste disposal illustrates, at no time

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20. Recently promulgated final regulations make clear that waste repository licensing will continue to be the responsibility of the NRC. See 46 Fed. Reg. 13,971 (1981).

21. 42 U.S.C. §§ 2011, 2133(d) (1954); 10 C.F.R. §§ 50.57(a)(6) (1975), 50.91 (1974).

22. *E.g.*, Pub. Serv. Co. (Seabrook Station, Units 1 and 2), 6 N.R.C. 33, 41 (1977).

23. For a full discussion of DOE's approach to siting and performance of waste repositories, see Brown & Bergholz, *Nuclear Waste—The Case for Confidence in Disposal*, 32 S.C.L. REV. 851, 879-87 (1981).

24. See note 26 and accompanying text *infra*.

has the problem been defined in an objective and rational way. Geologic media and waste forms have been chosen before adequate study of the characteristics required for successful performance of a repository has been completed. *In situ* testing to determine how various host media will respond to repository construction and operation has not been carried out. Basic technologies, such as those required for successful borehole and shaft sealing, have not been developed. Even the various parts of the effort are disconnected and diffuse. The agencies that share responsibility for the program lack direction and focus.[25] The result is an effort that is unlikely to succeed in developing and implementing a safe, reliable and publicly acceptable waste disposal program, at least for the foreseeable future.

## II. The DOE Has Not Developed a Waste Disposal Plan That Meets Even Draft NRC Siting Criteria and Performance Requirements

### *A. Siting Criteria*

A major barrier to the release of radioactivity from a geologic waste repository is the geologic environment itself. The selection of a site for the location of a repository is, therefore, a critical decision to be made in the early stages of repository development. The effectiveness of all engineered barriers to radiation release will rely, at least in part, on the geologic environment chosen. For this reason, the NRC has begun to develop siting criteria which prohibit the location of repositories in areas with geologic features that could threaten their safe operation. These features include active faults, geothermal anomalies, acquifiers of potable water that could be disrupted or contacted by the repository, known or potential mineral resources attractive to humans, and fractures that provide pathways for fluid movement. As stated in the NRC draft technical criteria:

> Unfavorable site characteristics are identified to eliminate from consideration sites which would not be acceptable under any circumstances for a HLW geologic repository or which would present insuperable difficulties in terms of understanding the

25. These assertions are the opinions of Drs. Thomas Cochran, Terry A. Lash, Arthur Tamplin, and Ms. Georgia Yuan, technical experts at the Natural Resources Defense Council.

geology and hydrology of the site or would introduce or compound uncertainties which would affect negatively confidence in any licensing decision.[26]

The DOE's site selection process is in conflict with the NRC approach. The DOE has not incorporated an identification of unfavorable geologic characteristics into its site selection process. It has developed instead a set of siting criteria that are so general and vague that virtually any area could be found satisfactory for further investigation. Rather than specify features that would make a site unacceptable, the DOE calls for an assessment of the risk created by the existence of these features at the site. No site will be rejected unless the risk to the repository is judged to be "unacceptable." How an "unacceptable risk" will be defined and what degree of engineering and expense will be tolerated in reducing the risk inherent in a site have not been determined by the DOE. The public as a whole has a great stake in these two judgments and thus far has had virtually no input into the decisionmaking process.

With respect to the NRC, however, the DOE's approach to siting is likely to result in an unacceptable and, therefore, unlicensable site. Unless the two agencies coordinate their development of siting principles, the DOE is doomed to failure at the initial stage of repository implementation.

### *B. Performance Criteria*

The NRC has promulgated provisional, technical performance requirements for waste repositories, including:

> Assured retrievability of the waste for 50 years after emplacement;
> Containment by the waste package of all radionuclides for the first 1,000 years;
> For the period beyond 1,000 years, a limit on releases of one part in 1,000 of the activity present in the waste per year;
> Radionuclide travel times to the accessible environment must be at least 1,000 years;
> The block of host rock must extend beyond the repository for 2

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26. NUCLEAR REGULATORY COMMISSION, DRAFT TECHNICAL CRITERIA FOR REGULATING GEOLOGIC DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE 5 (Enclosure "A" from Consent Calendar item for the Commissioners from Robert B. Minogue, April 4, 1980), 45 Fed. Reg. 31,393 (1980), [hereinafter cited as DRAFT TECHNICAL CRITERIA].

km horizontally and 1 km vertically;
Areas potentially attractive to human intrusion must be avoided;
The various seals must provide barriers that are as effective as the undisturbed rock.[27]

The DOE program plan does not satisfy these NRC requirements. It is geared instead to vague and flexible "objectives." For example, the NRC's draft performance standards require the waste package to provide containment of all radionuclides for the first one thousand years after decommissioning of the geologic repository.[28] The DOE objectives, on the other hand, call only for containment to be "virtually complete during the period when radiation and thermal output are dominated by fission product decay," and further state that this containment will be done only "to the extent reasonably achievable."[29] The DOE also suggests that exposures of ten or more millirem per year would be permissible: "Radiological consequences should be maintained within the level of variations in natural background radiation associated with geographic location and domestic activities."[30] Finally, DOE imposes an economic standard to govern the operation of a repository: "[T]he environmental impacts associated with waste disposal systems should be mitigated to the extent reasonably achievable. *To the extent reasonably achievable* means that which is shown to be reasonable considering the costs and benefits associated with potential mitigative measures . . . ."[31]

With respect to the problem of human intrusion into a repository, the NRC draft technical criteria require the establishment of siting principles that will minimize the potential for such an occurrence. Since the most likely activities resulting in repository intrusion will concern exploration for natural resources and investigations of geophysical anomalies, the NRC criteria prohibit the location of a repository in an area with at-

27. *Id.*
28. *Id.*
29. DEPARTMENT OF ENERGY, STATEMENT OF POSITION, IN RE PROPOSED RULEMAKING ON THE STORAGE AND DISPOSAL OF NUCLEAR WASTE, II-6, NE-0007 (Apr. 15, 1980) [hereinafter cited as DOE STATEMENT OF POSITION].
30. *Id.*
31. *Id.* at II-16.

tractive natural features.[32]

The DOE has ignored the NRC's recommendations for siting criteria that would avoid the use of sites with valuable natural resources. The DOE continues to consider salt to be an acceptable repository host,[33] despite the fact that bedded salt and salt domes are far more attractive resources than granite, shale, or basalt. A special ad hoc panel of earth scientists commented on this consideration in its report to the Environmental Protection Agency, calling the resource value of salt "an important negative socio-economic factor" in the use of certain potential repository sites.[34] The report also stated that

> [t]he most likely targets for near-term exploitation . . . are salt domes because of the potential productivity of petroleum, halite, and sulfur; and bedded salt deposits because of their potash, halite, and gypsum. The United States has only 4% of the world's total proven potash reserves, and most of these are concentrated in the New Mexico area now being evaluated as an HLW repository. Future conflicts between the demand for HLW repositories in bedded salt and the needs of agriculture for potash seem inevitable, and may even now constitute an important negative socio-economic factor in the development of some repositories.[35]

The Waste Isolation Pilot Plant (WIPP) site in New Mexico is another example of DOE's disregard for formulating siting principles that would reduce the repository hazards for future generations. The site includes known accumulations of potash, natural gas, and oil, all of which are valuable now and are likely to become increasingly important in the future.

Two conclusions follow from the previous discussion. The first is that the two federal agencies with the greatest responsibility for waste disposal do not share a view of how to achieve a safe, reliable waste disposal program. This lack of coordination is likely to create severe conflicts at the federal level and further diminish the confidence of states and the public in the federal government's ability to provide a timely solution. The second

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32. DRAFT TECHNICAL CRITERIA, *supra* note 26, at 5.

33. *See* DEPARTMENT OF ENERGY, MANAGEMENT OF COMMERCIALLY GENERATED RADIOACTIVE WASTE (Final EIS, DOE/EIS-0046F, Oct., 1980).

34. STATE OF GEOLOGICAL KNOWLEDGE, *supra* note 15, at 40.

35. *Id.*

conclusion is that DOE is still proceeding in a haphazard and piecemeal fashion. The NRC's draft performance requirements are good benchmarks for the basic tasks to be accomplished in solving the waste disposal problem. That DOE has not met any of the requirements is a clear indication that its plan lacks definition and focus.

## III. The DOE Has Not Defined and Carried Out Basic Research and Development Tasks Necessary to the Implementation of a Safe, Reliable Waste Disposal Program

The DOE's waste disposal plan has not been designed to produce a comprehensive research effort. The program lacks coordination and specificity. Basic research tasks have not been defined and carried out in a systematic manner. Consequently, virtually every aspect of waste disposal research is plagued with technological problems.

The DOE has not yet identified a waste form that will remain inert during the thousands of years that nuclear wastes will remain hazardous to health. It has not identified which, if any, host rock is acceptable. Although the program historically has been directed almost exclusively to the use of salt as a repository host medium, the geochemical and mechanical response of salt to heat and water create severe problems for its use as a repository.[36] Unfortunately, however, the research and development program formulated for salt structures is unsuited for the investigation of other host rock structures, and no *in situ* testing has been conducted on any of the other candidate host rocks. *In situ* testing and the development of demonstration models essential for assessing the merits of geologic disposal lag behind other, less important research efforts. Site work has been restricted primarily to federal reservations in order to avoid public conflict.

Overall, the DOE has underestimated the technical difficulties inherent in the waste disposal problem. As a result, it has not completed even basic tasks in the design and implementa-

36. *See* U.S. Interagency Review Group on Nuclear Waste Management, Subgroup Report on Alternative Technology Strategies for the Isolation of Nuclear Waste, App. A, at 61 (TID-28818 (Draft), Oct., 1978) [hereinafter cited as Interagency Review Group].

tion of its program.

### *A. The DOE Has Not Identified a Suitable Waste Form*

The form chosen for ultimate disposal of radioactive wastes will provide the most important barrier to the release of radioactivity from a repository. Only a waste form that remains inert and stable for thousands of years under a variety of conditions will prevent escape of radionuclides to the biosphere. Although the selection of such a waste form has been the goal of past DOE efforts, none has been found.

The choice of a waste form must reflect an understanding of its potential interaction with the geologic repository. The waste form should be selected for its stability in specific environments. Unfortunately, glass continues to be DOE's "reference waste form," despite test results which cast doubt on its chemical stability.[37]

Although DOE states that it intends to compare glass with other waste forms before it decides which form to use, there is very little data with which to make the comparison.[38] In its haste to choose a form, DOE appears to be opting for the technology that is most easily implemented today, regardless of whether it represents an acceptable choice for future waste containment.

### *B. The DOE Has Not Identified An Acceptable Host Rock*

The DOE program historically has been directed almost exclusively towards the use of salt as a repository host medium. This early consideration of salt as a repository host was largely based on its high thermal conductivity, availability in areas of low seismicity, tendency to "self-heal" fractures, and dryness. Although these properties do make salt attractive for waste disposal, research has now uncovered significant problems with its

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37. F. Conath, *Relation of Solids to Nuclear Waste Isolation*, in PROCEEDINGS OF THE CONFERENCE ON SOLID WASTE FORMS 27 (Denver, Colo., Dec. 19-21, 1978); (Nuclear Regulatory Commission NUREG/CP-0005). *See also* McCarth, *Interactions Between Nuclear Waste and Surrounding Rock*, 273 NATURE ____, 216-17 (1978).

38. A recent National Academy of Sciences panel stated that "for wastes of high specific activity and thermal power density, research and development of waste forms other than glass should receive greater emphasis." NATIONAL ACADEMY OF SCIENCES, SOLIDIFICATION OF HIGH-LEVEL RADIOACTIVE WASTES 63 (pre-publication copy) (Sept. 1978).

geochemical and mechanical response to heat and to water.[39] These problems are sufficiently severe to eliminate salt as a potential candidate medium.

Furthermore, salt is, and will continue to be, a valuable resource. It is often associated with other valuable resources such as oil, gas, and potash. Salt mining and exploration for other resources in and near salt deposits has occurred in the past and will continue to occur in the future. Thus, salt can be eliminated from consideration as a host medium in accordance with NRC criteria designed to avoid the siting of repositories in areas where human activities could adversely affect the stability of the site, increase the migration of radionuclides from the repository, or provide pathways to the environment.

Salt is plastic and highly corrosive. Consequently, it also appears to be unacceptable as a host medium because it does not meet the technical criterion of assuring retrievability of wastes.

Finally, salt appears to be unacceptable on the basis of overall performance of the engineered system. Because of the human intrusion problem, the corrosive nature of brine and its migration, the ability of salt to provide for total containment for 1000 years and an annual release rate of one part in 1,000,000 of the total activity thereafter is highly doubtful. Although salt has been shown to be an unsuitable medium, an acceptable medium has not been identified. Further, the research and development program developed for salt is now found to be unsuited for the investigation of other host rocks.

The DOE is beginning to study basalt, granite, shale, and tuff as possible host media for a repository. In no case, however, has DOE identified a host unit of adequate volume and appropriate depth that also meets NRC draft technical criteria.

*1. Basalt.*—The Basalt Waste Isolation Project (BWIP) is evaluating DOE's Hanford site in southeastern Washington State to determine whether it contains a suitable location for a repository in basalt. It appears that the Hanford site was selected for basalt investigation in large part because it is a DOE site, and the agency, therefore, could avoid the political and institutional problems associated with siting a facility off the reservation. The site was not chosen on the basis of its favorable

39. INTERAGENCY REVIEW GROUP, *supra* note 36, at 60-67.

geological characteristics. The basalt at Hanford very likely will be excluded as a potential host rock for radioactive waste repository because of the proximity of acquifiers and the potential for radionuclide transport to the biosphere.[40]

*2. Granite and Shale.*—The Nevada Nuclear Waste Storage Investigations are evaluating the suitability of DOE's Nevada Test Site (NTS) for waste isolation.[41] As with Hanford, the NTS site was selected because it was a DOE site and its use would avoid the political and institutional problems associated with siting a facility on state or private lands. The site certainly was not chosen on the basis of its preferred geology. The geology of NTS is complex, a characteristic shared by all of the Basin and Range Province in which the NTS is located. The siting requirements of the NRC's draft criteria call for the selection of "relatively geologically simple sites" in order to compensate for geologic and hydrologic uncertainties.[42] If this criterion is to have any meaning, the NTS is excluded as a location for a repository.

*3. Other Media and Sites.*—There is little in the DOE program to justify the belief that radioactive waste can be disposed of safely in any other geologic media. While DOE's site exploration program is being expanded to a wider variety of rock types in diverse geologic environments, the program is in its infancy.

### *C. DOE Has Not Conducted Sufficient* In Situ *Testing*

The interaction of the waste form and the host rock is a key factor in the safety of geologic disposal. For this reason, the NRC's draft technical performance criteria require *in situ* testing to evaluate the interactions of waste form with the host rock.[43] The DOE has not conducted these tests on any of the potential rock structures, although recent studies show that vitrified high-level radioactive wastes are not as stable in the geologic repository environment as previously believed.[44]

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40. Opinion of Drs. Thomas Cochran, Terry A. Lash, Arthur Tamplin, and Ms. Georgia Yuan, technical experts at the Natural Resources Defense Council.

41. DOE Statement of Position, *supra* note 29, at II-118. Of the rock types that occur at NTS, argillite, granite, alluvium, and tuff have been considered for suitability as host rocks.

42. Draft Technical Criteria, *supra* note 26, at 5.

43. 45 Fed. Reg. 31,401 (1980).

44. *See* F. Conath, *supra* note 37.

### *D. DOE Has Not Developed the Technology for Successful Borehole and Shaft Sealing*

If not properly sealed, the boreholes and shafts used to define the structure of the rock at a repository site and in construction of a facility may provide conduits for the release of radioactivity during all phases of repository operation. Recognizing this, the NRC requires "[t]he sealed shafts and boreholes to provide a barrier to radionuclide migration which is at least equivalent to the barrier provided the undisturbed rock."[45]

Past applications of sealing technology to oil and gas wells and exploration boreholes largely have been concerned with safety on the surface and not with ensuring that the entire length of the shaft or borehole remains dry and competent for thousands of years. Although this experience may provide a starting point for the development of sealing materials appropriate for repository application, the materials have not been systematically tested over long periods.[46] Additionally, sealing materials never have been tested systematically for their response to the varying temperatures and pressure conditions that can be expected in a repository.[47]

Predicting the long-term integrity of sealing materials will require gathering data on the chemical interactions between the seal and the shaft linings and the surrounding rock mass. These interactions must be studied under a variety of conditions with respect to contact with water, *in situ* as well as in the laboratory. Emplacement techniques for seals must be developed with particular attention to sealing zones with fractured or disturbed rocks.

Although these matters are being addressed to some degree by DOE, its research largely is limited to borehole and shaft sealing in salt, and to a lesser extent, in basalt.[48] Research on

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45. 45 Fed. Reg. 31,393 (1980).

46. CALIFORNIA ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION, STATUS OF NUCLEAR FUEL REPROCESSING, SPENT FUEL STORAGE AND HIGH-LEVEL WASTE DISPOSAL 166 (Draft Report Jan. 11, 1978).

47. *Id.*

48. OFFICE OF NUCLEAR WASTE ISOLATION, THE STATUS OF BOREHOLE PLUGGING AND SHAFT SEALING FOR GEOLOGIC ISOLATION OF RADIOACTIVE WASTE, (Report No. ONWI-15, Battelle Memorial Institute, Columbus, Ohio, Jan., 1979); OFFICE OF NUCLEAR WASTE MANAGEMENT AND U.S. GEOLOGICAL SURVEY, EARTH SCIENCES TECHNICAL PLAN FOR DISPOSAL OF RADIOACTIVE WASTE IN A MINED REPOSITORY, (DOE/TIC-11033 Draft, Apr., 1980).

borehole sealing of granite and shale lags so far behind that a study of research needs for these two rock types concluded: "[T]he art of borehole, shaft and tunnel sealing for long-term confinement of nuclear waste is still in its infancy and . . . a comprehensive testing program will be required before the effectiveness of such seals can be known."[49] Furthermore, DOE has yet to consider the problem of locating all the boreholes in the vicinity of repository sites. Boreholes used for exploration and geophysical studies prior to repository construction may be present at a site in large numbers.

### *E. The DOE Program Does Not Adequately Identify and Resolve the Problems Inherent in Short- and Long-Term Repository Monitoring*

Two aspects of repository monitoring that must be considered in assessing the DOE program of waste disposal are: (1) health physics monitoring for occupational and population exposure during the operational phase, and (2) monitoring for data collection to determine whether the repository is capable of meeting predetermined performance criteria.

Experience with the day-to-day health physics monitoring of radioactive waste management facilities operated by DOE offers little confidence that this aspect of radioactive waste disposal will be conducted adequately for the long term. Monitoring programs often have failed to collect the data necessary to predict accurately the presence or extent of a problem. They have not included periodic review of procedures. Nor have they provided plans for follow-up actions once a problem has been detected.[50]

An example of these deficiencies is the program designed to monitor the high-level radioactive waste storage tanks at the Hanford Reservation.[51] The Hanford program, which collects data on ninety tanks containing radioactive waste, categorizes

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49. LAWRENCE BERKELEY LABORATORY, GEOTECHNICAL ASSESSMENT AND INSTRUMENTATION NEEDS FOR NUCLEAR WASTE ISOLATION IN CRYSTALLINE AND AGRILLACEOUS ROCKS 133 (Symposium Proceedings, Lawrence Berkeley Laboratory, Berkeley, Calif., July 16-20, 1978).

50. See note 25 *supra*.

51. Report on Alleged Coverups of Leads of Radioactive Materials at Hanford, DOE Office of Inspector General (Jan. 22, 1980).

the tanks according to whether leakage is occurring. A recent report by the Inspector General of DOE concluded that the type of measurements being made was not useful for determining the extent of tank leaks.[52] Furthermore, there was no provision in the program for periodic review of the monitoring procedures. If reports of tank leakage had not been made by an employee of the contractor, it is questionable whether a review would have ever taken place.

The experience with monitoring thus far indicates that, even for the short term, there is little basis for believing that such systems will function as designed. The DOE has not demonstrated that it can monitor adequately existing waste storage facilities, to say nothing of a long-term repository holding several times the waste it presently oversees. Neither the nature of the monitoring needed for a waste disposal method nor the period of time for which monitoring will be required has been determined.

### *F. The DOE Program Places Undue Reliance on Risk Assessment to Determine Repository Performance*

The DOE waste disposal program relies heavily on risk assessment modeling to evaluate the performance of proposed geological repositories. Changes in the geological environment and the uncertainties associated with the infancy of repository technology, however, make predictions about long-term performance unreliable.

Furthermore, design and utilization of risk assessment models depend, at a minimum, upon the following: (1) an understanding of the processes that will influence the migration of nuclides in the event of failure of the repository; (2) empirical and experimental data characterizing the environment, the waste, and the interaction of the two; (3) estimates of the probability of occurrence of natural geologic events and engineering failure; and (4) characterization of potential future scenarios.[53]

The deficiencies in available data and current knowledge about all of the factors concerned with nuclear waste storage prevent the preparation of a model that can represent accurately

52. *Id.*
53. See note 25 *supra.*

the risks of long-term storage. Even the best models cannot make up for an incomplete understanding of the system being modeled. For this reason, the NRC has limited specifically the extent to which modeling results can be relied upon.[54]

Although the technical problems that DOE faces are substantial, they pale in comparison to the social and political obstacles facing its waste disposal program. The DOE ignores whole sets of important social, economic, and political factors, and it does not include any clearly defined organizational plan for implementation of a waste disposal system.

## IV. The DOE Has Not Identified or Addressed the Social, Political, and Economic Issues Involved in Implementation of a Publicly Acceptable Waste Disposal Program

The management and disposal of radioactive waste is not simply a technical problem. Technologies are not self-implementing. The success of any waste management program depends as much upon its social, organizational, and institutional features as on its designs and engineering. An NRC task force concluded in 1978 that the "past failures of proposed radioactive waste management systems have stemmed in large part from neglect of nontechnological necessities in [the] implementation . . . of systems."[55] In 1979, the Interagency Review Group on Nuclear Waste Management reported to the President that "the resolution of institutional issues . . . is equally as important as the resolution of outstanding technical issues and problems" and that such resolution "may well be more difficult than finding solutions to remaining technical problems."[56]

Despite these warnings, neither the NRC nor the DOE has come to grips with the significance of these issues. The DOE has only just recognized that these issues exist. It recently requested the National Research Council to "attempt to identify social and economic issues to be considered in selection of repository sites" in order to "recommend ways in which to take various social and

54. Draft Technical Criteria, *supra* note 26, at 5.

55. Nuclear Regulatory Commission, Essays on Issues Relevant to the Regulation of Radioactive Waste Management 57 NUREG-0412 (W. Bishop, N. Hilberry, I. Hoos, D. Metlay, and R. Watson (eds.) 1978).

56. NTIS Report, *supra* note 16, at 87.

economic impacts into account in site selection . . . ."[57]

As a result, DOE has failed to confront and resolve the social, political, and institutional problems inherent in implementation of a waste disposal program. The Institute of Governmental Studies at the University of California at Berkeley cautions that failure to consider social and political issues as an integral part of the planning process for waste disposal is to "run the risk of serious political opposition," which may doom an otherwise acceptable program.[58]

To be successful, the DOE program must meet dual objectives. It must be a program that the public sees as legitimate and in which it has confidence, as well as one that provides reliable and safe waste disposal operations. If the first objective cannot be met, the nation may be unwilling to commit the necessary political, technical, and economic resources to carry out the chosen method, and thus the method will fail.

Achievement of the first objective requires the identification and assessment of the relevant social and institutional obstacles to implementation of the major phases of the waste disposal program: the initial phase of siting, construction, and licensing of the first waste repository; the second phase of program expansion to cope with the increased volume of wastes produced by the current and near future generation of light water reactors; and the third, long-term management phase in which the technological and institutional arrangements previously created will be tested over long periods of time. In each of these phases, new issues will present themselves for resolution, and social, political, and organizational arrangements appropriate to an earlier phase may require modification.

### *A. Phase One—Start Up*

The phase of greatest concern at present is the initial start-up of the waste disposal program. The DOE is compelled by the decision in *Minnesota v. Nuclear Regulatory Commission*[59] to

57. NATIONAL ACADEMY OF SCIENCES, 30 NEWS REPORT.

58. Rochlin, Demchak, Hershberger, Hoberg, Jr., LaPorte & Windham, SOCIAL AND INSTITUTIONAL ASPECTS OF RADIOACTIVE WASTE MANAGEMENT: SOME PRELIMINARY FINDINGS, S.3 (195/RW001, Oct., 1979) [hereinafter cited as SOCIAL AND INSTITUTIONAL ASPECTS].

59. 602 F.2d 412 (D.C. Cir. 1979).

develop a waste disposal program that can be implemented successfully before the expiration of the licenses of currently operating nuclear plants. Failure to do so threatens the continued viability of the domestic nuclear program, the substantial investment made by utilities and the industry, and, to a significant extent, public confidence in the ability of government to act decisively on a major social issue. The historical development of nuclear power in the United States has linked inextricably the federal government to the nuclear industry. Thus, the implementation of a waste disposal system is seen both by the public and the industry as a governmental responsibility.

The initial phase presents the greatest number of social and political uncertainties. Many of these have been identified and discussed in the *1977 Report on the Task Force for Review of Nuclear Waste Management* (referred to as the *Deutch Report*)[60] and in the work of G.I. Rochlin and R. Kasperson, among others.[61] Key social and political obstacles are discussed below.

*1. Public Opposition and Lack of Trust.*—Foremost among the obstacles to implementation of the DOE program is the serious level of public opposition to nuclear power in general and waste disposal locations in particular.[62] This opposition is coupled with an increasing lack of trust in the ability of institutions and persons charged with protecting the public from the hazards of radiation to carry out adequately that responsibility.

The unwillingness of the public to accept a waste management program manifests itself in the efforts by towns, counties, and states to restrict federal authority to transport and store wastes within their political boundaries. By October 1980, seven states had enacted laws banning nuclear waste importation for terminal disposal and twenty-five others had passed laws restricting nuclear waste disposal. Thirty-one states have limited or banned the transport of nuclear wastes within their boundaries. Indeed, by August 1980, only eight states had no laws relat-

60. Office of Energy Research, (DOE/ER-004/D, UC-70, Feb., 1978).

61. *See, e.g.*, Testimony of Roger Kasperson, Institutional and Social Uncertainties in Radioactive Waste Management, presented to the Ohio Power Siting Commission (June 27, 1978).

62. Comptroller General of the United States, Report of the General Accounting Office, Nuclear Energy's Dilemma: Disposing of Hazardous Radioactive Waste Safely (Sept. 1977).

ing to the control of radioactive waste.[63]

Former President Carter, in his statement of February 12, 1980, outlined a "consultation and concurrence" process as a means of resolving differences between the states and the federal government over the siting of waste disposal facilities.[64] Implicit in this policy is the idea that the sharing of information will lead to agreement on siting questions. However, there is doubt that simple information sharing will eliminate or even reduce the increasing reluctance of the states to be chosen as waste dumping grounds. The states are not willing allies of the DOE and other federal waste management agencies. They are unlikely to side voluntarily with the federal government on waste disposal issues.

The consultation and concurrence concept was included in the nuclear waste legislation which passed the Senate on July 30, 1980.[65] The bill provided for federal consultation with state governments concerning decisions to site waste repositories and spent fuel storage facilities. States were also given an opportunity to oppose a DOE decision to site a facility within their boundaries. The bill, however, set up three different procedures for federal override of state objections. If a state rejected the siting of a spent fuel storage facility, the bill provided for an override by a presidential directive that the facility was in the national interest. If a state objected to the location of a waste repository, the project would proceed unless the state was able to convince one house of Congress that its objections were justified. Finally, state objections to the disposal of military waste could be overridden by a declaration from the President that disposal was necessary for national security.

The states are likely to regard such consultation as inadequate participation in waste disposal decisions. Their continued opposition to siting threatens to frustrate the federal ability to implement a program, regardless of which disposal method is

63. NUCLEAR REGULATORY COMMISSION, OFFICE OF STATE PROGRAMS, INFORMATION REPORT ON STATE LEGISLATION (1978-79); BROOKHAVEN NATIONAL LABORATORY DIVISION OF REGIONAL STUDIES, SUMMARY OF NUCLEAR WASTE LEGISLATION (Unpublished draft document) (Nov., 1980).

64. President's Message to Congress, Comprehensive Radioactive Waste Management Program, *reprinted in* [1980] U.S. CODE CONG. & AD. NEWS 541, 541-45.

65. S.2189, 96th Cong., 2d Sess. (1980). The House passed similar legislation, H.R. 8378, but differences between the Senate and House versions were not resolved before Congress adjourned.

chosen; yet this matter has not been addressed by DOE.

*2. Questions of Equity.*—Closely tied to the problems of public acceptance are questions of equity. Because the benefits and risks of nuclear power are not shared equally around the nation, some members of the public will be asked to bear the risk of waste disposal for others. The degree of opposition at the local level indicates how the public feels about this burden.

The success of the waste disposal program will depend upon the development of siting principles that reflect both a systematic analysis of various social, political, and economic environments, and a determination of fairness and justice in allocation of the risk.[66] No such systematic analysis has been conducted by DOE. Considerations of fairness and justice must be applied both spacially and temporally. The latter relates primarily to the intergenerational transfer of the risks associated with waste disposal, the former to the "not in my backyard" syndrome. A comprehensive approach to considerations of justice must also address the issue of compensation of persons who live near a waste repository.

The DOE has failed to consider any of these issues in a direct or comprehensive way. Its views must be inferred from its

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66. SOCIAL AND INSTITUTIONAL ASPECTS, *supra* note 58. The editors include in their study a table, which lists the kinds of information that should be collected about the social, economic, and political characteristics of representative or potential repository sites. Some examples include:

- sociological data:
  - urban/rural mix;
  - professional/non-professional mix;
  - racial and ethnographic data;
  - age, sex and family data.
- political profile:
  - attitude towards nuclear power generally;
  - sensitivity to local, extended and global environmental issues;
  - attitudes towards remote, centralized authority (state and/or federal);
  - historical local independence and self-sufficiency.
- social profile:
  - activities;
  - mobility;
  - degree of social stratification;
  - lifestyle preferences;
  - median education level;
  - typical wages/salaries;
  - seasonal and migratory labor patterns, if any.

*Id.* Table 3.B.3, at 3.32. Data of this sort have not been collected by DOE.

adopting, as one of its program's objectives, President Carter's requirement that "[t]he responsibility for resolving military and civilian waste management problems shall not be deferred to future generations,"[67] and its meager discussion of "Social Concerns" in the *Statement of Position* submitted in the NRC's "Waste Confidence" Proceedings. This discussion alleges that "there is growing public recognition that nuclear waste management is a national problem and that solutions to the problem should not be postponed for future generations."[68]

*3. Conflicts in Regulatory Policy.*—The history of the waste disposal program in the United States is a story of fits and starts and major changes of direction and focus. The DOE and its predecessors have seized upon a single waste disposal solution, only to be forced to begin almost anew when the solution proved not to be feasible. It is likely that developments nationally, particularly in Congress, will result in further redirections of the program.

Although DOE has chosen geologic waste disposal, Congress has not made a similar commitment to this option. The Senate bill which passed on July 30, 1980,[69] provided for long-term away from reactor (AFR) storage and retrievable surface storage of high-level wastes. The bill also provided for the rapid development of unlicensed "demonstration" waste repositories on federally owned sites. All of these provisions would divert resources and efforts away from the development and implementation of a safe geologic disposal system.

Because the House was unable to pass its waste disposal legislation[70] before adjourning, differences between the House and Senate bills were never resolved. The House bill did not provide for retrievable surface storage of wastes or for an AFR program. It did require waste repositories to be licensed and subject to full review in accordance with the National Environmental Policy Act.

Other congressional efforts threaten to undercut the DOE program. For example, the Energy and Water Development Ap-

67. DOE STATEMENT OF POSITION, § II.A.1.3., at II-18.
68. *Id.* § III.F.2.2.2., at III-87.
69. S.2189, 96th Cong., 2d Sess. (1980).
70. H.R. 8378, 96th Cong., 2d Sess. (1980).

propriations Act,[71] which passed the House on October 1, 1980, provided only $199,477,000 of the requested $245,337,000 for commercial waste management. The bill provided only $175,551,000 of the requested $219,651,000 for commercial nuclear waste management operating expenses. Cuts were made in terminal isolation research and development, waste treatment technology, and support programs.

These cuts are indicative of the House Energy and Water Subcommittee's views about the DOE waste disposal program. The Committee Report stated that there should be a "major redirection of effort" in the program including: (1) increased emphasis on the construction of "demonstration" long-term storage facilities for nuclear wastes, (2) increased emphasis on using existing federally owned sites that have already been subject to radiation effects for long-term storage or disposal; and (3) reduced emphasis on "costly and unnecessarily extensive multiple site investigation and geological evaluation."[72]

Overall, the Committee bill provided a slightly more than one-half of the requested $20,513,000 for spent fuel, storage-energy supply research and development. The Committee called for an $8,000,000 reduction from the President's $19,513,000 proposal.

The Energy and Water Development Appropriations Act also provided appropriations for the Nuclear Regulatory Commission. The Committee recommended $34,000,000 for the Office of Nuclear Materials Safety and Safeguards, whose functions include the agency's nuclear waste management responsibilities. This appropriation was substantially less than the budget estimate of $43,680,000. The Committee Report explained the reduction as follows: "Until the question of commercial reprocessing is settled, the issue of commercial waste management cannot be settled."[73]

The Science and Technology Committee reported versions of Title I and Title VII of the DOE Authorization Act, which seriously undermine the DOE geologic disposal program.[74] The

71. Pub. L. No. 96-367, 97 Stat. 1331 (1980).

72. HOUSE APPROPRIATIONS COMM., ENERGY AND WATER SUBCOMM., 96th Cong., 2d Sess., REPORT 81 (Comm. Print 1980).

73. *Id.* at 148.

74. H.R. 6627, 96th Cong., 2d Sess. (1980).

Committee's amendments provided for the reprocessing of commercial spent fuel and storage of reprocessed wastes. Accordingly, the Committee eliminated critical funding for geologic disposal activities and instead provided funding for development, virtually irrespective of geologic conditions. Moreover, the Committee's approach to geologic storage called for four demonstration repositories, the first to be in operation by 1986. Contrary to the recommendations of the Interagency Review Group, these repositories would not be licensed by the NRC and the opportunities for state and local participation in siting decisions would be limited.

The development and implementation of a safe geologic waste disposal program requires a commitment from Congress as well as the executive branch. Both must share a view of what is required to solve the waste disposal problem, and Congress must provide adequate funds to complete the task. At present, it appears that DOE and Congress are at cross purposes.

*4. Managerial and Regulatory Uncertainties.*—In Roger Kasperson's view, "management and regulatory issues constitute perhaps the most formidable obstacles to a timely resolution of the radioactive waste problem."[75] Of particular concern is the absence of a mechanism for the coordination of all the departments within the federal government that have responsibility for nuclear waste.[76]

Ten different institutions share responsibility for radioactive waste matters,[77] three of which were created in 1980.[78] Each

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75. Testimony of Roger Kasperson, *supra* note 61, at 20.

76. The *DOE Statement of Position* stated that arrangements are being made for interagency cooperation among a few of the organizations concerned with waste management. § III.D.2., at III-42. These are far from complete, however. The necessary memoranda of understanding have not been prepared, nor have the substantive procedures required for collaboration and implementation of the program been developed. *Id.* III.D.2.1.1., at III-42. Furthermore, the existence of cooperative arrangements does not supplant the need for a means of over-all coordination of the waste management effort. As "lead agency" for the development of a waste disposal method, DOE should function in this capacity. It is apparent from its statement of position that it does not.

77. These institutions are the Nuclear Regulatory Commission, the Department of Energy, the Environmental Protection Agency, the Department of Transportation, the U.S. Geological Survey, the Council on Environmental Quality, the Office of Science and Technology Policy, the Federal Radiation Policy Council, the Nuclear Safety Oversight Committee, and the State Planning Council.

78. The Federal Radiation Policy Council is responsible for the development of federal radiation protection policy. It will review actions of the NRC which affect public and

of these organizations has its own mandate and agenda and its own views on the appropriate shape and course of the waste disposal program. There is no consensus that the program will produce a safe method of disposing of wastes within a reasonable time period. The U.S. Geological Survey, for example, has expressed doubts about the adequacy of the technical information supporting the program and the validity of the geological assumptions used.[79] The Office of Science and Technology Policy has stated its opinion that "the knowledge and technology base available today is not sufficient to permit complete confidence in the safety of any particular repository design or the suitability of any particular site."[80]

A significant reason for the lack of confidence by other federal agencies in DOE's program is that DOE still has not determined what must be done to design and implement a waste disposal program. The DOE is presently trying "to define the technical efforts required for successful mined geologic waste disposal. . . . [These include] site identification and characterization, rock mechanics, repository sealing, waste/media interactions and repository performance assessment,"[81] matters which should have been the subject of research efforts at the beginning of the waste disposal program. It is astonishing to find DOE attempting to "define the technical efforts required" for achievement of a goal that is more than twenty years old.

Because DOE does not have a clear idea of what is required for implementation of the program, it cannot integrate the work of other agencies into its own or direct their efforts in a meaningful way. No priorities have been established for the various agency programs based on an overall schedule. Nor are the individual agencies fully aware of the efforts and schedules of other organizations.

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occupational health. The Nuclear Safety Oversight Committee is charged with overseeing industry and government programs for improving reactor safety. The State Planning Council is responsible for coordination of waste policy between the federal and state and local governments.

79. Carter, *Nuclear Wastes: The Science of Geologic Disposal Seen as Weak*, 200 SCIENCE 1135 (1978).

80. T. BEDEHOEFT, A. ENGLAND, D. STEWART, N. TRASK, & I. WINOGRAD, GEOLOGICAL DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES—EARTH SCIENCE PERSPECTIVES, U.S. GEOLOGICAL SURVEY CIRCULAR 779 (1978).

81. DOE STATEMENT OF POSITION § III.D.2.1.1.1., at III-44.

A potentially more serious problem is the lack of consistency in the programs and schedules of various agencies. For example, DOE began searching for repository sites several years before the NRC promulgated its site suitability criteria. As noted earlier, the NRC's approach to siting is different from that of DOE, which may result in selection of a site that is unacceptable to one or the other agency. This conflict may have occurred already. The site chosen by DOE for the Waste Isolation Pilot Plant (WIPP) has significant potash deposits, although the NRC criteria would prohibit the location of a repository at a site with such valuable mineral resources.[82]

The DOE acknowledges that the NRC's procedural requirements for licensing a waste repository could have a "major impact on costs and schedule."[83] In fact, these requirements could mean the success or failure of the DOE program.

### *B. The Second Phase—Scaling Up*

The entire focus of the present DOE program is on the location, construction, and operation of one repository, designed to accommodate the nuclear waste DOE anticipates will be produced by the year 2000.[84] The DOE has yet to address the technical and organizational problems of "scaling-up" from one facility to a disposal system capable of accommodating the wastes from an expanding nuclear industry. The need to solve these problems is far from theoretical. The roughly 200 GWe (gigawatts electric) of nuclear power already on the books—that is, in plants in operation, under construction, ordered, or publicly announced—will produce enough high-level radioactive waste to fill two repositories, if the DOE capacity figure of 100,000 tons of waste per a 2,000 acre repository is used,[85] or six repositories, if the California Energy Commission figure of 35,000 tons per repository[86] is relied upon. If a nuclear commitment of 300 GWe by the year 2000 is assumed,[87] these numbers

82. *See* DEPARTMENT OF ENERGY, FEIS ON WIPP 9-17 to -27 (DOE/EIC-0026, Oct., 1980).

83. DOE STATEMENT OF POSITION at III-73.

84. *Id.* at III-22, 57-59, 77.

85. Opinion of Dr. Thomas Cochran, technical expert at the National Resources Defense Council.

86. *Id.*

87. The Electric Power Research Institute has argued that about 400 GWe by the

increase to three and nine repositories respectively.

One fundamental problem with expansion of the waste disposal system is that it must be essentially error-free from the outset. "[T]he incremental approach to perfect performance . . . is explicitly not an option for the waste management program."[88] In other words, the public simply will not tolerate a "learning curve" for waste disposal operations.

Second, the organization required to support an expanded network of disposal sites will have different and more serious problems than those confronting the location and operation of a single repository. The organizational complexity of an expanded waste disposal program is not linear with its size. As more waste repositories are needed, the problems associated with site selection, facility, design, security, and transportation are multiplied, wholly apart from the purely technical problems involved. Furthermore, as the waste disposal system expands, public confidence in its ability to perform without malfunction is likely to decrease. In part, this is due to the application of that "bit of organizational folklore, Murphy's Law":

> The larger the volume of waste materials and the more varied its composition, the larger and more complicated the total system is likely to be; and the more complicated the system, the more we are prone to imagine that, if anything can go wrong, invariably it will at some time or another.[89]

As the accident at Three Mile Island demonstrated, the least reliable factor in an elaborate scheme to control nuclear dangers is the *human* factor. This factor will become increasingly crucial as the program expands. According to one commentator,

> [a]s the volume of wastes increases, the most crucial scarce resource may well become the people who are highly skilled and who can be motivated sufficiently to perform continuously at extraordinarily high levels of reliability, even though it is likely that the jobs will generally be routine and boring on a day-to-

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year 2000 reflects a minimun growth figure for the nuclear industry to survive. See EPRI, *Nuclear Waste Management Status and Recent Accomplishments*, Final Report (NP-D87, May, 1979).

88. SOCIAL AND INSTITUTIONAL ASPECTS, *supra* note 58, at 3.47.

89. LaPorte, *Nuclear Waste: Increasing Scale and Socio-Political Impacts*, 201 SCIENCE 26 (1978).

day basis.[90]

Increased dependence on human reliability requires that the organization be equipped with an "error detection mechanism" that will "reward detection and correction of error rather than its denial or cover-up."[91] Nothing in the DOE program is responsive to this problem.

Third, DOE has failed to analyze the impact of an expanded waste disposal system on the social structure of the communities directly affected by transportation and repository siting. The DOE has assumed that "social concerns" about the safety of nuclear waste disposal will be resolved because of the "growing public recognition that nuclear waste management is a national problem."[92] This attitude ignores a critical set of issues that could lead to rejection of a waste management program. For example, DOE has not determined whether it will locate a series of waste repositories at one site or region, or spread them out in various locations across the nation. The social, economic, and political implications of these two strategies differ, yet DOE has not assessed them.

Finally, DOE has not prepared a detailed cost estimate of a comprehensive waste management program. The need for organizational refinement and superior personnel necessarily will lead to a high cost program—a cost which may be disproportionate to the "benefits" of nuclear power production. Moreover, the cost to civil liberties that results from an authoritarian waste disposal bureaucracy that decides which communities become perpetual hazardous dumping grounds may be too great for society to bear.

### *C. The Long-Term Management Phase*

The final phase of the waste disposal program, which must be assessed in terms of the social, economic, and political obstacles to its implementation, is the long-term management phase. In this phase, the disposal technology and institutional arrangements will be tested over long periods of time.

It is impossible to make any predictions about the stability

90. *Id.* at 23.
91. SOCIAL AND INSTITUTIONAL ASPECTS, *supra* note 58, at 3.47.
92. DOE STATEMENT OF POSITION, at III-87.

of the social fabric or social and political institutions for the length of time during which the nuclear wastes generated today will remain hazardous. As a consequence, it may not be possible to design any system other than an engineered one for the protection of future generations. This does not, however, excuse consideration of the fundamental question of whether society has a right to subject future generations who may share none of the benefits of nuclear energy to the risks inherent in its waste. The DOE's continuing failure to address seriously this issue is a clear indication of its lack of understanding of the social and political obstacles to the implementation of its program.

## V. CONCLUSION

The history of the federal government's efforts to find a solution to the problem of nuclear waste disposal provides no basis for confidence on the part of the American public that nuclear wastes will be managed safely in the future. It is a history of "unbroken failure to produce an acceptable method of waste disposal,"[93] a history of fits and starts and major changes in direction and focus from geologic disposal to retrievable surface storage and back again. Along the way the federal government has adopted and then been forced to abandon disposal sites, media, and technologies. The federal government has aroused the ire of local politicans and the opposition of the public. It has failed to understand that the problems are not only technical, but institutional and social as well. Finally, it has underestimated the complexity and difficulty of the task. The history of the government's waste disposal effort shows that little has been learned in the past twenty years.

The DOE has not developed a plan that will meet even the NRC's draft performance criteria for geologic repositories. In numerous instances, DOE's program objectives are in conflict with the NRC's criteria. Even when its objectives are not in conflict, there is no evidence that the NRC criteria will be met by the DOE program.

There is no evidence that any of the specific alternative disposal schemes, media, and sites presently being pursued can and will be used for safe waste disposal. Of the ten alternative dispo-

93. Address by G. Speth, *supra* note 19, at 7.

sal methods allegedly under consideration by DOE, only geologic disposal is a viable candidate. Others lag far behind in development or are so theoretical as to be beyond the realm of present possibility.

With respect to geologic disposal, DOE's program has failed to identify an acceptable site or host rock that meets the NRC's technical criteria. The NRC criteria appear to rule out the use of salt and basalt, and possibly granite, shale, and tuff as well. The DOE's research and development program is not designed to provide the comprehensive research effort required to resolve the outstanding problems with its waste disposal plan. Basic research tasks have not been defined and implemented in a systematic manner. For example, *in situ* testing and the development of the technology for successful borehole and shaft sealing lag far behind other, less important research efforts. The program does not address adequately the uncertainties asociated with the selection of a suitable host rock nor will the plan lead to the choice of an adequate waste form. Site work has been restricted mostly to federal reservations in order to avoid public conflict.

Finally, DOE has not identified or addressed the social, political, and economic issues involved in the implementation of its waste disposal program. Its emphasis continues to be on the technical features of the waste disposal system, although the resolution of institutional issues is of equal importance. Indeed, failure to properly resolve the social obstacles to implementation may doom an otherwise acceptable program.

For these reasons, many segments of the American public have substantial doubts about DOE's continued promises of a prompt solution to this fundamental and long-standing problem with the application of nuclear technology. Without doubt, the disposal of nuclear waste is a problem that should have been solved before the wastes were generated by the nation's nuclear power plants. That DOE is still far from achieving a solution is cause for dismay. It is also cause for continued opposition to the licensing and operation of nuclear waste producing facilities.