Appendix B

Waste Management System Issues Resolved in the Nuclear Waste Policy Act of 1982

Introduction

This appendix discusses the major waste management system issues that were debated in the 97th Congress and addressed in the Nuclear Waste Policy Act of 1982 (NWPA). Questions concerning development and operation of the waste management system authorized by NWPA are discussed in chapter 6.

When the 97th Congress began its debate of radioactive waste management legislation, no firm agreement had been reached on whether final isolation of radioactive waste would be accomplished through storage or disposal, where and when to develop final isolation facilities, or how to store the waste before final isolation.

Several factors complicated congressional decision-making about storage and disposal. First, the unavailability of disposal and reprocessing had created the need for greater and longer term spent fuel storage capacity than originally envisioned. Because of the delays in developing both reprocessing and disposal facilities, it appeared likely that most of the spent fuel generated in this century would still be in interim storage facilities at the end of the century—even if direct disposal of spent fuel were to begin on the earliest possible schedule estimated by the Department of Energy (DOE). Furthermore, the possibility that reprocessing might become economical sometime in the future raised questions about whether to plan for storage of spent fuel as a potential resource or disposal of spent fuel as a waste—or both.

Thus, for the next several decades, waste management would consist almost entirely of spent fuel storage, and any reprocessing that occurred would simply convert some of the stored spent fuel into stored wastes of various types (solidified high-level waste, transuranic waste) and, perhaps, unrecycled plutonium. Moreover, it appeared that even after the capacity for disposal were available, storage might continue to be a major part of waste management—either because disposal would be deferred after disposal facilities were available (e. g., to maintain access to spent fuel for possible reprocessing or to reduce the heat output of the waste before disposal) or simply because it would take a long time to eliminate the backlogs of spent fuel built up in storage by the time disposal began.

The following policy issues address:

1. the overall Federal strategy for developing a final isolation system for high-level radioactive waste;
2. the schedule for developing final isolation facilities;
3. whether the final isolation system should accept only high-level waste, spent fuel, or both; and
4. the Government's role in interim spent fuel storage until final repositories are available.

These issue discussions were written prior to the passage of NWPA, and were the basis for OTA'S summary report published in April 1982 during the debate on the Act and for extensive OTA testimony and staff analyses provided to Congress during that debate. These issue discussions are presented in the present tense, as they were originally written, to give a clear picture of how the issues and possible options were viewed during the debate that occurred before final passage of the act. Each issue discussion is followed by a brief description of the resolution contained in the NWPA.

ISSUE 1:

What approach should be used for developing facilities for final isolation of high-level radioactive waste?

Prior to passage of the NWPA, existing laws and regulations gave DOE the authority and responsibility to develop a final isolation system for high-level radioactive waste. While there was broad agreement that the Federal Government should proceed to develop such a system, there was less agreement about the kind of isolation needed and the pace of the program for developing isolation facilities.

In particular, there was disagreement about whether final isolation should be accomplished through disposal, which does not depend on continued human maintenance and monitoring to provide isolation, or through storage, which does. Existing law did not specify which approach to final isolation would satisfy the obligations of the Federal Government and did not ***even*** clearly distinguish between the terms "storage' and "disposal. No generally accepted approach for the final isolation

I See app. note.

program had yet emerged from the congressional debates or from the administration's review of waste management policy. The history of the waste management program made it clear that resolution of this issue in law would be needed to avoid continued shifts of direction in the waste management program.

OPTION: 1. Develop a disposal system of mined geologic repositories.
2. Defer developing geologic disposal and do research on many disposal technologies before selecting one for full-scale development.
3. Develop a permanent storage system.

The Debate

The three options differ in the degree of commitment to the development of a disposal system. Option 1 immediately commits to developing the disposal technology that is best understood—the mined geologic repository. Option 2 assumes that a disposal system must be developed sooner or later, but defers that action for an extended period—say, 50 years or more. Option 3, in contrast to the others, favors developing a permanent storage system instead of a disposal system, based on the assumption that such storage would be an acceptable method for final isolation.

Since there is no alternative to continued storage of spent fuel (or reprocessed waste) until a disposal system is available, the options also entail different emphases on the development of Federal storage facilities. Option 1 is compatible with the provision of little, if any, Federal spent fuel storage capacity (see issue 4), since the option emphasizes prompt development of geologic repositories to which utilities could deliver their spent fuel. With option 2, the immediate focus of the waste management program would probably be development of centralized Federal facilities for extended storage of spent fuel and high-level waste; meanwhile, research and development (R&D) activities could be conducted on a number of disposal technologies until a decision were made to select one and develop it full-scale.

In option 3, like option 2, the immediate focus would be on development of appropriate storage technology, location of suitable sites, and construction of facilities. In fact, since a permanent storage program may involve use of facilities designed to be replaced periodically, perhaps every 50 to 100 years, there may be little if any difference between the storage facilities developed under options 2 and 3. The following discussion briefly summarizes the principal arguments cited in favor of each option and compares the options in terms of a range of criteria.

OPTION 1:

Develop a geologic disposal system.

Some supporters of this option feel that an ***acceptable*** disposal technology, not necessarily the ***best*** possible one, is needed to complete the nuclear fuel cycle and that there is enough agreement about the potential of the mined geologic repository to justify its development as the first-generation nuclear waste disposal system. A commitment to developing a disposal system of mined geologic repositories—the most well-defined and extensively studied disposal concept—is justified by the fact that geologic disposal has survived many intensive reviews without identification of any insurmountable scientific or technical barriers to its safe implementation. Moreover, development of geologic disposal provides continuity with Federal waste management policy of the last several decades and is consistent with the Environmental Protection Agency's (EPA's) proposed general regulatory criteria, which preclude reliance on institutional control of a repository for longer than several hundred years.

Perhaps the principal argument in its favor is that it would avoid deferring an ultimate solution of the waste problem to future generations.[2] Because disposal, unlike storage, does not require perpetual human control to assure continued safe isolation, it avoids burdening future generations with a problem they did not create, Moreover, a disposal system provides better assurance that long-term safety will not be compromised by the loss or abandonment of adequate institutional control of the repositories before the emplaced waste has decayed to innocuous levels. Such concerns prompt some people to view development of a disposal system as a necessary step for removing the waste problem as a hindrance to future use of nuclear power.

OPTION 2:

Defer development of geologic disposal and do research on many disposal technologies before selecting one for full-scale development.

Those who agree that disposal will ultimately be required for final isolation of high-level waste disagree about how quickly a commercial-scale disposal system should be developed. This disagreement results from concerns about existing uncertainties associated with various disposal technologies and from not knowing when and if spent fuel will ever be reprocessed. Because the future role of reprocessing is unclear, it is also uncer-

[2]Interagency Review Group on Nuclear Waste Management (IRG), *Report to the President*, TIO-29442, March 1979, p. 37; see also U.S. Atomic Energy Commission, *Preliminary Draft Environmental Statement: Retrievable Surface Storage Facility—Commercial High-Level Radioactive Wastes* (Richland, Wash.: Nov. 8, 1974).

tain when there would be any solidified high-level waste for disposal and when or if it would be economical to dispose of spent fuel directly as waste. This consideration leads some to conclude that there is ample time to explore a number of disposal alternatives before selecting one for development.

Completion of R&D on a number of disposal technologies would allow disposal techniques to be selected when required. Supporters of this approach argue that since there appear to be no compelling health and safety reasons for rapid disposal of high-level radioactive waste, and since safe and relatively inexpensive extended storage facilities can be developed, there is simply no urgency to choose a specific disposal technology immediately. In addition, extended storage prior to disposal would simplify the task of disposal by allowing the waste to cool longer and would allow easy retrieval of spent fuel in case reprocessing is begun in that period. Thus, an extended period of storage would avoid any irreversible actions while uncertainties about disposal technologies and the economic value of spent fuel are resolved.

The concept of extended storage was embodied in the Retrievable Surface Storage Facility (RSSF) that was proposed by the Atomic Energy Commission in 1974 but was subsequently dropped in favor of an aggressive pursuit of the development of mined repositories. Interest in development of facilities for extended, and perhaps permanent, storage was renewed in 1979 by a proposal to use existing tunnels at the Nevada Test Site for this purpose[3] and was subsequently embodied in a bill (S. 2189) approved by the Senate in 1980 that would have provided for the construction of Monitored Retrievable Storage (MRS) facilities.

OPTION 3:
Develop a permanent storage system.

Several principal arguments are made in favor of permanent storage over disposal for final isolation. First, permanent storage avoids the uncertainties about the long-term performance of geologic barriers that have been the center of the debate about geologic disposal. Second, since suitable storage facilities could probably be available earlier and at less cost than disposal facilities, they could provide an earlier demonstration of long-term isolation than would be possible with geologic repositories.

Third, since isolation in a storage facility does not depend on the properties of the facility site, suitable storage sites closer to the sources of waste generation could be found more easily and quickly than sites for geologic disposal facilities. Finally, storage provides ready retrieval of spent fuel for later reprocessing or for final isolation using a better technology, if one is developed later. It thus preserves options for future generations.

Comparison of Options

PUBLIC HEALTH AND SAFETY

The principal objective of waste management is isolation of radioactive waste from the biosphere so that it poses no significant threat to human health and life. Several safety-related factors affect the choice between the three options under consideration.

All options could involve extended storage before disposal because they either defer availability of a disposal system for many decades (options 2 and 3) or might continue storage even after disposal facilities are available (option 1). Thus, the decision addressed in this issue is not when to dispose of waste irretrievably, but when to make available the capacity to do so. However, in order to highlight the differences between the options, this discussion of safety questions assumes that under option 1, disposal would begin as soon as a geologic repository becomes available.

Both the Interagency Review Group (IRG) report and DOE's environmental impact statement on high-level radioactive waste explicitly considered the safety benefits of early disposal in mined geologic repositories (Option 1) compared with those of extended storage (up to 40 years) to allow development and possible use of alternative disposal technologies (option 2). The reports concluded that there are no compelling reasons of public health and safety for rapid disposal of high-level radioactive waste, since safe interim storage for such periods could be accomplished.[4]

On the other hand, they also concluded that mined repositories offered the most immediate and sure choice for development of an adequately safe disposal system and that there were no clear safety advantages to waiting for development of a better system, so long as a technically conservative repository development process were used.[5] In addition, EPA's proposed general criteria for radioactive waste disposal implicitly rule out storage as a permanent solution by excluding reliance on long-term institutional control as a means of assuring isolation.[6] Finally, the IRG agreed that a disposal system should be developed:

[3]Phillip Hammond, "Nuclear Wastes and Public Acceptance," *American Scientist,* vol. 67, No. 2, March-April 1979, pp. 146-150.

[4]IRG, *Subgroup Report on Alternative Technology Strategies for the Isolation of Nuclear Waste,* TID-28818, October 1978, p. 53; U.S. Department of Energy (DOE), *Final Environmental Impact Statement on Management of Commercially Generated Radioactive Waste (FEIS)* vol. 1, DOE/EIS-0046F, October 1980, p. 131.

[5]DOE, op. cit,, pp. 7.39-7,4 1; IRG, *Report to the President,* ch. 2.

[6]U .S. Environmental Protection Agency, *Draft Environmental Impact Statement for 40 CFR 191: Environmental Standards for Management and Disposal of Spent Nuclear Fuel, High -Level and Transuranic Radioactive* Wastes, December 1982, p. 123.

> The responsibility for establishing a waste management program shall not be deferred to future generations. Moreover, the system should not depend upon the long-term stability or operation of social or governmental institutions for the security of waste isolation after disposal. '

As noted in chapter 3, the possible ways that radioactive waste might escape from a geologic repository over periods of a million years or longer have been considered in great detail by many analysts. In developing release standards for geologic disposal, EPA evaluated a wide range of possible release mechanisms, including inadvertent human intrusion, and concluded that a geologic repository could produce health effects over a 10,000-year period that are small compared with the effects of background radiation. The expected health effects would also be within the range of effects that could be caused by exposure to the bodies of uranium ore needed to produce the amount of fuel that would be contained in the repository.

No analysis comparable in time horizon or range of accident conditions now exists of the safety of storage as a substitute for, rather than simply as a prelude to, disposal as a means of permanent waste isolation (option 3). Potential risks of storage over a 10,000-year period would have to be analyzed in order to allow a consistent comparison with geologic disposal in terms of the proposed EPA standards.

Perhaps the basic question in comparing the safety of permanent storage with geologic disposal is whether the uncertainties about the reliability of the barrier provided by continued institutional control and maintenance are greater or less over such a long time period than those related to the performance of the geologic barriers they are intended to replace. Some qualitative insight can be gained by comparing the risks from a permanent storage facility with those from a geologic repository under two possible scenarios for institutional control: 1) the technical capacity and the societal will to maintain such control continue for the required period of isolation, and 2) the capacity or the will is lost at some point during that period.

1. ***Institutional Control Is Maintained.*** —Permanent storage may provide greater assurance than could geologic disposal that radioactive waste will not escape into the biosphere as long as the storage facility is kept under adequate control by today's standards and as long as repairs and replacements are made, as needed, to ensure continued isolation. Moreover, waste leaked from a storage facility could be easier to detect and clean up than waste leaked from a geologic repository. It should be noted that published calculations of the long-term health effects of geologic disposal, such as those performed by EPA, generally assume that the releases from the repository are ***undetected*** and therefore that no efforts are made to mitigate them or to prohibit the use of contaminated water and food.

In either case, as long as society can and will continue to monitor a waste repository so that leaks can be detected, such leaks will not impose an ***involuntary*** health risk on future generations. They would have the choice of accepting the risks or bearing the financial and social costs of mitigating the effects of the leaks. While permanent storage instead of disposal could reduce the cost of cleanup and mitigation measures in the unlikely event of significant unanticipated releases from a repository these potential savings would have to be **balanced against the certain higher financial costs, as well as radiation exposures to workers involved in maintaining a storage facility and in providing replacement facilities, as needed, for millennia.**

2. ***Institutional Control Is Lost or Abandoned.—If*** there is significant concern that adequate institutional control will be terminated prematurely, geologic disposal may appear to be the safest final isolation alternative. In that event, the risk from a permanent storage repository would probably be greater than from a geologic repository since the former would more likely be located at or near the Earth's surface and would be designed to provide long-term isolation only with continued human care. In contrast, a geologic disposal facility would be several thousand feet deep at a site carefully selected to minimize the likelihood of significant releases—on the assumption that institutional control would not be used to provide the desired degree of isolation.

Adequate institutional control could cease either because of loss of social ability to care for the waste (through war or social regression) or because of carelessness or neglect. It can be argued that if something serious enough to cause society to lose its ability to care for radioactive materials occurs, then the possibility of low-level leakage from a waste repository may be one of the less important problems that society faces. On the other hand, it can be argued that the acceptability of the risks imposed on future generations should be independent of any consideration of unrelated risks they may be facing.

It can also be argued that the Government can be expected to act responsibly as long as it has the technical capacity to do so and that, in any case, this generation cannot take responsibility for the decisions of future generations. On the other hand, stored nuclear waste might be mishandled in the future in the same way that some toxic chemicals have been mishandled in the past, posing a risk not only to the generation responsible, but also to the generations that follow it. In some cases, the immediate risk to the generation responsible or to its

'IRG, ***Report to the President,*** p. 16.

immediate descendants might be relatively low, since the waste canisters should provide a barrier to release for perhaps a century or longer (depending on the design).

The risk would be imposed on later generations when the facility and the waste packages have deteriorated substantially and the waste has had time to leach into water and be transported to drinking water or food—a process that could take centuries. Thus, reliance on continued institutional control as the principal means of protecting future generations requires confidence that each successive generation will have the same ability to manage waste and will maintain our degree of concern and responsibility for the safety of the generations that come after them. In contrast, permanent disposal in facilities that do not require continued care and maintenance is not vulnerable to the possibility that today's standards for protection of health and safety of future generations will not be maintained.

Permanent storage involves one additional safety consideration if spent fuel rather than reprocessed waste were to be stored—the possibility of theft to recover the plutonium in the spent fuel for use in nuclear weapons. As long as the storage facilities are under control, this risk is low, particularly with spent fuel that is less than 100 years old and therefore too highly radioactive to handle easily. Older spent fuel could be a more attractive target for theft—a serious concern in case institutional control of the facility were lost. While spent fuel that had been disposed of in a geologic repository could also theoretically be recovered for use in nuclear weapons, this clearly would entail a much more difficult and time-consuming process than recovery from a surface storage facility.

STATUS OF TECHNOLOGY AND LICENSING[7]

Technical reviews have concluded that suitable sites for a geologic repository could be found, and a repository could be developed, licensed, and operating by the end of the century (perhaps earlier), provided adequate and stable resources were devoted to the task. The steps required in the National Environmental Policy Act (NEPA) for a DOE decision to develop a geologic disposal system have been completed, and the technical basis for the decision has been published in the required environmental impact statement.[8]

The remaining uncertainties about geologic disposal can only be reduced by proceeding to locate, characterize, and develop candidate repository sites, a process now being carried out by DOE. Moreover, the Nuclear Regulatory Commission (NRC) has issued final regulations for procedures to be used in licensing a geologic repository and for technical requirements for such a repository. EPA has developed tentative performance criteria for geologic repositories, and issued them for comment. It appears likely that the entire regulatory structure for licensing geologic repositories could be in place within several years.

Little technical doubt appears to remain that storage facilities suitable for extended periods can be designed and operated to meet current radiation protection standards as long as institutional control is maintained. One of the new dry storage technologies would probably be used for this purpose.[10]

NRC has issued regulations (10 CFR 72) for facilities designed for interim spent fuel storage for periods of up to 20 years, renewable at the discretion of NRC. Analysis by DOE suggests that a facility to meet these regulations could be designed, constructed, and licensed in about 10 years. However, it is not certain that these regulations would apply without modification to a facility explicitly designed for extended storage, as contemplated in option 2.

This regulatory uncertainty is even greater for a permanent storage facility (option 3). If the 10,000-year release criteria now under development by EPA for geologic repositories would also apply to a permanent storage facility, additional design requirements (e. g., a more complex and long-lasting waste package design) might be needed to protect against loss of institutional control during that period. It might also be necessary for NRC to develop a special set of technical regulations for permanent or extended storage facilities analagous to those proposed for geologic repositories.

COST

A detailed comparison of the costs of the three options must await both clarification of the regulatory requirements for storage and disposal facilities and development and analysis of alternative system designs that are comparable in total capacity and annual handling rates. Available studies indicate, however, that for several reasons it will be less expensive to develop storage facilities than disposal facilities.

First, the less stringent technical requirements for storage sites should reduce the initial costs of system development. Determining the suitability of potential sites for geologic repositories requires extensive and expensive tests at the proposed repository depth—estimated to cost more than $100 million per site. Such testing is not required for siting surface storage facilities. In addition, it may be necessary to incur these high costs at

[7]See ch. 3 for a more extended discussion of the status of storage and disposal technology,

[8]DOE, *FEIS*.

[10]D. E. Rasmussen, *Comparison of Cask and Drywell Storage Concepts for a Monitored Retrievable Storage/Interim Storage System,* Battelle Memorial Institute, Pacific Northwest Laboratory, PNL-4450, December 1982.

a number of sites in order to find one that survives the entire evaluation process.

Second, the construction costs would probably be lower for a storage facility located at or near the Earth's surface than for a geologic repository mined at a depth of several thousand feet. The initial capital costs of a geologic repository are likely to exceed $3 billion[11] compared with initial capital costs of perhaps $500 million for a long-term surface dry storage facility using casks or drywells.[12] Even if mined tunnels (as proposed in one design) were used for storage, such a facility should involve less mining than a geologic repository for a given amount of waste because the continued ventilation in an open storage facility would allow more waste to be emplaced in a given area while maintaining temperatures at acceptable levels.

In addition, the acceptable temperatures might be higher in a storage facility than in a geologic repository. With a storage system there is less concern about the long-term effects of heat on the characteristics of the site, and any adverse effects on the facility or the waste canisters could be repaired. Higher acceptable temperatures could further reduce the comparative cost of a storage facility.

It is difficult to compare long-term costs because storage involves a perpetual stream of payment for maintenance, repair, and replacement of facilities, while geologic disposal involves, at most, the continued cost of monitoring once the facility has been filled and sealed. Disposal thus concentrates costs nearest the time the waste is generated, while storage spreads the costs out over many generations. Therefore, the costs of permanent storage over the entire period of monitoring and maintenance could exceed the costs of disposal, which can be fairly well defined and bounded because they are limited to a relatively short period of time.[13]

If storage were intended only for an extended period (say 50 to 100 years) prior to development of a disposal system (option 2), then the costs of storage would be an addition to, not a substitute for, the costs of the prospective disposal system. However, extended storage might reduce the direct costs of disposal somewhat because the cooling of the waste over that period could allow greater loading of waste in a geologic repository. (It should be noted that if the intention is to increase the long-term safety of the repository or the predictability of its long-term performance by cooling the waste before it is emplaced in the repository, thereby lowering repository temperature, it may not be possible to increase significantly the amount of waste emplaced without losing this advantage.)

Any discussion of long-term costs must take account of discounting, a procedure that gives more weight to early expenditures than to later ones in order to reflect the time value of money. Discounting is used to calculate the present value of a future expenditure by determining what amount of money would have to be invested in the present at the assumed discount rate (or interest rate) to yield an amount equal to the future expenditure by the time that expenditure is incurred. For example, since $1 invested at 10 percent would yield $1. 10a year from now, the present value of an expenditure of $1.10 a year from now, using a 10 percent discount rate, is $1. At a 3 percent annual discount rate, $1 spent 100 years from *now* would have a discounted present value of 5 cents.

The discounted total cost of permanent storage could be less than the total cost of disposal, since the discounted cost would be determined primarily by the costs of construction and maintenance of the initial storage facilities, which should be less than the same costs for disposal facilities. The cost of replacing storage facilities, which might be necessary after the first 100 years or so, would have little effect on the discounted total cost. For the same reason, the discounted cost of interim storage followed by disposal (option 2) could be less than the cost of early disposal, simply because deferral of disposal costs reduces the contribution of disposal to the present value of total waste management costs.[14]

There is no consensus about whether it is appropriate to use discounting when considering costs and benefits that affect many generations, because discounting strongly favors present benefits over future costs. To avoid shifting the costs of maintaining a storage system to future generations, the present generation would have to collect the discounted present value of those costs now and invest them at a rate of return sufficient to earn the discount rate assumed in calculating the present value, over and above the rate needed to keep pace with inflation. No analysis has been done of possible financial mechanisms that could be used to assure that the costs of perpetual care of radioactive waste would be borne primarily by the generation that created the waste.

FLEXIBILITY

All three options for final isolation offer some flexibility for taking advantage of more desirable alternatives in the future or for maintaining access to radioactive waste; even option 1 allows the choice to continue

[11] DOE, *Report on Financing the Disposal of Commercial Spent Nuclear Fuel and Processed High-Level Radioactive Waste*, DOE/S-0020, June 1983, table 3.4, p. 13.

[12] Rasmussen, op. cit., tables A.27 and A.28, pp. A.28-A.29.

[13] DOE, The Monitored *Retrievable Storage Concept, DOE/NE-0019*, December 1981, p. 2-35.

[14] Ibid.

[15] See, for example, Robert E. Goodin, "Uncertainty as an Excuse for Cheating our Children: The Case of Nuclear Wastes, *Policy Sciences*, 10, 1978, pp. 25-43.

storage even after disposal facilities are available. Thus, a decision to develop a disposal system is ***not*** the same as a decision to dispose of anything irretrievably on any particular schedule in the future; indeed, it is difficult to imagine how a decision could be made that would effectively force future decisionmakers to dispose of waste irretrievably on any fixed schedule if it appeared unsafe or unwise at that future time to do so.

The capacity for surface storage could be provided at mined repository sites for a relatively small incremental cost, since a mined repository would have a waste receiving and packaging facility that could package waste for emplacement either in a surface storage system or in the repository.[16] In fact, a mined **repository may require surface storage capacity to handle surges in deliveries to the repository, to continue receiving waste if loading of the repository were temporarily halted, or to allow the repository to be unloaded expeditiously if that became necessary. Thus, the higher cost of developing a system of mined repositories would provide the technical capacity and the sites for both storage and disposal.**

From this perspective, the difference between option 1, on the one hand, and options 2 and 3, on the other, is not ***whether*** Federal facilities for long-term storage would ever be built, but ***where*** they would be built—at sites that are suitable for untended disposal or at sites that are only suitable for monitored and maintained storage.

Option 3, and the initial phase of option 2, would provide the option only of storage. A later decision that a disposal system was needed would entail the expenditure of additional billions of dollars by future generations to find and develop suitable disposal sites and to construct additional handling and packaging facilities at those sites. Thus, a decision to store waste for an extended period would be more reversible if the storage were done at a mined repository site than at a site suitable only for storage, since the capacity for disposal would be immediately available onsite (if the repository were already built and money were available) and the costs of moving the waste from storage into the disposal facility would be minimal. In addition, the extended storage period at the repository site could be used to continue analysis of the suitability of the site for permanent geologic disposal, thus providing a larger body of data on which to base a decision about irretrievable disposal.

A decision to develop long-term, easily expandable Federal storage facilities instead of or before disposal facilities would probably create strong budgetary pressures to continue to expand the storage capacity and to defer raising and spending the additional funds needed to develop a disposal system. Availability of Federal storage facilities would remove a major source of pressure for developing a disposal system by providing an effective solution to the waste problem for utilities. In addition, expansion of storage facilities using modular dry storage technologies would be easier and cheaper than developing a disposal system. These advantages lead some to conclude that the decision in option 2 to defer commitment to development of disposal facilities could be, by default, a decision to store waste permanently.

If approval of permanent storage for final isolation (option 3) satisfied State laws linking continued licensing of reactors to the existence of an approved final isolation method, it might imply that no other system need be developed as a precondition for continued generation of waste. Moreover, if permanent storage were approved, it might be difficult to justify charging nuclear utilities and their ratepayers any more than is required to cover the costs of a Federal storage system. In that event, a waste management trust fund financed by direct fees on the users of nuclear electricity would be adequate only to assure continued maintenance and replacement of storage facilities as needed. The longer the period of storage, the more difficult it could be to raise the additional billions of dollars needed for disposal from future utility ratepayers or Federal taxpayers who did not contribute to the generation of the waste or to decisions about how waste would be managed.

Thus, development of a stand-alone storage system, required for options 2 and 3, may be less reversible than development of a geologic disposal system, which provides a relatively easy choice between continued storage or disposal. ***In fact, there maybe little practical difference in reversibility between options 2 and 3, even though the storage facilities required in option 2 are only intended to be used as an interim step prior to final disposal.***

PUBLIC ACCEPTABILITY

There appears to be little disagreement that developing a disposal system that meets appropriate safety standards would satisfy public concerns about the obligation to protect the health and safety of this and future generations. However, there is disagreement about whether it is ***necesszuy*** **to** develop a disposal system now, or whether development of a Federal storage system would be sufficient to allow the continued generation of waste. The history of strong and successful opposition to Federal efforts to develop storage facilities (first the retrievable surface storage facilities, later an away-from-reactor facility) demonstrates that some feel strongly that storage is not an acceptable alternative to disposal. Moreover, they fear that the availability of Federal

[16] Rasmussen, **Op. cit.,** pp. 1.5-1.6.

storage facilities might lead to continued deferral of development of disposal technology.[17]

Supporters of options 2 or 3 argue that storage for the foreseeable future might be more acceptable because it avoids the technical uncertainties in geologic disposal that result from reliance on predictions of very long-term performance of natural and manmade barriers. They are concerned that an exclusive focus on development of a geologic disposal system would make the demonstration of a satisfactory solution of the waste problem dependent on resolution of many complex technical debates about the performance of a geologic repository, a process that may take decades. They contend that an adequately safe storage system could be demonstrated more quickly and with greater confidence.

On the other hand, a shift in focus from disposal back to storage could create the impression that the Federal Government has serious doubts that technical uncertainties can be dealt with at all—an impression that could heighten, rather than reduce, public concerns about the waste problem.

Some argue that storage simply changes the nature of the uncertainties about safety from technical (associated with performance of geologic and manmade barriers) to social (associated with the dependability of continued institutional control). No hard evidence suggests that the public would be significantly less concerned about social uncertainties than about technical ones. From this perspective, demonstrating that waste can be safely stored as long as institutional control is maintained would simply not address the unavoidable long-term institutional uncertainties of final waste isolation.

The history of resistance to any deferral of the development of a disposal system suggests that if the Federal Government decided to construct a storage system (as either an interim or a permanent measure), concerns about the lack of progress on disposal could in the future become a major encumbrance on the use of nuclear power; for example, if there were efforts to expand the nuclear power system substantially before a disposal system were developed.

EASE OF SITING FACILITIES

Storage facilities may be technically easier to site than geologic repositories. Since the storage site would not be the major barrier to release of the contents of the facility, the technical requirements of the site would be less stringent, and the long-term performance of the site would not have to be demonstrated in the licensing process. (This advantage might be offset considerably in the case of permanent storage [option 3] if assurance of continued institutional control for a period of millennia must be demonstrated in the licensing process.)

It should be noted that various storage technologies may differ significantly in ease of siting. A preliminary screening by DOE indicates that about 20 percent of the area of the United States would be favorable for surface storage facilities (e.g., surface drywells), while only about 2 percent of the United States would be favorable for tunnel facilities (e. g., the tunnel rack system).[18]

The less demanding siting requirements for surface or near-surface storage compared to geologic disposal may not translate directly into substantially greater ease and speed in siting facilities. An underlying not-in-my-backyard sentiment may be a major obstacle to siting, regardless of the type of facility being sited.[19] Although the greater number of potential storage sites should make it easier to find some States willing to accept a storage facility, site selection on that basis may limit the flexibility to locate facilities near the site of waste generation— one of the potential advantages of storage facilities compared with geologic repositories.

In practice, the relative flexibility of siting for storage facilities may increase their vulnerability to not-in-my-backyard sentiments precisely because the technical reasons for choosing any particular site would be much less strong than would be the case with a geologic repository. State and local resistance to a waste facility may be stronger if there is no compelling safety-related reason why it could not be located somewhere else just as easily. In addition, if a storage facility were proposed as a way to deal with delays in a disposal program resulting from political resistance to siting a geologic repository, it might not be unreasonable to expect the same sort of resistance to siting the storage facility.

INSTITUTIONAL IMPLICATIONS

It maybe more difficult for the Federal Government to adopt and implement a commitment to the more expensive and complicated goal of developing a disposal system than to the less expensive and more incremental option of constructing storage facilities. The normal Federal policymaking and budgeting process tends to favor incremental actions for the most pressing problems, to defer decisions about issues that seem to require no immediate action to avoid serious consequences, and to avoid irreversible actions wherever possible—particularly when there is substantial uncertainty about the outcome of those actions.

[17] DOE, *The Monitored Retrievable Storage Concept*, p. 2-37.

[18] Ibid., p. 3-17.

[19] A DOE study concluded that the mitigating measures needed to deal with State and local concerns would be very similar, if not identical, for either geologic repositories or long-term storage facilities. DOE, *The Monitored Retrievable Storage Concept*, p. 2-38.

For several reasons, this Federal decisionmaking process appears to be more compatible with the implementation of options 2 and 3 than with option 1. For instance, development of a Federal storage system would deal with what some see as the most pressing waste management problem— the utilities' need for some way to end their open-ended liability for growing inventories of spent fuel—while allowing the problems of siting geologic disposal facilities to be deferred. In addition, the annual Federal budget process may tend to favor storage over disposal, since it will be less expensive in the short run to construct a new storage facility or expand an existing one than to build a disposal facility.

The near-term cost advantage of storage would be increased by use of the dry storage technologies, now under development, that allow easy incremental expansion of storage capacity. While the continuing costs of maintaining storage facilities may make the total budget outlays for storage much greater than for disposal in the long run,[20] the near term cost advantages could tend to dominate decisions.

Substantial changes in the institutional approach to waste management may be needed to give high credibility to a commitment to option 1 (see ch. 7), whereas no such changes would be necessary for options 2 or 3. The very flexibility and high degree of annual oversight and control normal in Federal programs opens the possibility that an option 1 policy would be changed in the future and storage facilities built as a way to buy time if problems arose in the disposal program or if the Federal budget were particularly tight when large appropriations for construction of a full-scale geologic repository were required.

The Resolution

In adopting the NWPA, Congress in effect chose option 1 by making an explicit commitment to development of mined geologic repositories, thus embodying in law the policy that had earlier been adopted by DOE. With regard to long-term storage of spent fuel or high-level waste, the Act recognizes that such storage is a potentially useful waste management option and requires DOE to submit an analysis of the need for MRS facilities and site-specific designs for the first such facility. However, the Act requires that disposal in geologic repositories should proceed regardless of whether an MRS facility is built. Development of a plan for long-term storage facilities would thus provide a backup option in case serious problems arise in the geologic repository program.

The remaining issues in this chapter discuss primarily those decisions that logically followed the selection of option 1 of issue 1. The question of the role of MRS facilities in the waste management program is considered at greater length in the discussion of the radioactive waste Mission Plan in chapter 6.

[20]Ibid., table 2-5, p. 2-25.

ISSUE 2:

What kind of schedule should be adopted for developing mined repositories?

One principal obstacle to development of a widely accepted waste disposal policy has been disagreement about the appropriate pace for developing geologic repositories. People who believe that the current base of knowledge will permit an acceptably safe system to be developed and implemented fairly quickly recommend rapid action to allay public concerns about waste disposal. Others believe that pressures for hasty action could lead to premature commitment to a repository site that is inadequate or, at the very least, to actions that would jeopardize the credibility of the Federal waste disposal program.

OPTION: 1. Accelerated schedule.
2. Conservative schedule.

The Debate

OPTION 1:
Accelerated schedule.

An accelerated schedule for developing a repository would involve evaluating the minimum number of possible sites (three) and geologic media (two) —required by NRC for selecting the candidate site for the first geologic disposal repository-so that submission of a license application for a repository would not be delayed while a broader range of alternatives was examined. Proponents of the accelerated schedule believe that a geologic disposal repository can be developed rapidly with little risk of failure and that any further delay would be interpreted by the general public as a lack of Federal commitment to complete the task and, perhaps, even as evidence that the job cannot be done at all. If successful, this approach could lead to a licensed repository in the late 1990's.

An accelerated schedule carries several potential risks. First, such a schedule could raise fears that safety might be compromised, in turn leading to continued efforts to delay or change the schedule yet again, as well as to criticisms of the program that could increase the doubts of the general public. Second, accelerating the schedule of development of a technology and licensing process for which there is no previous experience increases the risk of real or perceived failures to find or license sites.

Such failures could reduce public confidence in the Federal waste management program.

A basic problem in establishing a schedule for development of a geologic repository is the first-of-a-kind nature of the process in terms of both the technical and institutional steps involved. Concerning this point, an official of the U.S. Geological Survey (USGS) stated:

> The types of information needed for site characterization and performance evaluation for licensing are fairly well understood by the interested agencies; however, the time required to perform the tests to obtain this information is uncertain . . . The site characterization phases will be a learn-as-we-go procedure in which we cannot accurately predict schedules, To complicate the scheduling, sociopolitical aspects of State and public participation can also impose unplanned delays in obtaining technical information. z'

Adoption of an accelerated schedule in the face of uncertainties about siting poses three major risks. First, it may lead to premature selection of candidate sites on the basis of inadequate data, which could increase the chances that the first site recommended to NRC would not be approved. Considering the great political importance attached to the first repository, the negative effects on public confidence of rejection of the first site could be severe, especially if the selection were accompanied by considerable optimism about the ease of developing a repository. Second, slippages in the schedule, more likely to occur in an accelerated schedule, could weaken the credibility of the entire schedule, particularly if they occurred in the early stages of the process.

Third, to the extent that the feasibility of an accelerated schedule is questioned by the technical community and the involved agencies, the responsibility for real or perceived failures resulting from the schedule will be shifted to some extent from the involved executive branch agencies to Congress. This shift could reduce the extent to which the agencies could be held accountable for progress. Agency accountability will be greater if the agencies themselves develop and certify the feasibility of the schedule they are to meet.

OPTION 2:
A conservative **schedule.**

Advocates of a more conservative schedule for repository development—one that allows for unforeseen delays and provides ample time to review more sites and media and to resolve the remaining technical uncertainties—argue that a conservative approach is needed to build public confidence that the job is being done safely and that no corners are being cut in haste. (This approach is typified by the IRG recommendation of a cautious repository development process involving review of four to five sites in two to three geologic media before selecting a site for development.)

A conservative schedule poses risks of its own. In the first place, it maybe no more capable of gaining broad public support than an accelerated schedule. While a conservative schedule deals with the concerns of those who fear that haste could compromise safety, it may not be responsive to concerns of those who believe that a rapid demonstration by the Federal Government of both the will and the technical capacity to dispose of radioactive waste is needed. In fact, strong dissatisfaction with the schedule implied by the Carter administration policy, which envisioned a repository perhaps not available until 2007, was a major reason for congressional efforts to accelerate the schedule and for the decision by the Reagan administration to speed up the process by examining only three sites in two media, the minimum required by NRC, before selecting a site for development.

Such a distant target date could generate a relaxed attitude towards the program schedule by those responsible for implementing it and may increase the risk of planning being minimal, of milestones being missed with few apparent consequences, and of the goal continuing to recede into the future.

Moreover, the further away the target date for a repository, the more strongly the utilities could argue that the Federal Government has a responsibility to take some earlier action to relieve them of the storage problem created by the slow Federal approach to repository development. If this action involved construction of a new Federal storage facility, such a facility would probably use one of the easily expandable dry storage technologies, such as the surface drywell, thus further reducing pressures for development of a repository and creating a relatively easy and economical way to continue to defer the costs of the disposal system.

Selection of the pace for repository development requires balancing the concerns that too fast a pace would not be consistent with safety against the concerns that too leisurely a pace would not allay public fears about waste disposal in a timely manner and would not adequately address utilities' concerns about an open-ended liability for storing growing inventories of spent fuel.

Agreement about an appropriate schedule maybe facilitated by shifting the focus of the argument from the ***speed*** of the. schedule to its ***certainty*** and ***commitment.*** Analysis performed by OTA suggests that what is most important in securing and sustaining public confidence, and in providing utilities with a solution to their spent fuel storage problem, is not how quickly a repository can be made available, but whether it will be available according to a firm schedule, backed by a firm Federal commitment, and accepted widely (by utilities, environmentalists, and all other interested parties) as feasible

[21] Testimony of James F. Devine, Assistant Director of Engineering Geology of the USGS, before the Committees on Energy and Natural Resources and on Environment and Public Works, of the U.S. Senate, Oct. 6, 1981.

and reasonable in view of the remaining technical and institutional uncertainties about siting.

A firm Federal ***commitment*** to accept waste at a repository on a fixed but relatively cautious date would represent a strengthening of Federal determination and could provide the most complete and credible solution to the waste disposal problem for both the public and the nuclear utilities. Such commitment to a date might greatly ease the utilities' job of providing interim storage until that date by removing one of the major sources of objection to expanded at-reactor storage: the concern that such storage would become de facto final isolation.

A major concern with this approach is that the credibility of any future Federal schedules may be very low because schedules for the availability of a geologic repository have slipped drastically from 1985, as estimated in 1976, to 2006—at the latest—according to 1982 DOE estimates.[22] The problem is compounded by the significant institutional and technical uncertainties affecting progress in waste disposal.

A credible commitment to a firm date would require both a realistic target date and a conservative technical program for meeting it. The target date must strike a balance between speed and certainty. On the one hand, locating sites as early as possible would limit the buildup of spent fuel in interim storage facilities. On the other hand, too optimistic a date runs the risk of failure, which could have significant political impacts and could create difficulties for utilities that have made storage plans based on that date. To the extent that utilities need a ***firm*** schedule for their ***own*** planning, the reliability of the schedule may be more important than the speed.

A conservative target date for operation of the first repository would allow ample time for a second candidate site to be identified and carried through the licensing process independently of the first-thus increasing the confidence that a firm commitment to the target date could be met even if the first site were rejected by NRC. Such a possibility must be considered because of the lack of technical consensus about the likelihood of a site that appears acceptable after characterization ultimately receiving an operating license. If ***the first site proves to be acceptable to NRC, a repository could be available earlier than promised.***

Recent DOE analysis concludes that a site in a medium (granite) not now under consideration for the first repository could be licensed by early 1999.[29] This suggests that a full-scale repository could be in operation by 2008 even if none of the sites under consideration at the time NWPA was being debated proved acceptable, provided that a backup siting program is pursued.

An acceleration and expansion of ongoing DOE activities may be needed to give high confidence that a commitment to a firm schedule—even a conservative one—can be kept in spite of technical and institutional uncertainties. In particular, the technical program would require enough backups to each component of the disposal technology and to each site to ensure that at least one acceptable combination would be available by the target date, even though more or less predictable difficulties and failures occur. 24

There is now no technical consensus about the likelihood that any particular site that appears suitable for licensing at the end of site characterization will, in fact, survive the entire licensing process. For this reason, commitment to a schedule for the activities involved in identifying a first candidate repository site and taking it through the licensing process is not equivalent to a commitment to a schedule for availability of a licensed repository site.

The relevant agencies could meet every deadline in a schedule for the first candidate site and still wind up at the end of the licensing process with a rejection from NRC and thus no operating repository. While another site could be submitted if the first were rejected, the repository availability date would slip significantly, a fact which the public might well perceive as a major failure in the waste management program.

The most straightforward way to reduce the risk of licensing rejection is *to* provide the time and resources necessary to carry more sites than necessary through the site characterization process and into the licensing process so that backups are immediately available if the first site considered cannot be licensed. This redundant approach might increase the initial costs of developing the repository system. However, it appears certain that more than one site will eventually be needed anyway, so the effect on total management costs in the long run may be less significant.

Commitment to a fixed schedule will thus be more expensive, if the probability of failures is minimized, than commitment to a more flexible target date because of the greater redundancy needed to assure success on schedule. A detailed analysis of the additional cost would require development of a more detailed program plan than has been available to date.

In any case, the additional cost should have no significant effect on the economic competitiveness of nuclear power. For example, a program that was 160 percent more expensive than DOE's proposed program would add only about O. 1 cent per kilowatt-hour to the

[22]DOE *National Plan for Siting High-Level Radioactive Waste Repositories and Environmental Assessment—Public Draft,* DOE/NWTS-4, February 1982, p. 112.

[23]DOE *Mission Plan for the Civilian Radioactive Waste Management program,* DOE RW-0005 Draft, April 1984, vol. I, p. 3-A-44.

[24]Redundancy is a standard design procedure in the development of highly reliable systems, and is routinely used in the U. S, space program.

cost of nuclear generated electricity.[25] Furthermore, any cost increase may be more than offset by the reduced risk of incurring the costs of failure if reactors are forced to shut down. From this perspective, the extra costs of a conservative approach can be seen simply as the premiums for insurance against the costs of failure.

The Resolution

The NWPA made a Federal commitment to a firm schedule for repository development by requiring that the first geologic repository begin operation by January 1998, the nearer end of the range of dates that DOE had estimated for that event. DOE analysis suggests that this date can only be met if the first site submitted for licensing is approved (or if a backup site is submitted at the same time as the primary candidate so that it would be available with no delay if the first is rejected); and if initial operation of the repository is achieved before the repository's full-scale receiving and packaging facilities are completed.[26] A more extensive discussion of this question, and of the program implications of the commitment to a firm schedule, is found in chapter 6.

ISSUE 3:

What provision for the possibility of reprocessing should be made in the waste management system?

As discussed in chapters 3 and 4, there is strong disagreement about whether spent fuel should ever be disposed of directly without reprocessing. This has been reflected in debates about the appropriate design for the high-level radioactive waste disposal system.[27]

OPTION: 1. Design the disposal system assuming that all spent fuel will be reprocessed.
2. Design the disposal system assuming that no spent fuel will be reprocessed.
3. Design the disposal system to accommodate both spent fuel and reprocessed waste.

The Debate

OPTION 1:

Design the disposal system assuming that all spent fuel will be reprocessed.

This option has two implications for system design. First, no provision would have to be made for direct disposal of spent fuel. A spent fuel disposal package and the equipment and facilities for packaging and emplacing spent fuel in a repository would not be developed, and sites with geochemical conditions suited for spent fuel disposal would not be sought. Second, provisions would probably have to be made for extended and indefinite storage of spent fuel because of the uncertainty about when reprocessing would be economical. This is quite compatible with a decision to provide a disposal system on a fixed schedule (issue 1). Once disposal sites were licensed, construction of full-scale disposal facilities could be deferred, if desired, and extended storage facilities could be constructed at the sites instead.

This option allows continued access to the unused uranium and plutonium in spent fuel and greater flexibility in the choice of a disposal systetn. Geologic disposal of reprocessed waste, and not spent fuel, permits tailoring the waste form to the characteristics of a particular repository and would allow separation and separate disposal of the heat-producing, but relatively short-Iived fission products from the cool, but very long-lived transuranic elements in the waste. This option might also allow use of disposal systems such as space disposal that are not practical with spent fuel.

On the other hand, it now appears possible, if not likely, that even if the demand for electricity increases sharply enough to warrant large-scale use of breeder reactors, only part of the spent fuel expected to be generated by light-water reactors might have to be reprocessed to provide enough plutonium to start up the breeders. If breeder reactors are not used, there may be little commercial incentive to recycle uranium and plutonium for use in light-water reactors. Even if some recycling occurs, there could be an economic incentive to dispose of spent fuel containing plutonium that had been recycled several times previously.

Furthermore, a requirement that only reprocessed waste be disposed of could increase the cost of waste disposal by requiring reprocessing of spent fuel in some cases in which the cost of reprocessing could not be offset by sale of the recovered uranium and plutonium. Since this situation would probably require expenditure of billions of dollars for construction and operation of federally owned reprocessing plants, and since existing and proposed regulations would allow direct disposal of spent fuel without reprocessing, it seems likely that the choice would be made to continue to store spent fuel while developing the capacity to dispose of it directly. Thus, a decision not to provide the capability to dispose of spent fuel may lead to additional disposal costs in the future, either for uneconomic reprocessing of some spent fuel or for additional storage of that spent fuel while the capacity to dispose of it is developed,

[25] Congressional Budget Office, *Financing Radioactive Waste Disposal*, September 1982, summary table p. xv.
[26] DOE, *Draft Mission Plan*, fig. 3-A-5, p. 3-A-38.
[27] See discussion of reprocessing in ch. 3 for technical background and references.

OPTION 2:

Design the disposal system assuming that **no** spent fuel will be reprocessed.

Developing the disposal system for spent fuel alone would involve planning for the use of disposal capacity as soon as it is available. The policy of the Carter administration appeared in many respects to be similar to this option, Reprocessing was deferred, work on waste forms was limited to the military program, and most studies of disposal policy published by the administration showed spent fuel being directly disposed of as rapidly as repositories could be made operational; however, the policy's stated purpose was to develop a disposal system that did not preclude future decisions to reprocess.

Developing the capacity to dispose of spent fuel directly would enable an earlier large-scale demonstration of waste disposal than would occur if the disposal system were designed only for reprocessed waste. Significant quantities of spent fuel could be disposed of as soon as a repository was available. A demonstration of disposal at commercial scale—which could involve emplacement of perhaps a thousand tonnes of spent fuel or more over a period of years—could answer questions about ability to license and operate a full-scale disposal system more completely than could a small-scale unlicensed technical demonstration.[28] It would also permit observation of repository performance under a significant heat load for an extended period.

One cost of the demonstration would be loss of the potential resource value of the spent fuel used. However, since existing reactors and those with construction permits alone would generate over 100,000 tonnes of spent fuel during their lifetimes, disposal of even 10,000 tonnes would represent less than 10 percent of the total and would lead to only a small increase in total uranium requirements if recycling and an expansion of nuclear power ultimately occurred.[29] The benefit of an early, tangible demonstration of commercial-scale waste disposal could offset the lost resource potential.

There are several disadvantages to designing repositories for spent fuel only. First, since practically all military high-level waste is reprocessed waste, designing a commercial system to manage only spent fuel would limit the range of options for dealing with military wastes. Second, the burden of developing the capacity to dispose of reprocessed waste may shift to the future if it turns out to be more economic to reprocess spent fuel than to dispose of it directly. Modifying the initial spent fuel disposal system design later to handle reprocessed waste could increase disposal costs.

OPTION 3:

Design the disposal system to accommodate both spent fuel and reprocessed waste.

The major advantage of this option is that it gives future decisionmakers the greatest range of choices and leaves open the option to reprocess spent fuel. This neutrality aboul reprocessing may be seen as a disadvantage by those who favor or oppose reprocessing for reasons not related to waste management. As discussed above, it is not clear that either option 1 or 2 can do more than inconvenience future decisionmakers, who can always use extended storage if reprocessing or direct disposal of spent fuel do not appear advisable.

As noted in chapter 3, recent major studies of the subject have concluded that mined repositories could be designed for both spent fuel and reprocessed waste without compromising safety. Of course, a system designed to handle both forms may be somewhat more expensive over the short term than a system optimized for one or the other, although no data are available to support an estimate of the additional cost. However, such a system may be less expensive in the long run since it avoids the possible costs of extended storage and system redesign necessary for conversion from a single-waste form system to a multiwaste-form system.

The Resolution

The NWPA provides that geologic repositories shall be capable of receiving either spent fuel or reprocessed high-level waste.

ISSUE 4:

What responsibility should the Federal Government assume for interim spent fuel storage before a permanent repository is available?

The delays in availability of both reprocessing and a Federal waste repository have presented utilities with two related problems. First, the existing spent fuel storage basins at reactors are filling up. Even if the capacity of existing basins is expanded by reracking to the maximum extent possible, and if utilities are allowed to transship fuel from reactors whose basins are filled to unfilled basins at other reactors, some face the risk of forced reactor shutdowns by the 1990's unless additional storage space is made available on a timely basis.[30]

[28] Along these lines, one nuclear industry group recommended that some spent fuel should be placed in terminal waste disposal repositories for near-term demonstration purposes, although they did not recommend that spent fuel be routinely disposed of in repositories, "Spent Fuel and Nuclear Waste," a statement by the Atomic Industrial Forum's Study Group on Waste Management, Oct. 18, 1978.

[29] One study has concluded that a policy of disposing of spent fuel when it is 20 years old would not significantly limit the ability to develop breeder reactors. Brian G. Chow and Gregory S. Jones, *Nonproliferation and Spent Fuel Disposal Policy*, a report prepared for the Council on Environmental Quality (Marina Del Rey, Calif.: Pan Heuristics, October 1980).

[30] DOE, *Spent Fuel Storage Requirements*, DOE/RL-83-1, January 1983, table 4, p. 17.

Many utilities have expressed concern about whether they would be able to provide the needed additional storage capacity quickly enough to prevent reactor shutdowns.

Second, even if utilities were certain that they could provide additional storage when needed, the uncertainty about when spent fuel could be shipped to a reprocessing plant or a Federal waste repository leaves the utilities with an open-ended liability for growing inventories of spent fuel and no clear basis for planning their long-term storage needs. There is an important linkage between this long-term problem and the near-term problem of providing additional storage quickly enough to prevent reactor shutdowns. As noted in chapter 4, there has been growing opposition to efforts to provide additional spent fuel storage capacity because of fear that availability of interim storage would reduce pressures for developing long-term solutions, thus turning interim storage facilities into de facto permanent waste repositories.

The effectiveness of a storage policy in preventing reactor shutdowns may be the greatest determinant of its potential economic impact. As noted in chapter 3, the cost of replacement power for a l-GWe reactor for 1 year could exceed the total discounted cost of permanent storage in a new water basin for all the spent fuel the reactor would generate during its operating lifetime. The ability to ensure timely availability of additional interim storage capacity is therefore a primary criterion for evaluating interim storage options. However, because the uncertainties about the long-term fate of spent fuel may constitute a serious obstacle to gaining the necessary approvals for interim storage facilities, it may be difficult to resolve the near-term storage problem in a timely manner without at the same time addressing the long-term question.

At present, it appears unlikely that the development of large-scale commercial reprocessing could provide a very timely or predictable way to ease the spent fuel storage problem at reactors. The private sector appears to have no interest in constructing and operating reprocessing facilities now, since reprocessing may not become economical until sometime in the next decade, at the earliest.

Even if the Allied General Nuclear Services (AGNS) reprocessing plant at Barnwell, S. C., began reprocessing operations at its projected full capacity of 1,500 tonnes per year in the early 1990's, it would at most be able to handle only the expected overflow of spent fuel from existing basins. It could not handle the total annual discharges from reactors expected to be in operation at that time. It would take one such plant over 25 years to eliminate the backlog of spent fuel that would have accumulated in reactor basins by that time. Because of the high cost of such plants and the very uncertain market for the uranium and plutonium recovered from spent fuel, it appears unlikely that the plants will be constructed on a reliable schedule by either the private sector or the Federal Government.

While a Federal waste repository would provide utilities with a way to get rid of spent fuel, a licensed, full-scale geologic repository could probably not be available before the late 1990's, leaving a need for additional spent fuel storage capacity for the interim period. DOE estimates that by 1998 over 60 reactors will need storage capacity beyond that available in their existing pools.[31] The interim period could be considerably extended if a very conservative schedule for availability of a repository were adopted (issue 2). Thus, the choice of a Federal interim spent fuel storage policy may depend significantly on the final isolation policy that is selected.

The Carter administration raised the possibility of a direct Federal role in interim spent fuel storage when it advocated that the Federal Government acquire an away-from-reactor (AFR) storage facility and offer to accept commercial spent fuel for storage until permanent disposal facilities were available. The 96th Congress did not authorize acquisition of an AFR facility, and the Reagan administration concentrated its efforts instead on helping the utilities provide their own storage capacity. The question of the appropriate Federal role in interim spent fuel storage was debated again in the 97th Congress. The following discussion evaluates the principal options considered in that debate, in light of the proposed options for providing a final isolation system considered in the preceding issues.

As background for this discussion, it is useful to understand the relationship between the two distinct storage issues considered in the 97th Congress: 1) the "AFR" issue, i.e., the question of the Federal role in interim spent fuel storage, and 2) the "MRS' issue, i.e., the question of whether the Federal Government should construct MRS facilities designed to store spent fuel and high-level waste for a long and perhaps indefinite period.

The distinction between these two concepts is not clear. An MRS has generally been thought of as being located away from reactor sites, and thus could be considered an AFR. Similarly, any storage facility, even if intended only for interim storage, as contemplated for AFRs, would be monitored and retrievable, and thus could be considered an MRS. Furthermore, it is possible that the same type of storage technology—metal casks or drywells—would be used in either case.[32]

[31] Ibid., table C-3, pp. 73-76.

[32] See Rasmussen, op. cit., which evaluates casks and drywells for both interim storage and monitored retrievable storage.

Finally, there is some overlap in intended function in that proponents of a Federal AFR argued that it would provide some flexibility in the event of slippages of the geologic repository schedule—one of the arguments for a Federal MRS facility.

The principal difference is that the AFR debate has tended to focus on the question of providing additional storage capacity until a geologic repository is available, with emphasis on the near-term problem of providing such storage in time to prevent reactor shutdowns. In contrast, the MRS debate has focused on the longer-terrn questions of whether to provide Federal storage facilities either as an alternative to rapid development of geologic repositories (considered in issue 1) or as a backup in case of slippage in the repository program (discussed in the chapter 6). Since a full-scale MRS facility could probably not be designed, sited, licensed, and constructed before 1994 or 1995,[33] such a facility would not address the immediate problems of the utilities which will exhaust the capacity of their reactor basins before then—the more immediate focus of the AFR debate.

The following discussion will concentrate on the interim storage questions raised in the AFR debate, while the question of the role of MRS facilities as a backup in case of slippages in the repository program is discussed in chapter 6.

OPTION: 1. No Federal role in interim storage; complete responsibility of private industry.
2. Federal assistance to private storage efforts by reducing legal obstacles; speeding the licensing process; and accelerating research, development, and demonstration of new storage technologies.
3. Federal provision ofa limited amount of storage capacity for emergency use only.
4. Federal storage capacity as an alternative to construction of new storage facilities by utilities.

The Debate

OPTION 1:

No Federal role in interim storage; complete responsibility of private industry.

In 1982, DOE analysis of utility-provided data showed that conventional reracking could meet all utility storage needs until 1986 or 1987 if transshipment were aUowed.[34] The need for additional storage could be deferred several more years if reactors did not maintain full core reserve—the amount of space needed to discharge the entire reactor core—although this would involve some risk of extended shutdown if the core had to be removed for maintenance or repairs. Moreover, it appears that new water basins or other new storage technologies could be constructed at reactors by 1988, perhaps sooner, if begun in 1981 or 1982 (when the AFR issue was being debated) .35

Thus, it appears theoretically possible that even with no Federal action, no reactor would have to shut down for lack of spent fuel storage capacity. There are, however, two important cautions in this conclusion. First, although several of the new storage technologies, especially casks, have the potential for faster implementation than conventional water basins, they will not be realistic alternatives for most utilities facing immediate storage decisions until their technical feasibility and their ability to be licensed have been demonstrated.

Second, it is not known whether the private sector will receive timely permission for constructing and operating any new spent fuel storage facilities, or even for reracking or transshipment. The primary potential sources of delays are complications in the licensing process and State and local laws and regulations that limit the quantity of fuel that can be stored at a reactor. Previously, such factors have not adversely affected reactor operations, although there appears to be considerable concern among utilities that this could be a serious problem in the future, particularly with new technologies for which there is no licensing experience. This concern underlies the utilities' desire for a Federal AFR facility, since many believe that the Federal Government will be better able to provide additional storage capacity in the face of opposition than utilities could.

One drawback is the concern that interim storage might become de facto permanent storage because of the uncertain status of spent fuel. Thus, adoption of a very conservative or open-ended schedule for availability of a Federal waste repository may make it more difficult for utilities to provide additional interim storage capacity on their own than would a program that included a fixed schedule for a repository.

OPTION 2:

Federal assistance to private storage efforts by reducing legal obstacles; speeding the licensing process; and accelerating research, development, and demonstration of new storage technologies.

Several Federal actions could help utilities provide adequate spent fuel storage capacity in time to prevent

[33] Ibid., p. 6.2.

[34] DOE, *Spent Fuel Storage Requirements*, DOE/RL-82-1, June 1982. An update of that analysis in 1983 reached the same conclusion, although it identified one reactor that might need 13 tonnes of additional storage in 1984—DOE, *Spent Fuel Storage Requirements, 1983*, op. cit.

[35] E.R. Johnson Associates, Inc., *A Preliminary Assessment of Alternative Dry Storage Methods for the Storage of Commercial Spent Nuclear Fuel*, JAI-180 (DOE/ET/47929-l), November 1981, table 7-1, p. 7-3.

reactor shutdowns. One would be Federal support of an accelerated program for rapidly developing new dry storage technologies and demonstrating their ability to be licensed for use at reactor sites. Many utilities may prefer to stick with proven technology-water basins with conventional reracking—for providing new storage capacity, even though the likelihood that at least some of the new technologies will prove acceptable appears high. However, one large utility, the Tennessee Valley Authority (TVA), is already planning to demonstrate some of the new technologies-rod compaction and dry storage—in the next few years before it commits to the construction of new interim storage facilities.

The availability of these technologies for general use by utilities might be significantly accelerated by an aggressive Federal research, development, and demonstration program to resolve remaining technical and economic questions and to share some of the costs of licensed demonstrations.

Approval of interim storage capacity might be hastened by an explicit statement of congressional intent about interim storage in existing or new storage facilities. Such a statement might speed the resolution of questions of Federal preeminence over State and local restrictions on spent fuel storage.

Adoption of a firm, credible schedule for the availability of a final isolation facility could reduce both the opposition to utilities' efforts to provide their own interim storage facilities and the financial risks created by the uncertainty about how long such facilities would be needed. Potential problems might be further lessened by a favorable resolution of NRC's ongoing generic confidence proceeding about the timely ultimate disposal of spent fuel and about the safety of continued storage until disposal is available. The proceeding was initiated precisely because of objections to provision of indefinite interim storage.[36]

OPTION 3:

Federal provision of a limited amount of storage capacity for emergency use only.

Although it is possible that utilities will be able to provide all their own interim storage capacity, it is not certain that all would be able to do so before their existing storage capacity is exhausted. Thus an argument can be made for providing some Federal storage capacity as a last-resort backup to prevent unavoidable reactor shutdowns while utilities construct their own new storage capacity. The need for such capacity depends on the importance attached to avoiding the risk of shutdowns and the associated economic costs of providing replacement power.

The amount of Federal storage needed as a last resort backup to utilities' storage programs could be much smaller than would be needed if Federal storage were intended to handle all spent fuel storage in excess of the capacity of existing basins. The major source of demand for emergency capacity would probably occur in the late 1980's and early 1990's as a result of possible delays in bringing new storage facilities online. Only 1,000 tonnes of storage, approximately the lifetime capacity needed for a l-GWe reactor, would be required to give every one of the 24 reactors projected to need new storage capacity before 1990 an additional 2 years to provide that capacity themselves.[37]

However, if Federal storage were used as a substitute for additional utility storage, rather than a backup in case of delays in utilities' efforts, about 5,000 tonnes of Federal storage would be needed to handle the needs of those same 24 reactors until 1998, the target date for operation of a geologic repository established by NWPA.[38] Of course, provision of limited Federal storage capacity for emergency use only would not deal with the utilities' long-term problem of liability for growing inventories of spent fuel, and thus might be more compatible with a fixed schedule for a Federal waste repository, which would solve that problem, than with a flexible or indefinite schedule.

A clear decision to provide Federal storage facilities for use only in emergency cases would demonstrate to utilities that they must immediately begin planning to provide their own facilities. Any possibility that the Federal Government might later provide an alternative to construction of new facilities by utilities could encourage them to defer action and could also discourage private efforts to develop new storage technologies.

To prevent Federal emergency storage capacity from dampening utility efforts to provide storage, several actions could be taken. First, utilities could be required to show that they have made their best effort to provide their own storage. Second, existence of State or local prohibitions on increased storage could be disallowed as a justification for use of the Federal storage option, thereby facing the affected communities with the choice of shutting down a reactor or allowing increased storage.

Several options for providing Federal storage capacity may be available in the next decade. The most readily available appears to be use of modular dry storage (casks or drywells) at existing Federal facilities on

[36] In Au_wst 1984, NRC issued a final rule embodying the results of the waste confidence proceeding, in which it stated that "there is reasonable assurance that one or more mined geologic repositories for commercial high-level radioactive waste and spent fuel will be available by the years 2007-2009, and that in any case, spent fuel could safety be stored at either reactor sites or offsite for up to 30 years after the expiration of the reactor's operating license. *Federal Register, vol. 49, No.* 171, Aug. 31, 1984, p. 34659-34660.

[37] DOE, *Spent Fuel Storage Requirements, 1983,* table C-1, p. 65.
381 bid., table C-3, pp. 73-76.

Federal reservations. Availability of space in Federal facilities could enable deferral of acquisition of other facilities for several years, allowing questions about the availability of new storage technologies for utility use to be resolved and permitting a more accurate estimate of the needs for Federal storage. While these facilities would probably not be licensed, they could be available quickly.

Federal acquisition of existing private facilities with storage basins has also been considered.[39]

OPTION 4:

Federal storage capacity as an alternative to construction of new storage facilities by utilities.

An offer to accept spent fuel at a Federal AFR facility would be an effective alternative for reducing the utilities' open-ended liability for spent fuel if the availability of final isolation facilities remains uncertain. However, several objections have been made to providing such a facility for this purpose. Some argue that the Government should not subsidize nuclear power by removing the burden of uncertainty about interim storage from the generators and users of nuclear electricity, which is a commercial responsibility. In addition, some object that a Federal AFR facility could take the pressure off Government and industry to decide whether and when to develop disposal capacity.

In support of this option, it can be argued that since the Federal Government has the responsibility to provide for permanent isolation of high-level radioactive waste and is itself directly responsible for the delays and uncertainties about providing this service, it has an obligation to the users of nuclear power to share the burden of spent fuel storage created by its own inaction.

Provision of an open-ended Federal interim storage capacity is the storage option most compatible with continued flexibility about the date of availability of a permanent repository. However, the amount of spent fuel moved to Federal interim facilities could increase rapidly if the availability of final isolation sites is deferred much beyond the turn of the century. Thus, providing Federal spent fuel storage capacity as an alternative to constructing new facilities by utilities may lead to an increasing amount of spent fuel being stored at AFR interim sites, since it appears that utilities, left to their own devices, may have an economic incentive to provide additional capacity at reactor sites, if possible.[40] There would be several effects of this action.

SAFETY

NRC has concluded that spent fuel can be safely stored either at reactor sites or at AFRs.[41] The additional handling and transportation involved in AFR storage could lead to some increase in worker and public radiation exposure compared to onsite storage.

TRANSPORTATION

DOE estimates that by 1998, over 7,000 tonnes of spent fuel will require storage outside the basins of the reactors in which they were produced.[42] Interim storage of that spent fuel at sites other than those at which they were generated will increase the total amount of handling and transportation of spent fuel, and could increase the total number of communities affected by radioactive waste management activities.

Movement of significant amounts of spent fuel to interim storage facilities away from the site of generation may occur before a repository is available even if the Federal Government plays no role in interim storage, because transshipment is more economically attractive than is construction of new facilities. In fact, DOE estimates that about 2,100 tonnes of the storage needed by 1998 could be met in this way.[43] (This amount could be reduced if rod consolidation—not considered in DOE's estimates of the maximum capacity of existing basins—proves to be usable at many reactors.)

However, provision of Federal AFR storage as an alternative to utility efforts once existing basins are full could more than triple the amount of spent fuel moved to interim storage before 1998.[44] In addition to increasing transportation impacts, use of a Federal AFR facility for this purpose could increase the likelihood of confrontations between the Federal Government and affected States or localities over transportation issues.

COST

Various DOE analyses of the costs of storage have concluded that federally owned facilities would be less costly to utilities than would privately owned facilities. To some extent, this is a result of the economies of scale involved in a large Federal AFR facility, an advantage that may be offset by transportation costs or the availability of less-expensive dry storage technologies for at-reactor use. To a significant extent, it is simply the result of the economics of Federal ownership. For example, DOE analyses indicate that the cost of privately owned facilities could be up to 100 percent higher than

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[39] These include the General Electric facility at Morris, Ill., which is already storing some commercial spent fuel, and the AGNS facility at Barnwell, S. C., which has an unused storage basin that could be reracked to provide 1,750 tonnes of capacity. DOE, *Spent Fuel Storage Fact Book, DOE/NE-0005*, April 1980, table 4, p. 24.

[40] As noted in ch. 3, the new modular dry storage technologies may be less expensive to implement at reactor sites, which already have handling facilities, than at a centralized site which would require new facilities.

[41] U.S. Nuclear Regulatory Commission, *Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel*, August 1979, NUREG-0575, vol. 1, p. S-3.

[42] DOE *Spent Fuel Storage Requirements, 1983*, table 3, p. 16.

[43] Ibid. Derived from table 3.

[44] Ibid.

identical federally owned facilities because of the lower cost of capital for the Federal Government and because of the Government's immunity to Federal, State, and local taxes.[45]

There has been no systematic comparison of the costs of at-reactor and AFR interim storage that includes the cost of transportation, that considers use of the new modular dry storage technologies both at reactors and at independent AFR facilities, and that uses a consistent set of financial assumptions for ail facilities, regardless of ownership. However, available studies suggest that at-reactor storage using modular dry storage technologies could be less expensive than AFR storage, even without considering the additional cost of transportation to an AFR facility.[46]

Nonetheless, any conclusions about the relative costs of at-reactor and AFR storage must remain tentative until a fully consistent comparison of at-reactor and AFR options is made. Since the modular dry storage technologies may have significant cost advantages compared with water basins, whether used at reactors or away from reactors, accelerated development and licensed demonstrations of those technologies could be very useful for determining their actual costs more precisely.

EQUITY CONSIDERATIONS

There may be significant differences among spent fuel storage systems in the distribution of their impacts among the private sector, the Federal Government, and various regions of the country. For example, with an at-reactor storage system, the health and safety risks and social impacts of storage are distributed among communities that have presumably benefited directly from the electricity generated by the spent fuel. These same communities would have to bear the costs of reactor shutdowns if additional storage space were not provided.

With an AFR system, the risks and impacts of storage are localized to those few communities in the vicinity of the AFR facility, which may or may not have benefited from the electricity generated by the spent fuel. Many additional communities would be affected by increased spent fuel transportation to the AFR facility. As a result of such distributional effects, provision by the Federal Government of a significant amount of AFR storage capacity as an alternative to utility provision of new storage facilities raises more equity considerations than do the options for Federal involvement which have less direct effect on the location of storage. As noted in chapter 4, such considerations have played an important role in debates about radioactive waste management issues.

ASSURANCE OF STORAGE CAPACITY

Reliance of utilities on the Federal Government for provision of a significant portion of their interim storage needs could increase the vulnerability of the storage system to failures. Analysis by DOE shows that by 1998, over 60 of the currently operating reactors could be relying on a Federal AFR facility for storage.[47] In this situation, any licensing delays, failures in acquiring additional AFR capacity, shutdowns of an AFR facility because of accidents or sabotage, or serious transportation problems could make many reactors vulnerable to potential shutdowns simultaneously. In contrast, a storage system in which utilities provide lifetime interim storage onsite, which would be encouraged by limiting Federal storage to backup use only, would completely insulate the utility and its ratepayers from any bottlenecks or failures elsewhere in the spent fuel storage and waste management system.

The Resolution

The NWPA incorporated a combination of options 2 and 3. Utilities are given the primary responsibility for providing the additional spent fuel storage needed until a Federal repository is available. To assist utilities in this effort, the Act provides for an accelerated program for licensed demonstrations of new storage technologies and encourages generic licensing of such technologies when possible. At the same time, the Act provides for a limited amount (1 ,900 tonnes) of last-resort Federal storage in existing Federal facilities, with NRC to make the determination about which utilities are entitled to use that storage. Federal acquisition of existing private facilities for spent fuel storage was not authorized.

Appendix Note

The original Atomic Energy Act made no reference to either radioactive waste or to waste disposal. The first formal regulations on the subject were promulgated by the Atomic Energy Commission in 1970 (Appendix F to Part 50 of Title 10 of the Code of Federal Regulations). These regulations required liquid high-level waste produced by reprocessing of spent fuel to be solidified

[45] DOE, *Technology for Commercial Radioactive Waste Management*, DOE/ET-0028, May 1979, vol. 3, p. 5.7.55.

[46] E.R Johnson Associates op. cit. , estimated that the cost Of at-reactor storage using surface drywells could be as low as $117 per kilogram of spent fuel. DOE, *The Monitored Retrievable Storage Concept*, p. 2-6, concluded that storage in a centralized privately financed 10,000-tonne drywell facility could cost from $100 to $170 per kilogram, with $160 per kilogram as the estimated fee based on the set of assumptions judged most likely to be accepted. Transportation from the reactor to an AFR could add around $16 per kilogram to this amount (table 2-4, p. 2-22). See also chapter note 1 in ch. 6.

[47] DOE, *Spent Fuel Storage Requirements*, 1983, table C-3, pp. 73-74.

and delivered to a Federal repository within 10 years of reprocessing, at which time the industry would pay a fee calculated to cover the costs of 'disposal and perpetual surveillance. While the regulations distinguish between temporary storage, which can take place on privately owned property, and disposal, which can take place only on federally owned and controlled land, there is no clear definition of either term, and the reference to perpetual surveillance suggests that "disposal" could be interpreted to mean permanent storage.

It should be noted, however, that the Atomic Energy Commission, in proposing the Retrievable Surface Storage Facility, did distinguish between storage and disposal in terms of the continued human control and maintenance that is required for storage but not for permanent disposal.[48]

The Energy Reorganization Act of 1974 (Public Law 93-438), which split the functions of the Atomic Energy Commission between the Nuclear Regulatory Commission and the Energy Research and Development Administration (ERDA), gave the new NRC the licensing and regulatory authority over ERDA facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under the act [Sec. 202(3)] and over Retrievable Surface Storage Facilities and other facilities authorized explicitly for subsequent long-term storage of high-level radioactive waste generated by ERDA, which are not used for or part of research and development activities [Sec. 202(4)]. These sections, which form the basis for NRC licensing authority, make no references to disposal facilities and do not define storage.

[48] U.S. Atomic Energy Commission, op. cit., pp. 1.2-11,12; and p. 2.3-21.

NRC has interpreted storage to include disposal, which it takes to mean emplacement of waste with no intention to retrieve. However, this definition is silent on the acceptability of a requirement for continued institutional control, since emplacement with no intention to retrieve could be effected in a storage facility that nonetheless required control to ensure safety. NRC has so far applied the term *disposal* only to geologic disposal facilities and has developed regulations only for such facilities.

Finally, the Department of Energy Organization Act (Public Law 95-91, August 1977,91 Stat. 565) explicitly gave the new DOE responsibilities for "the establishment of temporary and permanent facilities for storage, management, and ultimate disposal of nuclear wastes' [Title 42, Ch. 84, Sec. 7133. (8)(C)], and "establishment of programs for the treatment, management, storage, and disposal of nuclear wastes" [Sec. 7133 (8)(E)]. However, once again no definitions were given for storage and disposal, and the statement in (8)(C) can be read as allowing for permanent storage facilities. In addition, section 7133 (8)(F) gives DOE authority to establish fees or user charges only for nuclear waste treatment or storage facilities and makes no mention of disposal facilities, thus perpetuating the confusion between the two concepts.

The Nuclear Waste Policy Act of 1982 (Public Law 97-425) clarified the distinction by defining disposal as emplacement of waste in a repository with no foreseeable intent of recovery, and also defining a repository as a system for permanent deep geologic disposal. Since deep geologic repositories are designed not to rely on long-term institutional control and maintenance, this definition implicitly incorporates the idea that disposal does not require such continued care.