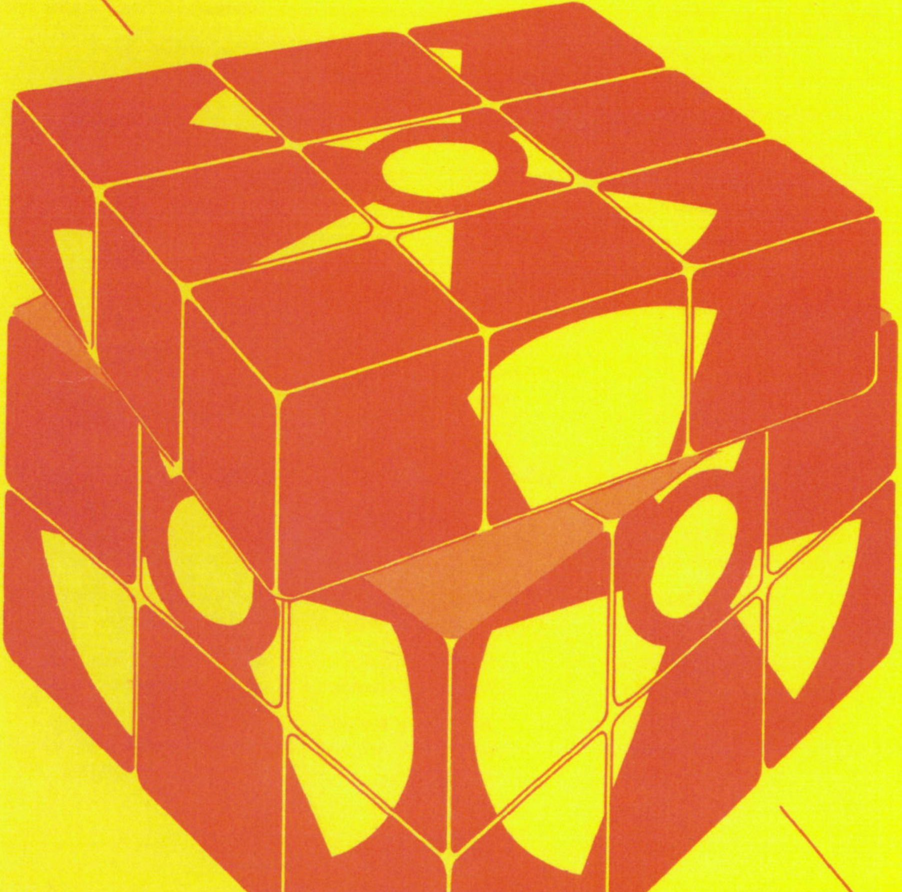
Managing Commercial High-Level Radioactive Waste



CONGRESS OF THE UNITED STATES
Office of Technology Assessment
Washington, D.C. 20510

Summary

Managing Commercial High-Level Radioactive Waste

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Foreword

This summary presents the findings and conclusions of OTA's analysis of Federal policy for the management of commercial high-level radioactive waste—an issue that has been debated over the last decade and that now appears to be moving toward major congressional action.

Both this summary and the full report are the final products of a 3-year effort at OTA. During that time we have contributed to committee actions and congressional deliberations on nuclear waste management—including such issues as storage technologies, away-from-reactor storage facilities (AFRs), funding, and the role of a comprehensive program in which actions to deal with near-term problems are designed as part of broader measures to deal with long-term problems. In July 1980, for example, an OTA memo for the Senate Committee on Environment and Public Works underscored the potentially high value of Federal efforts to demonstrate dry storage of spent fuel at reactor sites. Subsequently, such efforts became the main focus of the Department of Energy's spent fuel storage program. Similarly, OTA's analysis of the financing for the waste program—greatly aided by a paper prepared for us by the Congressional Budget Office—called committee attention to the merits of funding waste management activities by mandatory fees paid by nuclear utilities. This option is included in waste management legislation now under consideration by committees in both Houses of Congress and has been proposed by the President in the fiscal year 1983 budget, where it is projected to save the Federal Government some $235 million that year.

In conducting the study, OTA analyzed a wide range of views—from the technical community, Federal agencies, the nuclear industry, the environmental community, State and local officials, and the lay public. As a result of that effort, OTA identified the basic elements of an integrated high-level radioactive waste management policy that responds to the key concerns of the major affected parties. For that reason, we believe it could form the basis for the consensus needed to break the stalemate on waste disposal. The key elements of this policy were presented (October 1981) in testimony before major sponsoring committees of current draft legislation—Energy and Natural Resources and Environment and Public Works in the Senate and Science and Technology in the House. The policy in brief is presented on p. 38 of this summary, followed by a detailed discussion on p. 45. The detailed analysis of the technical and institutional issues and options on which this integrated policy is based is presented in the full report.

The assessment was originally undertaken at the request of the House Committee on Merchant Marine and Fisheries and focused on the ocean disposal of nuclear waste. OTA later broadened the study to include all aspects of waste disposal after expressions of interest and support by the Senate Committees on Energy and Natural Resources and on Commerce, Science, and Technology, and by the Senate National Ocean Policy

Study; and by the House Committees on Science and Technology and on Foreign Affairs.

If OTA has been able to shed light on the extraordinarily difficult and controversial issue of radioactive waste management, it is due in large measure to the excellent support and guidance received from many people representing the entire range of viewpoints on the issues. Finally, OTA has benefited from the full cooperation of the Department of Energy, the Nuclear Regulatory Commission, the Environmental Protection Agency, and other Federal agencies.

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*Resigned from panel Nov. 25, 1980

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OVERVIEW

After more than 20 years of commercial nuclear power, the **Federal Government has yet to develop a broadly supported policy** for fulfilling its legal responsibility **for the final isolation of high-level radioactive waste.** OTA's study concludes that until such a policy is adopted in law, there is a substantial risk that the false starts, shifts of policy, and fluctuating support that have plagued the final isolation program in the past will continue.

Final isolation—the last step in radioactive waste management—is intended to limit or prevent the release of highly radioactive byproducts of nuclear fission into the environment for the thousands of years that it takes for the radioactivity to decay to low levels. Nearly all of the radioactive byproducts produced thus far by commercial nuclear power are contained in **spent** (used) **fuel**—about 8,000 metric tons—that is temporarily stored in water-filled basins at operating reactors. The original expectation that all spent fuel would be reprocessed to recover usable uranium and plutonium, and that the radioactive byproducts would be separated as **high-level waste,** has not been realized. Since it now appears possible that at least some spent fuel may never be reprocessed, the term **high-level radioactive waste** applies in this report to both high-level waste from reprocessing and any spent fuel discarded directly as waste.

The continued lack of final isolation facilities has raised **two key problems** that underlie debates about radioactive waste policy. **First, some question the continued use of nuclear power until it is shown that safe final isolation for the resulting wastes can and will be accomplished,** and argue that the failure to develop final isolation facilities is evidence that it may be an insoluble problem. **Second,** because there are no reprocessing facilities or Federal waste isolation facilities to accept spent fuel, **existing reactors are running out of spent fuel storage space, and by 1986 some may face a risk of shutting down for some period** if there are delays in efforts to provide additional storage capacity. Because the 1990's are the earliest that facilities for reprocessing or final isolation could be available, **most of the 72,000 metric tons of spent fuel expected to be generated by the year 2000 will still be in temporary storage at that time.**

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Given its statutory role, the **central issue for the Federal Government in final isolation is how strong a commitment it will now make to develop disposal facilities**—which provide final isolation through use of manmade and natural barriers, rather than through the continued human control and maintenance required by **storage.** The disposal technology at the most advanced stage of development is the **mined geologic repository**—a mined facility several thousand feet deep in a geologic formation in which carefully packaged radioactive waste is buried. **There appear to be no insurmountable technical obstacles to developing such repositories** to meet tentative Environmental Protection Agency safety criteria **at a cost of no more than a few percent of the total cost of nuclear power,** provided that suitable sites can be found. Three or four such repositories will probably accommodate all of the radioactive waste expected to be generated by the reactors now in operation and under construction.

While it is possible that utilities could provide all necessary additional storage at reactor sites before existing basins are filled, some supplemental storage may be needed if there are delays in their efforts. The role of the Federal Government in providing such storage is a major unresolved issue. The lack of a stable and credible policy for final isolation has become a source of increasing opposition to both Federal and private efforts to provide interim spent fuel storage facilities, because of fears that such facilities would become de facto permanent waste repositories. Even after disposal facilities are developed, the United States may continue to store spent fuel for possible reprocessing or other reasons. But until such facilities are developed—which will take over a decade—the United States will have no choice but continued storage.

The greatest single obstacle that a successful waste management program must overcome **is the severe erosion of public confidence in the Federal Government** that past problems have created. **Federal credibility is questioned on three main grounds: 1) whether the Federal Government will stick to any waste policy** through changes of administration; **2) whether it has the institutional capacity to carry out a** technically complex and politically sensitive **program over a period of decades;** and **3) whether it can be trusted to respond adequately to the concerns of States and others** who will be affected by the waste management program.

OTA's analysis suggests that, if history is not to repeat itself, and the current stalemate on nuclear waste is not to continue, a comprehensive policy is needed that addresses the near-term problems of interim storage as part of an explicit and credible program for dealing with the longer term problem of developing a final isolation system. **Such a policy must:** 1) adequately address the concerns and **win the support of all the major interested parties,** and 2) **adopt a conservative technical and institutional approach**—one that places high priority on avoiding the problems that have repeatedly beset the program in the past. While this may require a more extensive program than now contemplated, the extra costs could be viewed as insurance against the potentially higher costs of failure to satisfactorily resolve the high-level radioactive waste problem.

OTA's study concludes that a broadly supported comprehensive policy would contain three major elements, each designed to address one of the key questions concerning Federal credibility:

ELEMENT I:
Commitment in Law to the Goals of a Comprehensive Policy.

Goal 1: To develop several final disposal facilities—mined geologic repositories—on a firm and conservative schedule with the first to be available by a target date that makes ample allowance for delays.

Goal 2: To contract with utilities to begin accepting commercial waste at a repository on a conservative date when a repository is likely to be available.

Goal 3: To aid the interim storage efforts of utilities by dry storage demonstrations and provide some Federal storage capacity for emergencies.

ELEMENT II:
Credible Institutional Mechanisms for Meeting Goals.

A. Congressional approval of a binding Management Action Program that details the steps and the resources required to meet the legislated goals.

B. Assured funding through a fund financed by a mandatory user fee based on the Management Action Program and paid by utilities as waste is generated.

C. Assurance of adequate and stable managerial resources by creation of an independent, single-purpose waste management agency.

ELEMENT III:
Credible Measures for Addressing the Specific Concerns of the States and the Various Publics.

A. Explicit plans and assured funds for involvement of the lay and technical publics.

B. Development of a regulatory process that makes ample allowance for the first-of-a-kind nature of the problem.

C. Provision in law of measures dealing with State and local concerns such as a formal role in siting decisions and impact compensation.

Managing Commercial High-Level Radioactive Waste

INTRODUCTION

For two decades, high-level radioactive waste from the commercial use of nuclear power has steadily accumulated in the form of spent (used) fuel stored in water-filled basins at reactor sites around the country. By October 1981, the United States had 74 nuclear plants in operation and some 85 additional plants under construction. When these plants were designed and licensed, it was assumed that the spent fuel that remained after the generation of electricity would ultimately be chemically reprocessed to recover plutonium and unused uranium for recycling in new reactor fuel. The high-level liquid waste from the reprocessing operation would be solidified and disposed of in federally owned and operated repositories. However, past efforts to develop commercial reprocessing and to locate suitable repository sites have not been successful. There are today no commercial reprocessing facilities or repositories.

Because high-level radioactive waste—defined as including both spent fuel that may be disposed of as waste and high-level waste from reprocessing spent fuel—remains potentially hazardous for hundreds to millions of years, there is general agreement that it must be isolated from the biosphere for a very long, but as yet unspecified, period of time. However, no firm agreement has been reached on whether final isolation of radioactive waste would be accomplished through storage or disposal, where and when to develop isolation facilities, and how to store the waste before final isolation. The lack of a demonstrated capability for final isolation of radioactive waste—which by law is the responsibility of the Federal Government—is seen by many as a major obstacle to the continued use of nuclear power.

Commercial reprocessing in the United States has also not developed as originally planned. Moreover, reprocessing does not appear likely to be commercially attractive for several decades. In the meantime, if existing institutional controls are maintained, spent fuel can continue to be safely and economically stored for many decades at reactor sites using existing technologies. However, if nuclear plants continue to operate, some existing storage basins will fill within the next decade, and new storage capacity must be made available by then to prevent reactor shutdowns. Thus, decisions must be made soon about how long, where, and by whom this spent fuel will be stored.

Decisions on both storage and disposal (see box below) are complicated by several factors. First, the unavailability of disposal and reprocessing has created the need for greater and longer term spent fuel storage capacity than originally envisioned. Moreover, the possibility that reprocessing may become economical sometime in the future raises questions about whether to plan for storage of spent fuel as a potential resource or disposal of spent fuel as a waste, or both. The resolution of many commercial waste management issues is also complicated by their real or perceived linkages to other issues, such as the future use of nuclear power, the proliferation of nuclear weapons, and the disposal of high-level defense waste generated during the production of nuclear weapons. Finally, it has become amply evident over the last decade that dealing with radioactive waste involves not only technical questions, but also larger social, ethical, and political questions, such as the obligation of one generation to another and the institutional capacity of the Federal Government to put together and carry out through many changes in administration a waste management policy that commands broad and sustained public support.

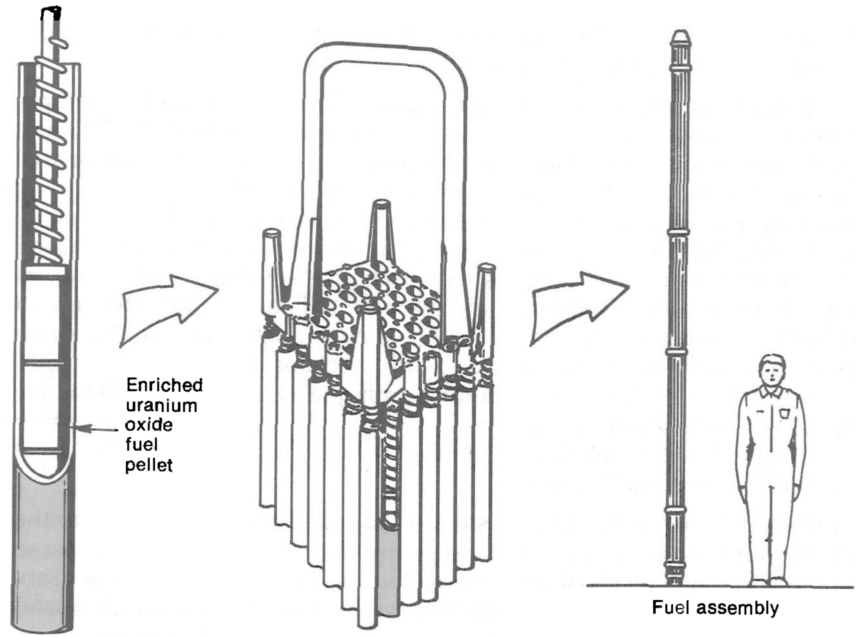
What Is High-Level Radioactive Waste?

Commercial nuclear power uses nuclear reactions to create heat that in turn produces steam to power an electricity-producing generator. The fuel for a nuclear powerplant consists of pencil eraser-size pellets of uranium oxide that are sealed in metal tubes that are bundled into fuel assemblies (fig. 1). In the core of a nuclear reactor, neutrons cause atoms of uranium-235 in the fuel assemblies to split (fission) into atoms of lighter elements (fission products) releasing radiation and energy, as well as other neutrons that continue the fission process. These fission products

Storage and Disposal: A Basic Distinction

Much of the debate about radioactive waste has been clouded by blurred and shifting distinctions between **disposal** and **storage,** which are different technological approaches to isolating radioactive waste from the biosphere. Briefly, **disposal** is isolation that relies only on natural (environmental) and man-made barriers, does not permit easy human access to the waste after its final emplacement, and does not require continued human control and maintenance. **Storage** is isolation that permits easy access to the waste after its emplacement and requires human control and maintenance in order to guarantee isolation. Thus, disposal is always designed to provide final isolation (the last step in the waste management process), while storage may be intended for either final or interim (temporary) isolation. Because storage requires human control and maintenance and disposal requires none, **disposal and storage are not synonymous terms.**

Figure 1.—Nuclear Reactor Fuel



build up gradually to a point where they interfere with the fission process, resulting in the need to replace about one-fourth to one-third of the fuel in a typical reactor each year. This irradiated, or "spent," fuel contains about 95 percent uranium oxide (of which about 1 percent is unfissioned uranium-235), 3.5 percent fission products and 1.5 percent transuranic (TRU) elements (primarily fissionable plutonium) that are produced when some atoms of uranium-238 (which is not fissionable in commercial reactors in current use in the United States) absorb neutrons and, instead of splitting into lighter atoms, change into heavier ones. While fresh fuel can be handled in the open, spent fuel is thermally hot and highly radioactive, and requires heavy shielding and remote handling.

Many fission products and all the TRU elements are unstable (radioactive) and undergo a spontaneous decay process, emitting radiation and heat as they change into progressively lighter elements until they reach a stable form. The decay process takes from minutes to millions of years, depending on the type of atom. In general, the fission products decay rapidly, and most will reach stable forms within 1,000 years. In contrast, the transuranics are very long-lived, taking from thousands to millions of years to decay.

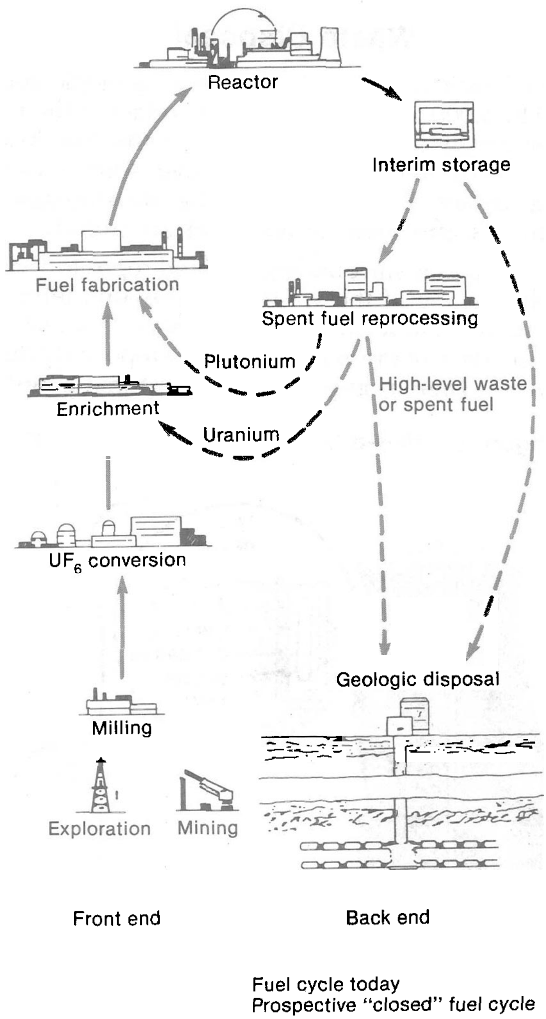
If such radioactive atoms are taken into the body in water, food, or inhaled particles, the radiation they emit can cause cancer, birth defects, or genetic mutations. The goal of final waste isolation is to delay any escape of these radioactive materials into the environment as long as possible, so that they can decay to low levels of radioactivity or stable forms that pose no significant threat to human health.

The fission products and the TRU elements (except for plutonium) are generally regarded as unusable wastes. However, the uranium-235 and plutonium in the spent fuel can be recovered for reuse in reactor fuel through chemical reprocessing, and the nuclear fuel cycle (fig. 2) was originally envisioned to include such reprocessing for all commercial spent fuel. Reprocessing would leave the fission products and unused TRU elements in liquid form as high-level waste which, under present regulations, would be solidified and placed into final isolation. Because of uncertainties about commercial reprocessing, it is also possible that some spent fuel would be treated as waste and placed into final isolation without reprocessing. The term **high-level radioactive waste** (or **radioactive waste** or simply **waste** for brevity) is used in this report to refer to either the solidified high-level waste from reprocessing spent fuel, or the spent fuel itself, if discarded as waste.

Other forms of radioactive waste are produced at various points in the nuclear fuel cycle. Though all must be treated with care, none of these produce the high levels of heat and radiation which complicate the problem of isolating high-level radioactive waste. **Transuranic (TRU)** wastes are materials contaminated with enough long-lived TRU elements to require the same sort of long-term isolation as high-level radioactive waste. The principal commercial sources of TRU waste would be reprocessing and fabrication of fuel using recycled plutonium, if these activities occur in the future. At present, the main source of TRU waste is the military nuclear weapons program. **Mill tailings** are the naturally slightly radioactive materials that are left over from processing uranium ore. Finally, **low-level wastes** are all radioactive wastes except high-level radioactive waste, TRU waste, and mill tailings and are produced by medical activities and research as well as operation of nuclear reactors. While most low-level wastes are relatively short-lived and have low radioactivity, some may present a significant radiation hazard.

Since there is no commercial reprocessing at present, the only significant source of high-level waste from reprocessing is defense plutonium production. This waste is stored in various forms at Department of Energy (DOE) installations. Most of the defense high-level wastes have not been concentrated and solidified, and their volume is much greater than that of the existing inventory (8,000 MTU) of commercial spent fuel. At present, spent fuel is being stored, awaiting decisions about its ultimate fate, and would not technically be classified as waste until a decision were made to discard it directly without reprocessing. However, the current inventory of commercial spent fuel already contains more long-lived fission products and transuranics than the defense waste, and the currently operating reactors will produce an amount of those radioactive materials every 3 years equal to the total defense waste inventory.

Figure 2.—The Nuclear Fuel Cycle



The commercial nuclear fuel cycle includes activities for preparing and using reactor fuel and for managing spent fuel and other radioactive wastes produced in the process. It was originally intended that spent fuel be stored for 6 months in water-filled basins at reactor sites to dissipate thermal heat and allow decay of short-lived fission products. The spent fuel would then be reprocessed and the resultant liquid high-level waste solidified and disposed of in a Federal repository. Since no repository has been developed and no commercial reprocessing is being done, spent fuel will remain in storage until decisions about how to close the nuclear fuel cycle are made.

SOURCE: Council on Environmental Quality.

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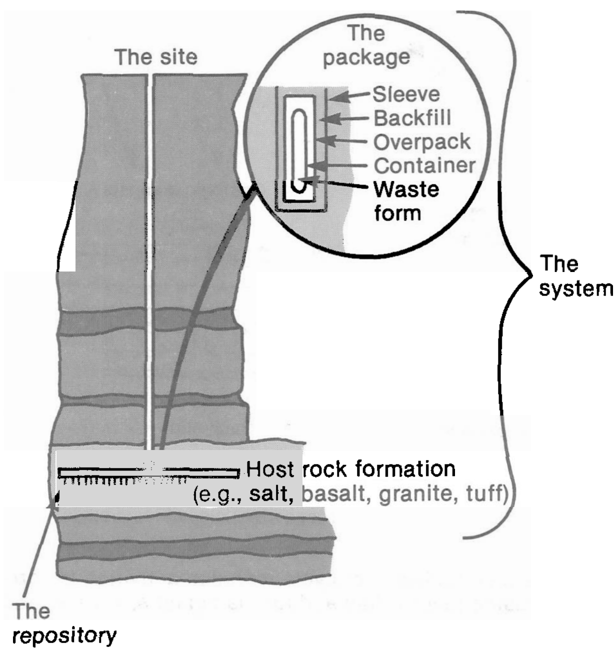
MAJOR FINDINGS

Waste Disposal

The disposal of radioactive waste in mined geologic repositories at depths of 2,000 to 3,000 ft below the Earth's surface is the final isolation technology most widely studied and favored by the worldwide scientific community (fig. 3). Three decades of extensive study have revealed **no insurmountable technical obstacles to the development of mined geologic repositories, provided suitable sites are found.**

The geologic formations surrounding a mined repository provide natural barriers to the escape of the waste over the long term, while engineered barriers such as the waste form and waste package would be used to enhance the isolation of the waste within the repository during the first few thousand years. **There is growing agreement that a multiple-barrier**

Figure 3.—Mined Geologic Disposal Concept



Mined geologic disposal will use a system comprised of engineered barriers (the waste package and the mined repository) and naturally occurring barriers (the host rock formation and the chemical and physical properties of the repository site itself) to provide long-term isolation of waste from the biosphere.

Department of Energy.

approach, combining engineered and natural barriers, can provide safe and effective long-term isolation despite the uncertainties about the performance of individual barriers—uncertainties that will remain even after a thorough technology development and site evaluation program has been completed.

There are as yet no licensed mined repositories for radioactive waste in the United States or elsewhere in the world. However, the failure to develop and license mined repositories stems mainly from such factors as inadequate and intermittent Federal support and a reluctance to acknowledge and address major institutional problems. The **main areas of technical disagreement concern not the ultimate feasibility of developing mined repositories but the degree of conservatism in design** (such as temperature limits and requirements on engineered barriers), and **the pace and scope of the research and development (R&D) program needed to develop a repository safely.** Technical reviews have concluded that most major technical uncertainties associated with the development of mined repositories could be sufficiently resolved over the next 10 years to allow the first repository to be constructed and licensed for operation as early as the mid to late 1990's, if no unforeseen technical or institutional problems arise. **Moreover, few repository sites will be required.** Three or four repositories will probably accommodate all of the radioactive waste generated over the 40-year operating lifetime of the nuclear powerplants in existence and authorized for construction.

The two principal modes of possible release of radioactivity from a well-designed and sited mined repository would be small, concentrated releases from human intrusion (from digging a well near or into a repository), which could expose a few individuals to large doses of radiation, or the gradual release of radioactivity from the repository into ground water (and ultimately into drinking water or food supplies), exposing a potentially large population to very small doses (compared to background radiation). **The Environmental Protection Agency (EPA) has calculated that both kinds of release from a well-designed and suitably sited geologic repository containing 100,000 MTU** (metric tonnes, or 2,200 lbs) **of spent fuel (or equivalent waste from reprocessing) could be expected to produce health effects in an exposed population over a 10,000-year period that are much less than 1 percent of the effects that could result in the same population from normal levels of background radiation.** The acceptability of that level of health risk is now being considered by EPA in developing safety criteria for geologic disposal of radioactive waste in mined repositories.

The most promising alternative to mined geologic repositories for radioactive waste disposal is subseabed disposal—the emplacement of packaged waste beneath the ocean floor within the thick (200 to 500 ft) clay sediments that cover large expanses of the deep (3 to 4 miles), mid-oceanic regions. These sediments could provide sufficient capacity for all the radioactive waste produced worldwide, if the concept proves technically feasible. Because these remote deep-ocean areas lack significant mineral and biological resources, the likelihood of human intrusion is low, and the ocean itself provides a substantial isolating barrier. In addition, the midoceanic regions are among the most stable and predictable geologic environments on Earth. On the other hand, subseabed disposal presents added safety risks from ocean transportation accidents. Although waste retrieval would be possible with existing technology, its cost would probably be prohibitive for all but safety reasons.

With subseabed disposal, the domestic political difficulties associated with siting land-based mined repositories might be replaced with similar difficulties in siting the shipping facilities. In addition, **significant international legal problems might require resolution before this concept could be implemented.**

Reprocessing

Since the reprocessing industry experienced numerous delays and setbacks in the 1960's and early 1970's, the United States now has no facilities for reprocessing commercial spent fuel. The most recent available analyses indicate that **the earliest that large-scale reprocessing of commercial spent fuel could begin in the United States would be about 10 years after a decision to do so.**

Recent major studies that have considered reprocessing in the context of waste management have concluded that reprocessing of commercial spent fuel is not required for safe waste isolation. Mined repositories can be designed for the safe isolation of either spent fuel or high-level waste from reprocessing, or both. Moreover, these studies have concluded that **reprocessing**—which generates additional radioactive waste streams and involves operational risks of its own—**does not offer advantages that are sufficient to justify its use for waste management reasons alone.** Instead, the decision to reprocess would depend on whether the recovery and recycle of unused fissionable material in the spent fuel is more attractive from an economic and energy policy point of view than the use of freshly mined uranium.

Since the actual cost of large-scale reprocessing of commercial light water reactor spent fuel and recycling of recovered uranium and plutonium is uncertain at this time, and since the worldwide excess uranium mining capacity may continue through the 1990's, **it is uncertain when reprocessing might become more commercially attractive than mining fresh ore.** In addition, unresolved regulatory uncertainties reduce the attractiveness of commercial investments in reprocessing and recycling. In any event, there is a growing agreement within the technical community that large-scale commercial reprocessing will not be economically attractive unless a nuclear reactor system is developed that includes breeder reactors. However, even if that occurs, it may not be necessary or economical to reprocess all the spent fuel that will be generated by the reactors now operating or under construction.

Storage

The expected delays in availability of either reprocessing or disposal facilities until the 1990's, at the earliest, mean that **large inventories of spent fuel will have to be stored for an extended period of time—perhaps many decades—before the fuel can be removed for reprocessing or direct disposal.** The approximately 8,000 MTU that have been discharged, to date, by currently operating reactors is now stored at the reactor sites in water-filled basins. By 2000, about 72,000 MTU will have been generated by these reactors and the additional plants that are now under construction. All together these reactors will produce approximately 150,000 MTU of spent fuel during their 40-year operational lifetimes.

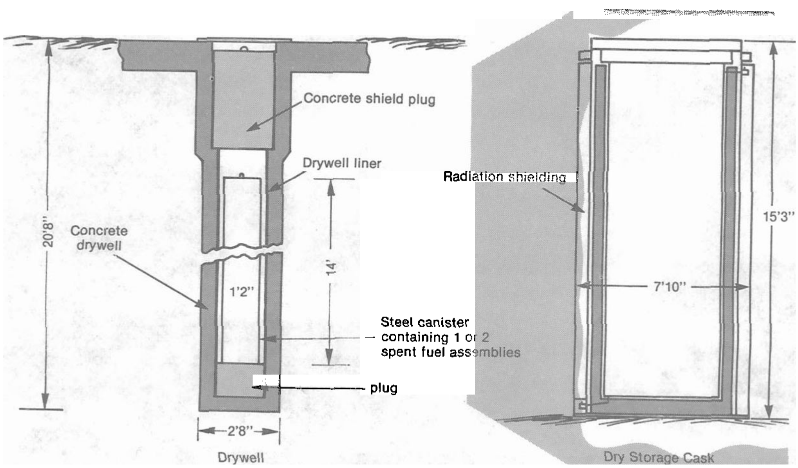
Photo credit: Department of Energy

Spent fuel storage basin at a commercial nuclear powerplant

There appear to be no fundamental technical questions about the ability to design, construct, and operate storage facilities for spent fuel or reprocessed waste to meet applicable radiation protection standards, as long as continuing surveillance and maintenance of the facilities is provided. Safe storage in water basins has already been demonstrated for periods of up to 20 years, and DOE analysis shows that **new dry storage technologies** (storage casks, drywells, and concrete silos) (see fig. 4) that can be added in small increments or modules as needed **are potentially much more flexible, quicker to implement, and less expensive for at-reactor use than water basins, and may even be less expensive than large-scale centralized storage** when the costs of spent fuel transportation and of acquisition or construction of centralized handling and packaging facilities are taken into account.

Since the water basins at most reactors were originally designed with a capacity for only 3 to 5 years' worth of spent fuel, additional spent fuel storage capacity must eventually be provided to prevent reactor shutdowns. However, there is no immediate need for a large amount of supplemental storage capacity beyond that available in reactor basins. DOE analyses indicate that if the installation of higher capacity racks in existing storage basins (reracking) continues as planned and transshipment of spent fuel is allowed between reactors within a utility system, **additional storage facilities to avoid the risk of reactor shutdowns may not be needed until 1987.** Since DOE analysis indicates that some dry storage technologies could be implemented at reactor sites in about 4 years, and

Figure 4.—Dry Storage Concepts for Spent Fuel



Each drywell would hold a steel canister containing about 0.5 tonnes of spent fuel (1 or 2 fuel assemblies depending upon the type of reactor).

Each cask would contain about 10 tonnes of spent fuel (24 to 52 assemblies).

If licensed, dry storage technologies like these may provide a relatively inexpensive, flexible alternative to water-filled basins for interim spent fuel storage.

water basins in 7, **it is theoretically possible that all necessary additional interim storage capacity could be provided at reactor sites before existing basins are filled.** However, because of uncertainties about licensing times (especially for new dry technologies) and about whether dry storage would be usable at every reactor, **a small amount of supplemental storage may be needed to prevent reactor shutdowns in case some utilities are unable, for technical or regulatory reasons, to provide additional storage capacity quickly enough.**

Storage for extended periods (100 years or more) has been proposed by some as a means of deferring irretrievable disposal, and by others as a satisfactory alternative to disposal for final isolation. Extended storage raises questions about the vulnerability of stored waste to events such as terrorism, acts of war, and inadequate maintenance, which have not been studied in the same detail as have the possible events that could cause waste to be released from a mined repository.

Existing Nuclear Regulatory Commission (NRC) regulations for licensing interim storage facilities may not be appropriate for extended storage, particularly if extended storage is used for final isolation. For instance, extended storage may require more sophisticated engineered features, such as waste packages, to control releases that might occur if institutional control were lost or abandoned.

Transportation

The transportation of spent fuel and radioactive waste will be the aspect of waste management that affects the largest number of States and communities. Although the public perceives the risks and impacts from the transportation of radioactive waste to be significant, **analyses by DOE and NRC conclude that significant releases of radioactivity from transportation accidents are highly unlikely if existing packaging regulations and transportation procedures are followed.** Safety in radioactive waste transportation is based on shipping cask requirements that are far more stringent than packaging requirements for other hazardous materials that are routinely transported. Thus, **confidence in transportation safety will depend on confidence that shipping casks will in fact be designed, constructed, and operated according to these regulations.**

Transportation risks and costs can be kept to a minimum by storing spent fuel at reactors as long as possible to allow its radioactivity and heat output to diminish before shipment and by siting simultaneously operating regional repositories or reprocessing facilities to reduce waste transportation. Increased demands for new shipping casks would require NRC and the Department of Transportation (DOT) to ensure that those casks are constructed and used according to established regulatory requirements.

Integrated Waste Management System

A commercial radioactive waste management system will involve the construction and operation over a long period of time of some combination of the technologies described above. Available analyses suggest the following conclusions about the operation of a waste management system.

Health Effects

There appears to be little chance of massive, uncontrolled releases of radioactive waste into the environment that would cause a large number of health effects in a short period of time. More likely would be small, localized releases from accidents during waste handling, transportation, and storage activities prior to disposal. A review of the risks associated with nuclear power conducted by the National Academy of Sciences concludes that the total exposure to future generations resulting from waste released from a repository would not likely exceed the radiation doses to the present generation from normal operation of the fuel cycle.

Socioeconomic Impacts

Waste management facilities would have the same kinds of socioeconomic impacts, such as "boomtown" effects and increased demands on State and local government services, that result from other aspects of the nuclear fuel cycle or from other kinds of energy development activities. Thus, these impacts do not appear to pose any unique or unfamiliar problems. Nonetheless, the affected populations may perceive the impacts as unfamiliar and perhaps quite serious, a consideration that may favor substantial public involvement and information programs as part of efforts to site waste management facilities.

The acceptability of waste management activities to a community may depend not only on their actual or perceived impacts, but also on the benefits the community expects to receive from the activities. **Generally, Federal activities are financially less attractive to local communities than those of commercial industry** because the Federal Government neither pays local taxes nor can compensate communities for the adverse impacts of its activities without explicit authorizing legislation.

Costs

The total costs of a radioactive waste disposal system (including interim storage and transportation) will be in the tens of billions of dollars, the actual amount depending upon the scale of nuclear power generation, the time that disposal occurs, and the final design of the repositories. While this is large in absolute terms, **it is small compared to the costs of the nuclear power system it would serve. In fact, the direct economic costs of radioactive waste management activities are estimated to**

be less than 5 percent of the cost of generating electricity from nuclear power. No analyses have yet identified any economic costs of a well-designed waste management system that would significantly affect economic decisions about nuclear power. It is thus unlikely that the operation of nuclear plants already in existence or under construction will be discontinued because of waste management costs. **The greatest potential cost impact of radioactive waste management policy may be not the direct cost of the management system, but the indirect costs that would result if delays in development of such a system led to shutting down reactors or to a moratorium on operation of new ones.**

System Logistics

Full-scale operation of a radioactive waste management system will involve handling highly radioactive materials in quantities and at annual rates that are unprecedented. For example, simply to load a single geologic repository fast enough to keep up with the projected rate of spent fuel generation in 2000, it could be necessary to package, lower into the repository, and emplace about one waste canister every hour, 24 hours a day, 365 days a year. Most of the analyses of radioactive waste management to date have concentrated on individual components—spent fuel storage, transportation, and disposal—rather than on their integrated operation in a full-scale system. However, available analyses indicate that **the flows of radioactive waste produced by existing and projected levels of nuclear power generation should be manageable, provided that careful planning is done** to avoid bottlenecks and minimize the strains that could result from the rapid increase in transportation and handling when a repository or reprocessing plant begins operation.

Backlogs of Spent Fuel

It appears likely that **most (up to 80 percent) of the spent fuel generated in this century will still be in temporary storage facilities** (most of it at the original reactor basins) **at the end of the century**—even if reprocessing or direct spent fuel disposal were to begin on the earliest possible schedule estimated by DOE. **Thus, for the next several decades, waste management will consist almost entirely of spent fuel storage,** and any reprocessing that occurs would simply convert some of the stored spent fuel into stored wastes of various types (solidified high-level waste, TRU waste) and, perhaps, unrecycled plutonium. Storage will of necessity be the *only* form of waste management until the capacity for disposal is available, and may continue to be a major part thereafter —either because disposal is deferred even after facilities are available or because an extended period is needed to work off the backlogs of radioactive waste that have built up in storage by the time disposal begins.

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PROBLEMS FOR WASTE MANAGEMENT POLICY

Despite thousands of technical studies, lengthy interagency policymaking efforts, and several years of debate within Congress, **the Federal Government has been unable to develop a comprehensive waste management policy with a broad base of support.** In fact, over the last 25 years, no formal agreement has been reached on whether radioactive waste contained in spent fuel should ultimately be disposed of or stored indefinitely. As a result, along with the thousands of tons of spent fuel that have accumulated, a host of problems have arisen that both complicate the task of developing a credible and comprehensive waste management program and cast a cloud of uncertainty over the future of nuclear power in the United States.

Key Policy Issues

Final Isolation

The central issue to be resolved concerning final isolation is how strong a commitment will be made now to the development of a waste disposal technology that, unlike storage, would not require continued human control and maintenance to assure safe isolation. Some argue that a disposal system should be developed with all deliberate speed. Others argue that a long period of interim storage (many decades) should be planned before developing a disposal system, so that more options could be made available and uncertainties about the economic value of spent fuel resolved before selecting a disposal techology for development. Still others argue that storage itself is a satisfactory approach to final isolation, so that no disposal system is needed. While DOE has made a formal decision to proceed with the development of mined geologic repositories, this decision has not yet been endorsed by Congress, and legislation under consideration in Congress contemplates extended storage in monitored retrievable storage facilities as an alternative to rapid development of a disposal system. Until there is a clear resolution of this issue in law, continued instability in the direction of the waste management program is possible, if not likely.

There is considerable disagreement about whether, or to what degree, the future use of nuclear power should depend on the development of an acceptable program for final waste isolation. Some argue that the United States should make no significant new commitments to nuclear power—and hence to the generation of more waste—until the safe and final isolation of nuclear waste has been satisfactorily demonstrated. They disagree, however, on whether there should be a complete moratorium on any new nuclear plants before the capacity for safe, final isolation is demonstrated or whether it is sufficient to link the licensing of future reactors to progress on final isolation. Others argue that the technology for safe, final isolation is available and that there is no technical justification for restricting waste generation. They regard a demonstration of final isolation as needed to allay public concerns that threaten the continued growth of nuclear power. From both points of view, therefore, it is important to resolve the existing uncertainties about final isolation of radioactive waste.

Even among those who agree that development of the capability to dispose of—rather than to store—radioactive waste is likely to be necessary for removing the issue as a potential encumbrance on the use of nuclear power, there is substantial disagreement about what must be done to demonstrate this capability and the urgency of doing so. Some believe that the current basis of knowledge about mined geologic repositories is adequate to permit an acceptably safe repository to be sited and constructed fairly quickly. They argue for rapid development of a repository (and perhaps an earlier unlicensed demonstration facility into which a small amount of waste would be emplaced) to allay what they perceive to be unfounded public concerns about waste disposal. Others believe that more time will be needed to develop adequate confidence that a suitable repository design has been developed and a satisfactory site found. They contend that emplacement of waste in a demonstration facility will not by itself allay public concerns about the safety of final isolation and fear that pressures for rapid action could lead to a premature commitment to a repository site or design that is inadequate or, at the very least, would lead to actions that would jeopardize the credibility of the Federal waste disposal program.

Some argue that resolution of disagreements about the technical feasibility of waste disposal would not, in itself, be enough to remove disposal as an issue affecting the use of nuclear power. **The demonstration that the Federal Government has the institutional capacity to actually carry out the difficult and sustained effort required to build and operate a waste isolation system for handling large amounts of waste safely and reliably may be even more important—because it is more heavily questioned—than the demonstration of the technical capacity to dispose of waste.**

Interim Storage

The fact that neither reprocessing nor a Federal waste repository is likely to be available for a decade or longer means that it will be necessary to provide interim storage for large quantities of spent fuel for at least the rest of the century. This poses two key problems for utilities. **First, reactors are running out of storage space, and some may have to shut down by the mid-1990's unless more storage space is made available on a timely basis**—even if existing basins are expanded as much as possible and if utilities whose basins are filled are allowed to transship spent fuel to unfilled basins at other reactors. Some utilities will face serious problems by the late 1980's if transshipment is not allowed. Because of the relatively long leadtimes needed for the construction and licensing of new storage facilities, these utilities must know within the next few years whether they must provide such facilities themselves.

Second, the fact that there is no firm schedule for either reprocessing or turning spent fuel over to the Federal Government leaves the utilities completely in the dark about how much additional storage capacity they will have to provide, when they will be able to end their liability for the growing inventories of spent fuel, and how much the total cost will be for storing and disposing of that fuel. There is increasing opposition to efforts to provide additional storage capacity, because of fear that easy availability of interim storage will reduce the pressures for development of a Federal disposal system, thus turning interim storage facilities into de facto permanent waste repositories. This opposition, in turn, has increased utilities' fears that they may not be able to gain approval for additional storage facilities quickly enough to prevent reactor shutdowns.

Concern about the utilities' capacity to provide additional interim storage quickly enough to prevent reactor shutdowns, especially in the face of the Government's failure to develop disposal facilities, leads some to argue that the Federal Government should provide away-from-reactor (AFR) storage facilities to give utilities one sure way to get rid of spent fuel once their existing basins are full. Others argue that the utilities should be responsible for interim storage, while the Federal Government concentrates on the disposal program. While the Carter administration proposed that the Federal Government acquire an AFR facility, the 96th Congress did not authorize it, and the Reagan administration has focused, instead, on helping the utilities provide their own additional storage. However, the question remains to be resolved in waste management legislation under consideration in the 97th Congress.

Factors Complicating Development and Implementation of Waste Management Policy

Linkage to Broader Issues

Resolution of disagreements about commercial waste management policy has been complicated by linkages to broader issues—the use of nuclear power, the future of reprocessing, and the disposition of high-level waste from defense activities. OTA's review of the history of waste management shows that disagreements about these broader issues have been a major reason for the inability of the Federal Government to agree to a firm policy for dealing with commercial waste, and that successful adoption and implementation of such a policy would be far less difficult if it remained neutral regarding the resolution of these broader issues.

The Use of Nuclear Power

While there is strong disagreement about whether there should be any formal linkage in Federal law between progress in developing a

final isolation program and the operation of nuclear reactors, there is already such a linkage in some State laws and in NRC policy. In 1976, the State of California passed a law that made the siting of reactors in that State contingent upon Federal assurance that a demonstrated technology for disposal of radioactive waste existed. While this law was overturned by a Federal court on the grounds that it was preempted by existing Federal law, it was upheld on appeal and ultimately may be considered by the Supreme Court. In addition, NRC has stated that it "would not continue to license reactors if it did not have reasonable confidence that the wastes can and will in due course be disposed of safely." As a result of a court action concerning objections to expansion of storage capacity at an operating reactor, NRC in 1981 announced its intention to conduct a generic proceeding:

> . . . to reassess its degree of confidence that radioactive waste produced by nuclear facilities will be safely disposed of, determine when any such disposal will be available, and whether such wastes can be safely stored until they are safely disposed of.

The proceeding, to which there are 40 parties, is expected to conclude in 1982.

An analysis of the merits of proposals to limit the further use of nuclear power, pending progress on waste disposal, involves questions of energy policy that are beyond the scope of this OTA study. However,**currently operating reactors have already discharged over 8,000 MTU of spent fuel, an amount that would increase to around 50,000 MTU by the end of their operating lives, even if no additional reactors were licensed for operation. The waste in this spent fuel must be isolated safely, regardless of the future of nuclear power.** Finally, whether or not there is a formal linkage, it appears likely that the degree of progress in the final isolation program in the next decade would affect decisions about the future use of nuclear power. If a policy can be adopted, maintained, and implemented steadily and successfully over an extended period it can be expected to have a positive effect on attitudes about nuclear power. Continued delays and shifts of direction, or discovery of major unforeseen technical problems, could be expected to have a negative effect on the willingness of utilities to invest in new reactors.

Reprocessing and the Potential Economic Value of Spent Fuel

In OTA's view, the uncertainty about when, if ever, it will become economical to reprocess spent fuel has unnecessarily complicated Federal decisions about interim spent fuel storage and about final waste isolation. Some have argued, for example, that because spent fuel is a potentially valuable resource, the capacity to dispose of spent fuel need not—and should not—be developed until a clear decision on reprocessing is made. Extended or permanent storage has been proposed instead of disposal as a means of ensuring that the potential economic value of spent fuel is indefinitely preserved. However, the development of a disposal capacity will take more than a decade, and **even when a disposal capacity is developed, spent fuel does not have to be disposed of.** Thus, the major decisions to be made now do not concern whether or not it is advisable to dispose of spent fuel, since the capacity to do so does not now exist; rather, they concern when (if at all) and at what rate the capacity to dispose of waste will be made available in the future and what provisions will be made for the storage of spent fuel and any reprocessed waste in the meantime.

If the economic value of spent fuel remains uncertain once a disposal capacity has been developed, the decision can be made then whether to continue storing spent fuel or to dispose of it. Developing the capacity to dispose of both spent fuel and reprocessed waste may, in fact, be the best way to ensure that the decision to reprocess or dispose of spent fuel is based mainly on the resource value of the spent fuel and not on the lack of a capacity to dispose of either spent fuel or high-level reprocessed waste.

The question of when (if ever) it will be desirable to dispose of spent fuel irretrievably is, therefore, quite distinct from the question of when it will be desirable to have the technical capacity to do so, although the two are frequently confused in discussions of waste management policy. The only irreversible decisions that can be made now are those related to the availability of technical capacity for disposal, since **the longer the development of disposal facilities is deferred, the longer future waste managers will have no choice but to continue storage.**

Defense Waste Policy

The defense and commercial high-level radioactive waste programs, merged under the Carter administration, have been separated by the Reagan administration. Disagreements about whether the same procedures for siting commercial waste repositories should also apply to repositories for defense waste were a major reason the legislation dealing with high-level radioactive waste did not pass in the 96th Congress.

In this regard, some people argue that no matter what is done with military waste, the Federal Government has an obligation to get on with the resolution of the commercial waste management problem, since the Government has, by law, reserved for itself the responsibility and the authority to dispose of high-level waste and has, thus far, failed to fulfill its responsibilities. They argue that efforts to deal with commercial waste should not be impeded by disagreements about policies for managing defense waste, as occurred during the 96th Congress. They also contend that the separation of the commercial and defense programs may allow more rapid progress in commercial waste disposal which could, in turn, make it easier to deal with defense waste by providing usable technology and sites. They note that there are no compelling public administration arguments for having a single organization dealing with the two problems and observe that there are precedents for separating military and civilian programs with similar technical requirements, as occurred when civilian space programs were assigned to the National Aeronautics and Space Administration (NASA). Moreover, some view a different institutional approach to siting repositories for defense waste as justified because they believe the balance of Federal authority should be greater in an activity associated with national defense.

Those who favor handling commercial and defense waste in a unified program cite the similarities between their technical and environmental needs for long-term isolation. Such an integrated approach, they argue, would be necessary for gaining public acceptance of a national repository program. Others cite the fact that since current law provides that any Federal repository for high-level waste, whether defense or commercial, would have to be licensed by NRC to meet the same environmental standards, separation of the programs would not necessarily lead to a less stringent approach with defense waste.

Credibility of the Federal Waste Management Effort

The greatest single obstacle that a successful waste management program must overcome is the severe erosion of public confidence in the Federal Government. For different reasons, the major interested and affected parties are united in the conviction that the Federal Government—on the basis of its past record—may not be able to do what is required to create and carry out an effective waste management program. Both the utilities and the nuclear industry doubt that the Federal Government will ever meet a schedule or stick to a policy. Environmentalists doubt that the Federal Government will deal adequately with safety concerns. States doubt that the Federal Government will deal openly and fairly with them. Below are some of the major reasons why the credibility of the Federal waste management effort is so low.

Policy Instability

The Federal waste management effort has been plagued by many and major shifts of policy, making steady progress difficult and undermining public confidence in the effort. A major cause of policy instability has been the failure of the Federal Government to consider a broad enough range of viewpoints and to address adequately the technical and nontechnical concerns of major interest groups, leaving some groups with a strong incentive to try to thwart or change the policies. As a result, changes in administration have often meant abrupt changes in waste disposal policy. In 1976, for example, President Ford responded to concerns about the need to demonstrate progress in waste disposal by announcing a 1985 target date for the first repository, a policy that led to an almost exclusive focus on salt as a disposal medium and on sites that had already been studied or were regarded as easy to secure. The Carter administration, responding to the resulting concerns that an accelerated schedule could lead to premature commitment to a medium or site, adopted a new policy involving the review of four or five sites in two to three media and an anticipated repository target date of 1997 to 2006. The Reagan administration has abandoned the Carter policy for one of examining three sites in two media, the minimum requirements of NRC, but has retained similar target dates of 1998 to 2006. With respect to interim storage, the Carter administration proposed that the Government acquire an away-from-reactor (AFR) facility and offer to accept spent fuel from utilities for interim storage prior to disposal. The Reagan administration rescinded the offer and announced that utilities would be responsible for interim storage. In view of such shifts, **some observers question whether any policy can be expected to outlast a change of administration.**

Capacity of the Federal Government to Implement a Policy

The history of the waste management program raises questions about the institutional ability of the Federal Government to implement any waste management policy successfully, even if the policy can be stabilized for an extended period. There are several reasons for this concern.

First, until the mid-1970's, the waste management effort was starved for the stable and sufficient resources—both people and money—needed to ensure success. Not until fiscal year 1972 did waste management exist as a distinct bureaucratic entity with its own independent budget, and not until fiscal year 1977 did the program receive substantial funding. Increases in the numbers and expertise of people the waste program needs to meet its responsibilities adequately have not kept pace with increases in funds. Moreover, **history suggests that the normal Federal budget process may not assure the adequate and stable long-term funding needed to enable timely development of final isolation facilities.** For example, inadequate funding of the Federal Government's geologic repository development program has led to a reduction in the number of alternative technologies and sites that have been investigated, thus increasing the likelihood that an acceptable system will not be developed in a timely manner and heightening concerns about the technical adequacy of the program.

Second, the past problems in the final isolation program have raised questions about the capabilities of DOE that will heavily burden its future efforts, even though the problems reflect not the competence of the people carrying out the program, but the low priority placed upon the effort, the lack of resources, and the sharp and frequent shifts of policy. Although the current DOE staff is generally regarded as technically competent, it does not appear to have enough people with the skills needed to handle the broad policy and strategic issues as well as the social, political, and institutional issues that concern States and local communities and other groups. It is the failure to address these kinds of issues, not just the strictly technical ones, that has undermined much of the credibility of the waste management program.

Finally, **the development and implementation of a comprehensive waste management policy will require an unprecedented degree of co-**

ordination within both the executive branch and Congress. At present, no single Federal agency or congressional committee has the jurisdiction to deal with the wide range of activities required to manage radioactive waste safely. There are six major executive agencies (see table 1) and some 12 congressional committees with jurisdiction over different aspects of waste management. History suggests that it will be difficult, under the best of circumstances, to coordinate the activities of all these Government entities. Agencies have consistently failed to meet deadlines

Table 1.—Principal Executive Agencies With Waste Management Responsibilities

Agency	Responsibility
Department of Energy (DOE)	Responsible for developing radioactive waste isolation technologies and for designing, constructing, and operating final isolation facilities for high-level and TRU wastes and spent fuel generated in National defense and commercial nuclear programs.
Environmental Protection Agency (EPA)	Responsible for developing generally applicable standards for radioactive materials. EPA is now developing such standards for geologic repositories for radioactive waste.
Nuclear Regulatory Commission (NRC)	Responsible for developing and implementing regulations to ensure public health and safety for storage and final isolation of high-level radioactive wastes, low-level wastes and radioactive wastes created in the mining of uranium ore. NRC is now developing regulations for mined geologic repositories that will implement the standards developed by EPA.
Department of Transportation (DOT)	Responsible for developing, issuing, and enforcing safety standards governing certain packaging and shipping containers for radioactive materials, and for the labeling, classification, and marking of all waste packages.
Department of the Interior (DOI)	**U.S. Geological Survey** (USGS).—Conducts geologic investigations in support of DOE's waste disposal programs, collaborates with DOE on earth sciences technical activities, and will act as consultant to NRC when NRC considers DOE applications for disposal facilities. **Bureau of Land Management** (BLM).—Serves as custodian of certain Federal landholdings and reviews any proposals to place waste disposal facilities on such lands.

to implement policies according to schedule, perhaps, in part, because waste disposal is only one of the many activities for which they are responsible. For example, NRC's draft technical regulations for high-level waste, scheduled for issue in 1977, were actually issued in 1981; EPA's overall standards for waste disposal, due since 1977, have not yet even been published for discussion. These delays have raised questions about the ability of the Federal Government to meet a long-term schedule requiring the coordinated actions of independent agencies.

Perceptions of Trustworthiness

Justified or not, there is the perception by States and others that the Federal Government cannot be counted on to keep its word on waste management matters, that it may not even mean what it says, and that, in general, it cannot be trusted. One example of the basis for this distrust is the series of policy reversals concerning the Waste Isolation Pilot Plant (WIPP), a pilot repository for defense TRU wastes, to be constructed at a site near Carlsbad, N. Mex. Initially, State and local officials supported WIPP because they believed it could give an economic boost to an area hard hit by a decline in the potash industry and because Federal officials had consulted extensively with them. However, Federal-State relations became strained in 1977 when the Energy Research and Development Administration (DOE's predecessor) considered emplacement of defense high-level waste in the facility and again in 1978 when DOE announced that some commercial spent fuel would also be emplaced at WIPP. Relations were further strained when President Carter signed an appropriation bill, passed by Congress in 1979, that continued the project as a defense facility not subject to NRC licensing and denied New Mexico veto powers, promised by DOE, over construction of the facility.

State Concerns

To make technical progress in waste disposal, the Federal Government must have access to potential disposal sites in order to perform the detailed study and evaluation needed to determine site suitability. Indeed, access to as many potential sites as possible is essential to a site selection process that is equitable and that can lead to a regional network of disposal sites that reduces transportation costs and impacts. However, **several States have sought to prevent DOE from conducting initial site investigations, and more than 20 States have enacted restrictive legislation banning various types of waste management activities within State borders without State approval.** Other States may feel obligated to adopt similar restrictions in order to make certain they do not, by default, end up with waste storage or disposal facilities.

State opposition to Federal siting activities has three main sources:

The Inherent Costs and Risks Involved in Waste Disposal

The presence of any amount of radioactive waste and the various steps involved in storage and disposal pose potential radiological risks and may have adverse social and economic impacts on States and localities. Although these impacts can be controlled or mitigated in many respects, there is no assurance that they can be entirely eliminated. Even if States had no other concerns about waste disposal, they would probably be reluctant to take on such costs and impacts. In its extreme form, the desire not to bear the costs and risks involved in waste disposal can lead to what has been called the "not in my backyard" or "anywhere but here" attitude, which may underlie at least some State opposition.

Fears of Unfairness in Siting Decisions

Many States fear that they could become a national dumping ground for waste—that they will be forced to take waste generated in other States or even from the entire Nation, thus bearing a disproportionate share of the waste disposal burden. Related to this fear is that of the "foot in the door"—the concern that if the Federal Government succeeds in siting any waste management facility, even a small research facility, it will try to save money and avoid fighting new siting battles by attempting to expand that facility, eventually creating a de facto repository at that site. A related State fear is that Federal siting decisions will be based far too heavily on considerations other than technical safety criteria, such as a desire to quickly site a repository to remove waste disposal as an obstacle to the use of nuclear power.

Low Federal Credibility

Many States have a low opinion of overall Federal competence and responsiveness in waste management activities and can cite a list of specific examples to support their view, such as the delay in formulating a national waste management plan, the failure to clarify the State role in waste management activities, and the abrupt changes in policy and scope of WIPP. States are also concerned that the Federal Government will not adequately recognize and deal with the nonradiological impacts of waste management activities, such as increased demands on State and local services caused by waste shipments.

Although restrictive State legislation may not stand up to Federal court challenges, the legal processes entailed in such challenges could cause delays, perhaps of years, to siting efforts. DOE has thus far been reluctant to contest State restrictions and has sought, instead, to conduct waste management activities at sites at which it is likely to encounter the fewest obstacles—either in time, cost, or political opposition. This approach can be defended on the grounds that if it speeds up the process and if the site eventually selected is technically sound, then it matters little how the site is chosen. However, this approach may increase resistance to Federal siting activities for two reasons. *First,* no site selection process is likely to be perceived as equitable or technically credible if it chooses, or appears to choose, sites mainly because they are the easiest to obtain. *Second,* this approach feeds States' fears that the Federal Government will increasingly follow a "path of least resistance" in seeking repository sites and thus strongly encourages those States that have not adopted restrictive or prohibitive measures to do so as rapidly as possible. No State wants to be last in the race to make certain that the path of least resistance does not lead straight into its borders.

Overall Impacts of History

The waste management program has substantially improved over time in resources, breadth of organizational commitment, and technical and institutional sophistication and has laid a solid technical groundwork for the development of mined geologic repositories. Nonetheless, current and future waste management programs bear the burden of past problems. Overcoming the Government's loss of credibility with States and the public will undoubtedly complicate efforts to manage waste, particularly from an institutional standpoint. After 35 years of struggling with nuclear waste there is limited tolerance for failures. Any major failure—real or perceived—could have grave consequences for both the waste management program and the future use of nuclear power.

A COMPREHENSIVE WASTE MANAGEMENT POLICY

OTA's fundamental finding is that, if history is not to repeat itself over and over again, and the stalemate on nuclear waste is not to continue, a comprehensive policy is needed that commands the support and addresses the concerns of all major interested parties, makes a formal Federal commitment to developing several disposal facilities according to a firm and conservative schedule, and guarantees the financial and managerial resources required to meet that commitment.

As a result of past history, there is today a widespread lack of confidence that the Federal Government *can or will* manage radioactive waste safely and efficiently. The doubts concern not so much the *technology* of disposal as they do the *institutional capacity* of the Federal Government to carry out the difficult and sustained effort required to build and operate a disposal system that can safely handle large amounts of waste. Unless major changes are made in the Federal approach to waste management, past problems are likely to plague the waste disposal effort with increasing intensity. The credibility of the Federal waste management effort appears too low for an open-ended, flexible, "trust us" approach—or a piecemeal approach focusing on near-term problems such as interim spent fuel storage—to succeed. The long-term uncertainties and strong doubts about the capacity of the Federal Government to cope with the nuclear waste problem are the main obstacles to the waste management effort. Only a comprehensive policy that focuses on solving the final isolation problem and that addresses institutional as well as technical issues is likely to overcome those doubts and uncertainties.

Key Elements of a Comprehensive Policy

Any waste management policy that is likely to endure must be both acceptable and credible to all concerned parties. Unless all parties can support a given policy—or at least have a strong stake in seeing it work rather than fail—the policy instability of the past is likely to persist, as each new administration changes the policy of the past one in order to satisfy one interest group or another. Thus, the more a waste management policy represents a formal agreement—a genuine treaty—that all sides can accept because it addresses their interests and concerns and because they believe it can work, the more likely it will be to survive changes of Administration and to avoid extensive judicial and other delays.

To be credible in the face of past difficulties, a waste management policy must adopt a conservative technical and institutional approach, which carefully identifies all the potential sources of technical and institutional failure, takes the steps necessary to keep the risk of failure to a minimum, and has contingency plans ready to deal with any failures that occur. In addition, because of the high level of distrust of the Federal waste management program, credibility requires a high degree of explicitness about and commitment to policies and programs.

The following section describes a comprehensive and integrated policy for commercial radioactive waste management designed to be both broadly acceptable and credible. While OTA's full report analyzes a range of technical and institutional options, **it is a major conclusion of the OTA study that the particular combination of options outlined below is capable of securing the credibility, stability, and broad support essential to a successful waste management effort.**

None of the individual ingredients of the policy are new. Each has been proposed at one time or another, and many are included in legislation now under consideration by Congress. What is new is the way these ingredients have been selected and integrated into a comprehensive policy based, in large degree, on the proposition that in waste management anything that has gone wrong in the past is likely to do so in the future unless specific measures are taken to prevent it.

The policy contains three broad elements, each of which is designed to address one of the historical bases of the current low credibility of the Federal waste management effort—policy instability, concerns about the institutional capacity of the Federal Government to implement a long-term policy, and perceptions of a lack of trustworthiness.

The Policy in Brief

Element I

Commitment in law to the main goals of a comprehensive national policy for interim storage and final disposal of commercial high-level radioactive waste.

- To develop several final disposal facilities—mined geologic repositories—on a firm and conservative schedule.
- To contract with utilities to begin accepting waste at a repository on a conservative date when a repository is likely to be available.
- To assist the interim storage efforts of utilities by supporting licensed demonstrations of dry storage technologies and providing a limited amount of supplemental storage capacity as an emergency backup in case of unavoidable delays in utilities' efforts to develop their own storage capacity.

Element II

Credible institutional mechanisms for meeting the policy goals.

- Congressional approval of a binding Management Action Program (MAP), developed by the administration, that spells out the technical and institutional actions and the financial and managerial resources required to meet the policy goals.
- Assured funding through a waste management fund financed by a mandatory user fee based on MAP and paid by utilities at the time the waste is generated.
- Assurance of adequate managerial resources through creation of an independent, single-purpose agency whose sole responsibility is to carry out the waste management program.

Element III

Credible measures for addressing the specific concerns of the States and the various publics.

- Explicit plans and assured funds for involvement of the lay and technical publics.
- Development of a regulatory process that makes ample allowance for the first-of-a-kind nature of the problem of demonstrating that a disposal system will provide the desired degree of isolation for millennia.
- Provision in law of measures dealing with State and local concerns, such as a formal role in repository siting decisions and impact compensation.

Policy Overview

Element I

Commitment in law to the main goals of a comprehensive national policy for interim storage and final disposal of commercial high-level radioactive waste.

Only a comprehensive policy can address both the concerns of utilities facing the near-term need for additional spent fuel storage and the concerns of those who feel that the highest priority must be given to the long-term task of developing a final isolation system for high-level radioactive waste. In a comprehensive policy, measures to deal with the near-term problems of interim storage are part of an explicit and credible program for dealing with long-term problem of developing a final isolation system. Such a policy must also formally spell out the relative responsibilities and rights of the major involved and interested parties—in particular, the Federal Government, the States and the utilities, but also the technical community and the general public. The policy should be legislated to demonstrate that the Congress as well as the administration is committed to it, and to help ensure the policy stability that has been lacking in the past.

Legislation spelling out this comprehensive radioactive waste policy would commit the Federal Government to three basic policy goals:

A. To develop several final disposal facilities—mined geologic repositories—on a firm and conservative schedule.

A commitment to develop disposal facilities, which rely on engineered and natural barriers to provide final isolation, is needed to deal with the concerns of those who feel that the current generation has a responsibility to provide a solution to the waste problem that does not place a burden of continued care and maintenance on future generations. Several repositories are needed to assure development of enough disposal capacity to handle at least those reactors already approved for construction or operation, to enable development of a system that can reduce transportation of waste, and to assure that no State becomes the Nation's sole "dumping ground" for high-level radioactive waste. A firm schedule provides assurance that the job will get done in a reasonable period of time, clear and fixed goals for an implementation program, and a firm basis for planning for interim storage. Conservative target dates that allow for delays and failures (such as rejection by NRC of the first site submitted to it for licensing) are required to make the schedule credible. An accelerated schedule that requires that everything will go right runs the risk of losing credibility at the first failure and could create pressures to cut corners that could be seen as compromising the fairness and integrity of the siting process. A conservative target that allows time for a second site in a different medium to be carried through licensing independently of the first candidate site could be between 2001 and 2006, DOE's current estimate of the latest date of operation of the first repository. A repository could become available earlier if the first candidate site is approved.

B. To contract with utilities to begin accepting waste at a repository on a conservative date when a repository is likely to be available.

The provision for contracts with the utilities assures both the utilities and the surrounding communities that spent fuel placed into interim storage can and will in fact be removed on a predictable schedule, and gives the waste management agency an additional incentive to meet the target dates for repository operation. The selection of a conservative date, such as the target date for the second repository, gives greater certainty that the contractual obligation can be met.

C. To assist the interim storage efforts of utilities by supporting licensed demonstrations of dry storage technologies and providing a limited amount of supplemental storage capacity as an emergency backup in case of unavoidable delays in utilities' efforts to develop their own storage capacity.

Leaving the primary responsibility for interim spent fuel storage with the utilities would allow the Federal waste management agency to focus all its attention upon the disposal program. It would avoid possible confrontations with States and localities that might result from efforts to obtain or construct a Federal interim storage facility, and would avoid raising concerns that availability of such a facility might undermine incentives for progress in the disposal program. Because of licensing uncertainties, new and flexible dry storage technologies are riskier prospects for utilities than the less attractive but more certain option of water basin storage. Thus, strong Federal initiatives to promote commercialization of these technologies are needed to ensure timely resolution of those uncertainties. The provision of emergency backup storage capacity (which might be accomplished with existing Federal facilities) would address utilities' concerns about the possibility that delays in the provision of additional storage capacity would cause reactor shutdowns.

Element II

Credible institutional mechanisms for meeting the policy goals.

The history of the Federal waste management effort strongly suggests that substantial changes in the Federal Government's management approach must be made in order to give credibility to the central component of Element I—a commitment to the development of a complex technological system, faced with technical and institutional uncertainties, on a firm schedule extending over a period of decades.

A. Congressional approval of a binding Management Action Program (MAP) developed by the administration, that spells out the technical and institutional actions and the financial and managerial resources required to meet the policy goals.

A credible commitment to long-term target dates requires a credible implementation program for meeting them. To be credible in the face of the history of problems and delays in past Federal waste management efforts, a program must identify the major possible sources of technical and institutional failure, provide measures that minimize the likelihood that these failures will occur, and include contingency plans for dealing with those failures that do occur. Such a program will likely involve an acceleration and expansion of ongoing DOE programs to include greater redundancy, particularly in the identification and characterization of candidate repository sites. This long-term program is needed to build confidence that the goals of the program can and will be achieved, to provide a basis for estimating the resources needed to do so, and to pinpoint clear milestones that can be used to hold the responsible agencies accountable for timely progress. Congressional approval puts teeth into the milestones, and demonstrates congressional commitment to the program. It also gives Congress a means of exerting long-term control over the program while allowing the independence from the annual budget and policymaking process needed to ensure steady progress.

B. Assured funding through a waste management fund financed by a mandatory user fee based on MAP and paid by utilities at the time the waste is generated.

The credibility of a Federal commitment to a long-term schedule for disposal facilities will depend on the degree of confidence that adequate financial resources will be available to carry it out. The traditional annual budget process lays great stress on keeping immediate costs as low as possible. Thus, it will tend to cut back on the redundancy in MAP that makes the target dates credible in spite of remaining technical and institutional uncertainties. Shifting the front-end funding directly to utility ratepayers at the time the waste is generated would provide a large and stable source of funds independent of annual competition with other Federal priorities, that would allow implementation of the expanded and more expensive program needed to meet a fixed schedule. This would also put the total costs of waste management on the users of nuclear electricity rather than on the Federal taxpayer. Establishment of a user fee based on MAP would allow funding levels to be determined by the desired program goals, rather than having the achievable goals limited by the availability of funds.

A revolving fund, not subject to annual appropriation control, is needed to insulate the funds collected from utilities from possible pressures for deferral of expenditures when the overall Federal budget is tight. Congressional control would be exercised through approval of a multiyear budget in MAP (and reapproval on a regular basis, say every 5 years), rather than through annual appropriations.

C. Assurance of adequate managerial resources through creation of an independent, single-purpose waste management organization whose sole responsibility is to carry out the waste management program.

Assurance of adequate management resources to direct the expanded program needed to meet a firm schedule for several repositories is as important as the assurance of adequate funds. The establishment of a single-purpose waste management organization, independent of other Federal nuclear programs, is needed to avoid the competition for manpower and policy-level attention that has adversely affected the waste management program in the past, to ensure that the staff's primary incentive is the safe and timely accomplishment of the goals of the waste management policy, and to insulate the program from future reorganizations of Federal energy programs. Because alternatives to the existing institutional structure for waste management have been given relatively little attention to date, Congress could direct the administration to develop and compare several institutional designs for later consideration, perhaps in parallel with the review of MAP. In this way, decisions about the crucial issue of the appropriate balance between independence and accountability would be made in the light of an explicit agreement—in the form of MAP—about precisely what the institution would be expected to do.

Element III

Credible measures for addressing the specific concerns of the States and various publics.

Because of the legacy of distrust of the Federal waste management program, explicit measures and guarantees are needed to assure the integrity of decisions concerning the siting, construction, and operation of waste disposal facilities, and to avoid actions that might create even the appearance that integrity could be compromised. History suggests that concerns about the safety and equity of Federal waste management activities on the part of affected States, localities, and the general public could become a source of increasingly effective opposition to implementation of a waste management program unless specific measures are adopted to deal with these concerns. Distrust of the Federal Government's willingness to respond to these concerns appears to be so high that efforts to proceed without dealing with these concerns may simply provoke greater resistance, confrontations, and failures to achieve program objectives on schedule. On the other hand, measures that adequately address these concerns in the waste management program are likely to broaden support for it in the first place, reduce opposition during implementation, and remove grounds for complaint.

A. Explicit plans and assured funds for involvement of the lay and technical publics.

The Federal Government, along with many others, has recognized that programs for public involvement in and peer review of decisions and actions of the waste management program can help build public confidence in and acceptance of the program. A requirement that explicit plans for coordinated action in these areas be developed by each involved agency and included in MAP to be funded through the mandatory waste management fee is needed to make clear to the public precisely how the Federal Government intends to proceed and to assure that funds are available to carry out pledges over a period of decades.

B. Development of a regulatory process that makes ample allowance for the first-of-a-kind nature of the problem of demonstrating that a disposal system will provide the desired degree of isolation for millenia.

Many believe that, with a first-of-a-kind problem such as high-level radioactive waste disposal in general, and the first geologic repository in the world in particular, the integrity and effectiveness of the regulatory process that passes judgment on the ability of a proposed repository to meet established safety criteria is perhaps the most vital element in assuring the ultimate safety of waste disposal. For this reason, support for the waste management program may be increased by measures that address expressed concerns about possible threats to the integrity of the repository licensing process. These include allowance of ample time in the licensing process (especially in the case of the first repository) to resolve unforeseen difficulties that arise, so as to avoid forcing a decision—either negative or positive—that may be seen as premature, and application for a license for a second site as soon as a suitable candidate has been qualified, to avoid concerns that a marginal site might be approved because of lack of any backup.

C. Provision in law of measures dealing with State and local concerns, such as a formal role in repository siting decisions and impact compensation.

The history of strong and effective State and local opposition to Federal high-level radioactive waste siting efforts suggests that a broadly supported policy will require assurances that State and local concerns about safety and equity will be addressed; and the concerns about the trustworthiness of Federal assurances suggest that any such assurances must be written into law to be credible. Explicit definition in law of the rules governing Federal-State relations in siting waste disposal facilities is needed to deal with State reluctance to agree to initial site exploration activities in the face of uncertainty about what rights they would have as the screening process narrows down to a few candidate sites. Provisions for compensation payments, and for monitoring and emergency response programs with assured funding through the mandatory fee, would ensure that States and localities that host waste facilities do not bear a disproportionate share of the burden of waste management.

Establishing the Policy

The technical and institutional elements of the policy outlined above are all mutually supportive and, in several respects, inseparable. For example, unless the policy is carried out by a single-purpose agency with assured and adequate funding, no comprehensive program that attempts to follow a firm schedule over a long period of time is likely to have much credibility with the general public or with the utilities. Similarly, it may be possible to gain broad support for a single-purpose agency with independent funding only if there is a substantial and formal agreement in advance about precisely what that agency is going to do and how it is going to do it, and if effective oversight mechanisms are assured.

Although it may be possible now to legislate the major goals of this proposed policy and mandate the execution of several other elements, it may be neither possible nor advisable to fully develop all the elements of the policy at this time. For example, MAP may have to be developed by the administration and approved by Congress prior to establishing a single-purpose agency with independent funding. **The establishment of the policy could, however, be accomplished over the next 4 to 6 years in two separate phases without interrupting the R&D activities that are now being performed by DOE.** Also, additional management and financial resources will be required to prepare MAP and initiate an expanded, nationwide site survey. By establishing this policy in two phases, responsibility and control over the program would be transferred to the independent agency gradually and only after its mission had been well-defined and mechanisms for maintaining its accountability well-established. The separate activities within each phase are indicated in the box below.

Policy Establishment Schedule

Phase I (2-3 years)

Congress	Legislate major policy goals and supporting elements dealing with the development of MAP and designs for a single-purpose waste management agency, guarantees to States, a review of regulatory standards, and authorization of a mandatory disposal fee.
President	Establish a separate waste management office within DOE (or its successor).
	Establish a high-level focus in the Executive Office of the President to oversee development of MAP.
DOE (or successor)	Continue current repository development activities.
	Develop MAP under guidance from the Executive Office of the President.
	Initiate expanded nationwide site survey.
	Demonstrate dry storage technologies.
	Provide limited emergency storage capacity for commercial spent fuel.
	Continue developing backup disposal technology (subseabed disposal).
EPA	Issue tentative waste disposal criteria for public review.
EPA/NRC	Conduct coordinated review of EPA/NRC criteria and regulations.
	Adopt criteria and regulations.

Phase II (2-3 years)

Congress	Review and approve MAP and collection of fees based on it.
	Review institutional options for establishing a single-purpose waste management agency and adopt one.

In summary, history suggests that comprehensive congressional action that deals with the institutional challenges of radioactive waste management as well as the purely technical ones will be needed to address the widespread doubts about whether the Federal Government *can* or *will* fulfill its statutory responsibility for safe final isolation of high-level radioactive waste. The history of radioactive waste policy is filled with attempts at partial solutions by policymakers who tried their best to use the limited levers under their direct control to break the logjam. The clear evidence is that, not only did these efforts fail, but they often made matters worse by lowering further the credibility of the Federal waste management effort. The radioactive waste management problem appears to be a nettle that, painful as that may be, must be grasped in its entirety if it is ever to be finally resolved.

The Policy in Detail

Element I

Commitment in law to the main goals of a comprehensive national policy for interim storage and final disposal of commercial high-level radioactive waste.

A legislated commitment to the specific goals of a complete and comprehensive policy is the first critical step toward insuring a credible, stable and widely accepted policy. Given the long history of shifting and short-lived waste management policies, nothing less than a commitment that has the force of law is likely to serve as convincing evidence that, this time, the Federal Government means business. The fact that past policies have been primarily the creatures of the executive branch and that Congress has never made a strong formal commitment to them is one of the main reasons they have changed so often and abruptly. A policy whose main goals are formally adopted by Congress is harder to change than a policy adopted by the executive branch alone and is more likely to adequately reflect the views of all affected parties.

Goals

***Goal 1:* To develop several final disposal facilities—mined geologic repositories—on a firm and conservative schedule.**

***1a:* Permanent disposal facilities.**—The history of strong and successful opposition to proposals to develop Federal storage facilities for commercial radioactive waste suggests that **nothing less than the development of final disposal facilities can satisfy public concerns about waste disposal and serve as the basis for a widely accepted and stable waste management policy.** Unlike storage, disposal does not place a burden of continued care and maintenance on the future and it is less vulnerable to carelessness or neglect on the part of some future generation. Moreover, a commitment to develop disposal facilities—especially facilities that can handle both reprocessed waste and spent fuel—would provide the future with a greater range of choices than would storage alone. Such facilities would give waste managers the option of disposing of either spent fuel or high-level reprocessed waste, or of placing any spent fuel delivered to a repository into extended storage at the surface. The development of such facilities would also ensure that waste management efforts are not impeded by debates about reprocessing.

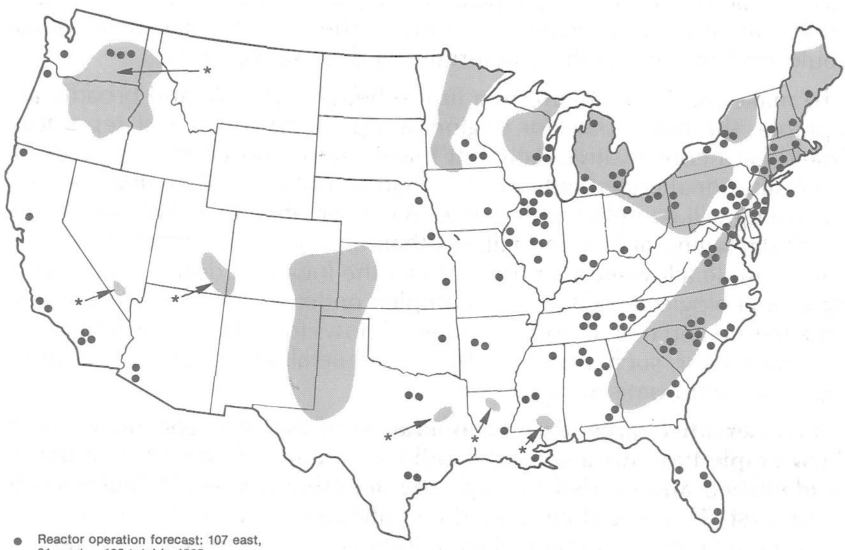
***1b:* Mined geologic repositories.**—The mined geologic repository is the clear choice as the disposal technology to be developed because it is the technology that has been most thoroughly studied and that is most widely favored by the international technical community. Both the technology and the required regulations exist or are being developed, and available analyses indicate that a licensed geologic repository could be developed within the next 20 years if adequate resources are devoted to the task. Moreover, a decision to develop geologic repositories would both demonstrate and promote policy stability, since it would involve no change in direction from previous programs and policies.

Unlike subseabed disposal (the most promising alternative disposal technology), disposal in mined geologic repositories in the continental United States does not raise the question of the need for international agreements for access to disposal sites. In any case, development of mined repositories would not preclude development of other disposal technologies and a later decision to use one that proved to be sufficiently attractive; and any geologic repository sites that had been developed by the time such a decision was made could still be used for supplemental purposes, such as disposal of waste forms (such as TRU-contaminated wastes) that might be too bulky for disposal using other technologies.

***1c:* Several repositories.**—There are **three main reasons for developing several simultaneously operating repositories instead of developing and filling one repository at a time.** *First,* such a network of repositories would be more equitable and could allay the fears of any State that it might become the Nation's sole dumping ground for nuclear waste. *Second,* the development of two or more sites is likely to encounter less political opposition than an effort to develop only the first single site of a centralized system. *Third,* if acceptably safe, licensable sites can be found in the East near the majority of existing and projected reactors (fig. 5), the costs and risks of waste transportation—as well as the number of communities affected by it—would be substantially less than those of a system based on a single repository in the West, where most sites now under consideration for the first repository are located.

To avoid strong budgetary pressures to continue to expand the first licensed repository and to defer the capital costs of developing a second one until the first has been filled, the development of a regional system requires a commitment in law to having a second repository available within some short, fixed interval—such as 5 years—after the first is operational. In this way, the actions needed to develop a second repository on schedule would be included in the Management Action Program (Element II-A), and the additional costs included in the disposal fee (Element II-B), so that the extra resources would be available as needed.

Figure 5.—Regions Studied or Now Being Considered for Geologic Disposal



SOURCE: Department of Energy.

1d: **A firm and conservative schedule.—OTA's analysis suggests that what is most important in securing and sustaining confidence in the waste disposal program on the part of either the public or the utilities is not how quickly a repository can be made available, but whether it will be available according to a firm schedule that is widely accepted as feasible and reasonable in view of the remaining technical and institutional uncertainties about the siting process.** An explicit Federal commitment to a firm, conservative schedule could give utilities and the general public grounds for confidence that the job will get done within a reasonable time. If the schedule is left open-ended and flexible, there is the real risk that the relatively low cost of additional storage would encourage continued deferral of the expenditures required to develop disposal facilities. Any extended delay in the development of disposal facilities would deeply concern both those who wish to remove the waste problem as a burden on the use of nuclear power and those who fear that interim storage would become a de facto permanent solution.

The commitment to a firm schedule for several geologic repositories would force the development of a credible implementation plan for achieving that goal (Element II-A: The Management Action Program) **which would include early milestones that could be used to measure progress toward the goal and to hold the lead agency accountable for timely progress. Together, that commitment and the plan could be the best way to build confidence quickly that a waste disposal system can and will be developed.** Such a commitment is consistent with a later decision to defer disposal of waste even after a repository is available, since waste could be stored at the repository site, and could, in fact, make such a decision far easier to make by removing the concern that such storage would lead to the indefinite deferral of a disposal capacity.

To make the commitment to a firm schedule credible and broadly acceptable, the target date for beginning operation of the first repository should be a conservative date that makes ample provision for technical and institutional uncertainties rather than an optimistic date that assumes everything will go right the first time. A conservative schedule entails less risk of damaging delays and failures than an optimistic schedule does. It makes ample allowance for the fact that the location, design, and licensing of a geologic repository is a complex endeavor that has never been done before and that, therefore, no one knows for certain how long it will take. Moreover, such a conservative schedule allays concerns that safety might be compromised to meet it.

A conservative target date for operation of the first repository would allow ample time for a second candidate site in a different medium to be identified and carried through the licensing process independently of the first. This would increase the confidence that a firm commitment to the target date could be met even if the first site is rejected by NRC—a possibility that must be considered because of the lack of technical consensus (resulting from lack of experience) about how likely it is that a site that looks good after characterization will ultimately receive an operating license. **If the first site proves to be acceptable to NRC, a repository could be available earlier than promised.**

The DOE national siting plan suggests that a conservative target date that would allow licensing of a site in a medium (granite) not now under consideration for the first repository **could lie between 2001 and 2006.** The precise date would depend on the extent to which DOE could accelerate its current schedule for characterization of additional sites.

***1e:* Program requirements for a firm schedule.**—Current DOE waste management plans have been developed with the assumption that the expected availability of appropriated funds would be at least as important a determinant of the scope of the repository development program as the long-term schedule, while the integrated policy discussed here assumes that safe achievement of a legislated schedule is the primary consideration and that the necessary funds will be provided through a mandatory user fee (Element II-B). Thus, **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.

An expanded program will probably involve costs—in terms of financial and managerial resources—that are greater than contemplated in the current DOE program, and that may be seen as unnecessary by those who believe that geologic disposal is a relatively straightforward technical enterprise that can be implemented fairly quickly and easily. However, **the extra costs of an expanded program can be seen as prudent insurance**

against the possibility of unforeseen technical problems that could otherwise lead to delays and real or perceived programmatic failures. If those who believe that geologic disposal will be easy to implement are proved to be right, an expanded program will produce a broader range of technical options and qualified sites earlier than they would otherwise be needed; if they are wrong, then it will provide insurance against the potentially much higher costs that could result from major delays or failures.

Experience in the national space program suggests that a program designed to give high confidence of success on schedule would have two main characteristics:

High redundancy. The program would pursue enough backups to each component of the isolation system (e.g., waste form and waste package) and to each candidate site to ensure a high probability that at least one acceptable combination will be available on the target date even though more or less predictable failures occur. In addition to increasing the probability of successfully meeting deadlines, a redundant approach would also allay a major source of concern about the program in the past: the fear that a focus on only a few of the most promising technical options would lead to pressures to stubbornly pursue them in spite of negative research findings. The cost of backups appears likely to be small compared to the political and financial costs of major program delays or failures. Redundancy is a standard design procedure in the development of highly reliable systems. It was employed, for example, in the most successful U.S. space effort—the Apollo program. Principal areas in which redundancy appears important are:

- **Expanded siting program.** DOE may need to expand and accelerate its identification and characterization of sites in order to ensure that enough adequately characterized sites are available to allow submission of a second site for licensing soon after the first, so that a backup would already be under consideration in case the first did not receive NRC approval. A redundant siting approach would also minimize concerns that budgetary or other institutional pressures would force continued development of a less-than-satisfactory site simply because of the lack of any alternatives. To ensure the availability of enough potential sites to support a more redundant characterization and licensing approach, a national site survey may be needed. A broader site survey could also facilitate the timely location of an eastern repository site.
- **Alternate disposal technologies.** A program with high redundancy would include sufficient support for the main backup technology—subseabed disposal—to test its feasibility in the 1990's, so that it could be available as an alternative if unforeseen difficulties occur with mined geologic disposal, or so that it could be used as a supplement to such disposal if desired.

Early testing of key elements of the system, in order to detect possible problems in time to avoid the need for expensive and time-consuming redesign and changes after facilities are constructed. For example, this could include **accelerated logistics tests.** To ensure that unforeseen bottlenecks do not prevent the Federal Government from accepting waste according to a planned schedule, prior experience at handling, packaging, and emplacing highly radioactive waste at operational rates would be valuable. This could be accomplished by conducting small-scale logistics tests before designing and constructing the first repository. Such tests could probably be conducted quickest at a site that is not suitable for a repository, which would avoid possible complications arising from concerns that the use of a potential repository site for test purposes might prejudice the later selection and licensing of that site for full-scale development.

To gain experience at a scale that will be useful in designing and operating repositories, a substantial quantity of spent fuel may be required. For example, 1,000 MTU, or 100 MTU per year over the next decade, would amount to less than 2 percent of both the projected annual handling rate and total capacity of DOE's current reference repository design. This fuel could be obtained from utilities with the greatest spent fuel storage problems—thus reducing or eliminating their need for additional storage space (see Goal 3 below)—and later emplaced in the first full-scale repository in the first phase of operation. Since a logistics test program would produce a supply of waste already packaged for disposal, it could allow DOE to apply for permission from NRC to emplace some waste in the repository soon after a construction permit is obtained, before construction of the repository's own packaging facilities. This would allow early in situ verification of the results of the logistics test program, as well as a much earlier test of NRC's process for deciding to allow emplacement of waste with no intention of retrieval than is now contemplated in DOE's repository development program.

***Goal 2:* Contract with utilities to begin accepting waste at a repository on a conservative date at which a repository is likely to be available.**

The commitment to develop several geologic repositories on a firm schedule should increase the confidence of utilities that an ultimate resolution of their growing spent fuel problem is on the way. However, it would still leave them with some uncertainty about interim storage unless it were combined with an explicit Federal commitment to start signing contracts to accept spent fuel when a repository is expected to be available. These contracts would specify a date (after the target date) at which each spent fuel assembly covered in the contract could be accepted at the repository, derived from a conservative repository loading schedule that allows for uncertainties in the achievable handling rates. **The contractual obligation of the Federal waste management agency to accept spent fuel on a fixed schedule would:**

- **create an additional incentive to have the first repository available on time;**
- **make it easier for utilities to pass on to consumers the disposal fees** required at the time the contracts were signed (Element II-B) by

assuring that the fees are regarded as payment for clearly defined and contractually committed Federal disposal services;

- **aid utilities in planning for interim storage requirements and costs;** and
- **reduce any public concerns that interim storage would become permanent and would encourage indefinite deferral of the development of repositories.**

Since there would always remain the possibility that unforeseen events will cause slippage in the first repository date, contracts would have to provide for what would be done with waste until the repository is actually available. Leaving spent fuel at reactors wherever possible until it could be physically accepted at a permanent repository would be consistent with the objective of keeping the transportation of waste to a minimum and would avoid diverting the attention and efforts of the waste management agency away from the repository program toward provision of an independent interim storage facility. Incentives for the agency to meet the schedule could be strengthened if the costs of additional at-reactor storage of spent fuel beyond the contractual date for acceptance by the agency (and perhaps title to and liability for the spent fuel) were transferred from the utility to the agency on that date. The risk that provisions for transferring costs would have to take effect could be reduced by using a more conservative target date for accepting spent fuel than the target date for the first repository, such as the target for the second repository. This would allow for the possibility of unforeseen problems with the first repository, and time to site a repository in the East before waste is removed from reactors in large quantities.

Goal 3: **Assist the interim storage efforts of utilities by supporting licensed demonstrations of dry storage technologies and providing a limited amount of supplemental storage capacity as an emergency backup in case of unavoidable delays in utilities' efforts to develop their own storage capacity.**

Utilities would be responsible for providing interim spent fuel storage capacity—including new storage facilities—until the spent fuel can be delivered to a repository. The Federal waste management agency would aid utilities in developing the needed additional capacity through cooperative licensed demonstrations of new dry storage technologies. **The agency would provide a limited amount of storage capacity on an emergency-only basis to utilities that are unable to provide their own storage capacity in time to prevent shutting down a reactor.** Such limited Federal storage would be provided on a full-cost-recovery basis only for spent fuel discharged during the period until the utility is able to arrange its own additional storage.

Utility responsibility for interim storage would allow the Federal waste management agency to focus its attention on the disposal program and avoid possible confrontations with host States and localities about efforts to obtain or construct a Federal interim storage facility. It would also allay concerns that availability of such a facility might undermine incentives for progress in the disposal program. Strong Federal initiatives to promote commercialization of new and flexible dry storage technologies are needed to ensure timely resolution of licensing uncertainties that make such technologies a riskier prospect for utilities than the less attractive but more certain option of the water basin. Provision of emergency backup storage capacity (which might be accomplished quickest and at least cost through use of existing Federal facilities) would address utilities' concerns about vulnerability to reactor shutdowns in the event of unavoidable delays in the provision of additional storage capacity, such as might occur if they attempt to use dry storage.

Because of the promise shown by new storage techniques—rod compaction, which increases the capacity of existing reactor basins, and dry technologies such as storage casks—the demand for such emergency backup capacity could be quite small, and could be further reduced to the extent that some quantity of spent fuel is obtained from utilities for use in R&D activities. While no analysis of the precise amount of emergency storage needed is available, it can be noted that only 1,000 MTU of storage would allow all of the 27 reactors projected to need new storage capacity by the end of 1989 an additional 2 years to provide that capacity. The waste management agency could provide that capacity by acquiring a fleet of 100 storage casks of the kind recently purchased by DOE for testing. A fleet of 100 of those casks may cost no more than $80 million and could be prelicensed and shipped to utilities to provide emergency storage onsite. Reactor sites in need of emergency storage that could not handle such casks could ship fuel to existing Government facilities for transfer into storage casks or drywells.

Element II

Credible institutional mechanisms for meeting the policy goals.

The history of the Federal waste management effort strongly suggests that substantial changes in the Federal Government's management approach must be made in order to give credibility to the central component of *Element I*—a commitment to the development of a complex technological system, faced with technical and institutional uncertainties, on a firm schedule over a period of decades.

A. **Congressional approval of a binding Management Action Program (MAP), developed by the administration, that spells out the technical and institutional actions and the financial and managerial resources required to meet the policy goals.**

OTA's analysis suggests that, next to the congressional commitment in law to the goals outlined above, **the development of a sound, widely accepted and congressionaly approved MAP—which shows precisely how the Federal Government plans to achieve the legislated goals—is the crucial next step in building public confidence that the job will get done safely and on time.**

MAP would lay out a coherent schedule for all of the required technical and institutional actions and describe in detail the technical and institutional policies and programs for interim storage, R&D activities, and development of repositories. It would include all of the mandatory activities of the radioactive waste management agency and the regulatory agencies. To ensure that the goals and milestones of the waste management program are achieved and that the resource needs are reasonably estimated, MAP would also identify potential technical and institutional failures and would include contingency plans for dealing with any failures that do occur.

A1: **Main Functions of MAP.** An implementation program that has undergone extensive public and technical scrutiny and received congressional approval would provide:

- *Enhanced public confidence that radioactive waste can and will be safely isolated.* Central to this integrated waste management policy is the conclusion, based on history, that the credibility of the commitment of the Federal Government to a schedule for repositories is in question, and that the cost of failure to meet a commitment could be high. Thus, **MAP would be designed to give a very high probability of success in meeting the legislated goals.**

  The current low credibility of the Federal waste program stems, in part, from instances in which strong optimism was shown by events to be unfounded, an optimism that is still reflected in current DOE plans that appear to assume that every milestone will be passed successfully. **The credibility of the program could be increased if MAP assumed that problems would occur and included measures to prevent them and mitigate their consequences, rather than assuming that everything would go right the first time.**

  By identifying the institutional as well as the technical steps required to develop a waste disposal system, and by making contingency plans for the things that could go wrong along the way, MAP would build confidence that the job actually will get done safely and on schedule. Since MAP would also include a feasible schedule for removal of spent fuel from interim storage facilities (as a basis for the dates specified in the contracts with utilities), it could help allay concerns that interim storage could turn into de facto permanent storage and, thus, could aid utilities' efforts to provide interim storage.

- *A firm basis for a disposal fee.* DOE analysis shows that the cost of waste disposal will mainly be determined by the scope of the repository R&D program, the timing of construction and operation of full-scale disposal facilities, and the design of the repository. Therefore, **to ensure that the fee to be charged to utilities to finance the waste management program** (Element II-B) **covers all of the costs required to meet the legislated objectives, it must be based on a clearly defined plan** for developing and operating a repository system.

MAP would provide such a plan. The fact that the fee would be based on an explicit repository development program could make it easier to pass the fee directly on to ratepayers as a charge for a well-defined service to be provided by the waste management agency.

- *A basis for oversight and accountability of an independent waste management agency with independent funding.* It appears unlikely that broad agreement can be reached on establishing an independent waste management agency with independent funding unless there is first explicit agreement about what the agency is going to do and how it is going to do it. Congressional approval of a detailed MAP for implementing the goals already enacted into law would establish such an agreement. Thus, the function of the waste management agency would not be to develop broad waste management policy, but rather to carry out a specific program to implement specific goals, both of which the Congress has formally approved.

A2: **Congressional Approval. The explicit approval by Congress of MAP, after extensive public and technical review, would make the program a formal agreement that has the force of law,** that can effectively guide and govern the entire waste management effort, and that can serve as the main vehicle for congressional and management oversight over the conduct of the waste management program. In addition, congressional approval of MAP ensures adequate congressional control while insulating waste management expenditures from the pressures of the annual budget and appropriations process.

The process of public and technical review could help develop broad national understanding and agreement on waste management policy. This agreement, combined with explicit congressional approval, could enhance the credibility and stability of the program by making arbitrary changes difficult. The requirement for congressional approval would also give the administration a strong incentive to develop a plan that could gain broad support and thus avoid the delays and loss of credibility that could result from congressional disapproval.

In developing the procedures for congressional approval of MAP, several considerations should be taken into account. *First,* the elements of MAP offered for congressional review and approval should not to be too detailed. For example, it may be appropriate for Congress to approve a long-term schedule of activities and associated expenditures derived from a more detailed plan, rather than to approve such a plan in its entirety. *Second,* the approval process should allow room for revision of MAP as new information and developments arise. Provision could be made, for example, for the agency to revise and resubmit MAP for approval as needed. *Third,* the approval process must include provisions to give the Congress sufficient ongoing control over the actions and expenditures of the management agency to warrant the relaxation of the normal annual budgetary control that appears necessary to ensure that the program has adequate funds available as needed (discussed later). One approach would be to require revision and reapproval of MAP at regular intervals, such as every 5 years. Between reapprovals, the waste management agency could be authorized to make expenditures from the revolving or trust fund as provided for in the multiyear budget contained in the approved MAP, without a requirement for annual appropriations or authorizations. *Fourth,* approval of the initial MAP, and subsequent revisions to it, should be sufficiently difficult that the program and its milestones, once approved, will be taken very seriously and arbitrary changes effectively precluded.

A3: **Development of MAP.** Because MAP would include all of the mandatory activities of both the waste management agency and the regulatory agencies (in particular NRC), giving DOE the final authority for development of the program could create an appearance of bias. In addition, if Congress wants a detailed proposal for an independent single-purpose management agency (discussed later) with independent funding to be developed along with MAP, it may be inappropriate for the DOE to perform that task.

It may be desirable, instead, to assign the responsibility for overseeing the development of MAP, and perhaps the design of a waste management agency, to a body in or associated with the Executive Office of the President. This body could be either an existing office (such as the Office of Science and Technology Policy), or a specially appointed council or commission, perhaps chaired by someone within the Executive Office of the President (e.g., the Vice-President or the Director of the Office of Science and Technology Policy). While the detailed contents of MAP could be prepared by the responsible agencies, this body would guide the development of the outline for the program, oversee the work of the agencies, and approve the final product for submission to Congress. Such an approach could both signal a high level of Presidential interest in the resolution of the radioactive waste problem and help to preserve the balance between the implementing and regulatory agencies. To ensure that the widest possible range of views is taken into account in developing MAP, such a council or commission could include non-government members representing State and local governments, utilities, environmental groups, and others.

A4: **DOE Actions During Development of MAP.** None of DOE's ongoing repository development activities need or should be deferred pending development of MAP and design of a single-purpose waste management agency. While these steps are taken, DOE can move ahead with an expanded site evaluation program and begin work on a test program designed to provide logistics data on the handling, storage, and disposal of waste.

B: **Assured funding through a waste management fund financed by a mandatory user fee based on MAP and paid by utilities at the time the waste is generated.**

Stable, adequate funding is essential if the Federal commitment to a firm schedule is to be met. The traditional annual budget and appropriations process lays great stress on keeping immediate costs as low as possible. Thus, it will tend to cut back on the conservative and redundant aspects of the technical program (such as multiple site review) that are vital to building confidence that the target date can be met.

B1: **Prepaid Fee.** Collecting a fee from utilities with nuclear reactors at the time the waste is generated would provide a large and stable source of funding for repository development that could also cover all indirect costs such as compensatory payments to affected States and localities and perhaps regulatory costs. **Basing the fee on MAP would allow the funding levels to be determined by the program needed to achieve the desired goals, in contrast to the current situation in which the program (and thus the achievable goals) are limited by the availability of appropriated funds.** A fee based on a conservative program could minimize the risk that unexpected problems would require additional funds from utilities at the time of waste disposal. Such a fee would probably amount to less than 5 percent of the cost of generating nuclear electricity and could be specified in the Federal Government's contracts with utilities to accept their waste. The Reagan administration has proposed such an approach in its budget for fiscal year 1983.

Use of a "prepayment" fee-collection mechanism would require the ability to adjust the fee periodically to account for inflation, and for changes in the estimates of the real costs of disposal. Since the waste management agency would in effect be a public utility with a mandatory fee on its users, it may be desirable to have an independent body, such as the Federal Energy Regulatory Commission (FERC), review and approve proposed fee increases to ensure that they are justified

B2: **Revolving or Trust Fund.** Based on the events of the past, the availability of funds for waste management programs cannot be guaranteed if the collected fees are deposited in the general fund of the U.S. Treasury. Considering the existing and future pressures to balance an increasingly tight Federal budget, some required expenditures might be deferred or eliminated, thereby jeopardizing steady progress on a program whose schedule has been fixed by contracts with utilities. To guarantee the availability of funds, a trust or revolving fund could be established. **Steady and assured progress on a long-term schedule requires the assurance that the revenues going into the fund be available for expenditure as needed.**

Congressional approval of the detailed MAP provides a mechanism for combining greater independence of expenditures with continued congressional control. MAP would include a detailed long-term plan for the expenditures required to achieve the objectives of the program, which would serve as a multiyear budget. Once MAP is approved, the responsible agency could then be given the authority to make annual expenditures from the fund as provided for in MAP's budget, while Congress could exercise annual oversight to ensure that the program is being carried out as planned and could approve any amendments to it.

C: **Assurance of adequate managerial resources through creation of an independent, single-purpose waste management organization whose sole responsibility is to carry out the waste management program.**

C1: **Need for a Single-Purpose Agency.** The assurance of adequate management resources is as important as the assurance of adequate funds. The Federal nuclear waste program in the past has had to compete for money, manpower, and policy-level attention with other areas of nuclear research and development regarded as more pressing and, often, more interesting. Despite the improvements of recent years, the managerial resources of the waste disposal program are likely to remain insufficient as long as the responsibility for waste management is assigned to one of many divisions of a large Federal department that is, itself, subject to frequent organizational changes.

The creation of an independent agency dealing solely with waste management may be the best, if not the only, way to ensure that its organizational resources would not be diverted to competing missions and that the efforts of the staff are focused entirely on the successful achievement of the goals set by Congress. Such an agency would probably undergo far less turnover in top management than the waste program has in the past, thus assuring greater continuity of leadership and sustained top-level attention to the conduct of the program. At present, there is no single policy-level individual at DOE who can devote 100 percent of his or her attention to the waste management program. The waste management program may be relegated to an even lower level if DOE is dismantled and the unit containing waste management is placed under another department, as the Reagan administration has proposed. Finally, separation of the waste management agency from other activities of the Federal Government that promote energy production could enhance the credibility of the program in the eyes of those who see a conflict of interest between such activities and the safe planning and development of a waste management system.

C2: **Alternative Structures for a Waste Management Agency.** Models for a separate waste management authority include a new executive branch agency similiar to NASA; an independent authority with loose ties to DOE or its successor, such as the Bonneville Power Administration; a Government corporation, such as the Tennessee Valley Authority; or a congressionally chartered non-Federal entity such as the Communications Satellite Corporation. **A corporate structure may be the most desirable for a number of reasons.** It is most consistent with the self-financing nature of a program funded entirely through user fees, and with the high degree of discretion over annual expenditures from a trust or revolving fund needed to give confidence that a long-term schedule can be met. It would also allow greater flexibility in hiring, promoting, and firing than a typical Federal structure would, which could increase accountability for the achievement of the goals of the program. Since the organization would be self-financed through the user fee, any additional costs involved in establishing and operating a new, single-purpose agency would be borne by the users of nuclear power rather than by the Federal taxpayer.

C3: **Establishment of an Effective Oversight Process.** An independent institution with independent funding seems the surest way to guarantee that a comprehensive program will be carried out on schedule. But such an institution raises **a crucial and difficult question: how to ensure the congressional oversight and public accountability that a democratic society demands?** Because of the low credibility of the Federal waste management program, there may be considerable reluctance to establish a single purpose agency with even greater independence than the current institutional structure for fear that it might be even less responsive to the concerns of the Congress, the administration, and the public. Thus, **achieving an acceptable balance between independence and accountability will be one of the central challenges in designing an independent waste management authority.** In seeking to develop a satisfactory institutional design, the following elements might be considered:

- **Role of MAP.** OTA's analysis suggests that **it may be possible to gain broad support for the creation of an independent institution with independent funding if, and perhaps only if, Congress has enacted the major waste management policy goals into law and approved MAP.** MAP can then serve as a yardstick by which the Congress—and a board of directors or any other body, including the public—can oversee the activities and expenditures of the waste management agency and measure its progress.
- **Oversight Structure.** The oversight structure of an independent waste management agency could be somewhat like that of a public utility since it would have a monopoly on disposal of commercial waste, and since nuclear utilities would have no choice about using its services. The structure could consist of 1) a board of directors, to monitor agency performance and review major decisions and 2) an independent regulatory agency (such as FERC) to review and approve changes in the disposal fee. Congress could exert control over the agency's activities by holding annual hearings, by directly controlling the agency's debt ceiling, by confirming its board of directors and, perhaps, by congressional nomination of some members of the board.

C4: **Interim Actions Before Creation of the New Agency.** Because alternatives to the existing institutional structure for waste management have been studied less thoroughly than the technical options, and because of anticipated difficulties in balancing independence and accountability, major changes at this point may be premature. In addition, it seems unnecessary to resolve the institutional issue now in order to adopt a long-term technical waste management program, and any effort to do so may impede progress in that area. However, it may be important at this point to set in motion a process to ensure that the institutional questions are addressed and resolved in the future, perhaps by inclusion in waste management legislation of a requirement that the administration develop a detailed analysis of alternative management agencies in parallel with MAP. **Choice of an institutional structure** (including the oversight mechanism discussed above) **could be deferred until MAP has been reviewed and approved.** In this way, the decision about the appropriate degree of independence for such an institution would be made in the light of an explicit agreement about precisely what it would be expected to do.

In the near future, Congress or the administration could try to stabilize the waste management organization at a higher policy level, to insulate it from competition with other nuclear policy areas or future Federal reorganizations, and to provide the degree of central, integrated planning and management capability needed to meet a long-term Federal commitment on schedule. These goals could be accomplished, for example, by establishing a waste management organization as a separate office headed by a Presidential appointee reporting directly to the Undersecretary of DOE, or its successor.

C5: **Relationship to Defense Waste Programs.** The pros and cons of the question whether the agency should be responsible for defense as well as commercial wastes have been discussed earlier in this summary. If the agency is to be responsible for both kinds of waste, then provisions may be required to ensure that the agency's ability to keep to the schedule for repositories—and thus to fulfill the commitments made in the contracts with nuclear utilities—does not depend upon the Federal appropriations needed to fund the defense side of the program. On the other hand, if the programs for commercial and for defense waste were separated institutionally, they could still be closely coordinated. For example, the defense waste program could be allowed to contract for space in commercial repositories on the same basis as the utilities, just as the military can now purchase services such as use of the space shuttle from NASA, the civilian space agency. This approach could financially benefit the nation since by buying into the civilian program on an annual basis, the large front-end capital costs of developing a separate defense repository system could be avoided. Such an arrangement could also help allay concerns that separation of the civilian and defense waste disposal programs could lead to indefinite deferral of progress on disposal of defense waste.

Because many of the lessons of the past that underlie the integrated policy outlined for commercial waste were drawn from the history of Federal activities dealing with defense waste, some of the elements of the policy may also be appropriate for an institutionally separate defense waste program. Of particular use might be the adoption of a schedule for disposal activities, a detailed implementation plan, and a trust fund or multiyear budget approach to assure stable and adequate funding over an extended period.

Element III

Credible measures for addressing the specific concerns of the States and the various publics.

History suggests that concerns about the safety and equity of Federal waste management activities on the part of affected States, localities, and the general public could become a source of increasingly effective opposition to implementation of a waste management program unless

specific measures are adopted to deal with these concerns. Distrust of the Federal Government's willingness to respond to these concerns appears so high that efforts to proceed without dealing with these concerns, using Federal preemption when necessary, may simply provoke greater resistance, confrontations, and failures to achieve program objectives on schedule. On the other hand, recognition of these concerns in the waste management program is likely to broaden support for it in the first place, reduce opposition during implementation, and remove grounds for complaint. Because of the legacy of distrust, explicit measures and guarantees are needed to assure the integrity of decisions concerning the siting, construction, and operation of waste disposal facilities.

A: **Explicit Plans and Assured Funds for Involvement of the Lay and Technical Publics.**

A1: **Public Involvement.** The history of the radioactive waste management program suggests that **an effective program of public involvement and information may be essential toward developing the broad public support needed for a waste policy to succeed.** Public involvement may be particularly important in the creation of an independent agency with independent funding, which could be regarded as less responsive to public concerns than the existing institutional structure. While considerable opportunity for public involvement in Federal activities is already required by existing law and administrative procedure, specific congressional action could help ensure that an adequate and sustained level of resources is devoted to this task during the development and implementation of a waste management program. Congress could require that a comprehensive interagency plan for public involvement be developed as part of MAP, that there be substantial public involvement in the development of MAP itself, and that the projected costs for public involvement be included in the waste management fee.

A2: **Peer Review.** Because confidence that a geologic repository will perform as desired over a period of millenia must ultimately rest on confidence in the soundness of the underlying scientific analysis, **extensive peer review of this analysis at each step can play an important role in assuring the public that waste will be disposed of safely.** While the responsible Federal agencies generally recognize the importance of peer review, public confidence that it would in fact take place could be enhanced by a requirement that MAP include a peer review plan that would be funded through the waste management fee.

B: **Development of a Regulatory Process That Makes Ample Allowance for the First-of-a-Kind Nature of the Problem of Demonstrating that a Disposal System Will Provide the Desired Degree of Isolation for Millenia.**

Many believe that, with a first-of-a-kind problem such as radioactive waste isolation in general—and the first geologic repository in particular—an effective regulatory process is perhaps the most vital element in assuring the ultimate safety of waste disposal.

B1: **Coordinated Review of EPA and NRC Criteria.** There are disagreements in the technical community about the philosophical approaches to regulating the safety of waste disposal reflected in the proposed technical criteria of both EPA and NRC. The issues in dispute include whether to base the safety standards on what is theoretically achievable by a well-engineered and sited repository, or on an independently determined standard of acceptable risk; whether to state the standard in the form of limits for the amounts of radionuclides that can be released by a repository over a fixed period, or in terms of acceptable levels of radiation exposures to, or health effects in, exposed populations or individuals; and whether to set performance standards for individual components of a repository system (such as the waste package), or only for the system as a whole. To help resolve such disputes, EPA could quickly publish its draft criteria for comment, and an extensive and coordinated public review of both EPA and NRC proposals could be conducted, with final publication of both regulatory frameworks due within 2 years. This approach could provide an excellent opportunity for broad public debate that could promote public understanding of the risks of waste disposal and encourage general agreement about the appropriate standards to be used. Inclusion of a requirement for a coordinated review process in waste management legislation could help assure that EPA and NRC devote adequate resources to public discussion and review.

B2: **Developing the "Technology of Prediction."** What must be demonstrated to show that waste can and will be safely disposed of is not just the physical technology of disposal, but also the institutional capability of the Federal Government to make a regulatory decision that a repository at a specific site can be expected to provide the required degree of waste isolation for a required period of time (10,000 years in tentative criteria under consideration by EPA). In addition to the physical technology, therefore, a broader "technology of prediction" is needed to show in a formal licensing process that a proposed repository is likely to meet established standards.

The repository development and licensing process is uncharted territory. The ability of a geologic repository to isolate radioactive waste for millenia cannot be directly demonstrated in the same sense that a new aircraft can be demonstrated to perform according to its design specifications. For this reason, there must be heavy reliance on predictions of the long-term isolation provided by the repository based on the use of mathematical models that embody scientific understanding of the behavior of the repository and its environment. Since such long-term prediction has never been done in a formal regulatory process, problems can be expected to arise the first time it is attempted. In addition, many analytic procedures to be used in the licensing process remain to be developed, including data collection and validation techniques, methods for verifying and validating scientific models, and the formal procedures for using such models to predict repository performance. Inclusion in MAP of a clear plan for resolving these uncertainties about procedures for demonstrating repository performance *before* the first formal licensing proceeding begins could avoid unnecessary delays at that critical stage of the waste disposal program.

B3: **Integrity of the Repository Licensing Process. For many who question the credibility of the Federal waste management program, confidence in the safety of waste disposal will depend upon their confidence in the NRC repository licensing process.** For that reason, support for an integrated waste management policy may be increased by measures designed to protect the integrity of the licensing process and to avoid even the appearance that the process has been compromised. Of particular importance is allowance of ample time (especially in the case of the first repository) to resolve unforeseen difficulties that might arise in licensing, and to provide a thorough basis of data and analysis before the first formal licensing decision is made. This would avoid the risk—inherent in any effort to streamline a licensing procedure for which there is no previous experience—that a schedule for quick decision could lead either to premature rejection of a site, or to suspicions about the adequacy of the data on which an early approval is based. A second measure that could increase confidence in the licensing process is the inclusion in MAP of provisions for submission of an application for a license for a second site as soon as a suitable candidate has been characterized, rather than submitting a second site only in the event that the first is rejected by NRC. This would increase confidence that a repository would be available according to the firm schedule that is central to the integrated policy, while at the same time reducing the concerns that a marginal site might be approved because of lack of any timely alternative.

C: **Provision in Law of Measures Dealing With State and Local Concerns, Such as a Formal Role in Repository Siting Decisions and Impact Compensation.**

The history of strong and effective State and local opposition to Federal radioactive waste siting efforts suggests that a broadly supported policy will require assurances that State and local concerns about safety and equity will be addressed. Concerns about the trustworthiness of Federal assurances suggest that any such assurances must be written into law to be credible. The stronger the guarantees in law, the more willing the States are likely to be to cooperate with the Federal Government. Some argue that State opposition is so strong that only Federal preemption can overcome it. It can also be argued, however, that any eventual attempt to preempt State restrictions will be more likely to succeed if strong efforts have been made to meet the legitimate concerns of States.

The States and localities that will be affected by waste management activities share a strong interest in the program for developing repositories and the responsiveness of the waste management agency to their concerns. Congress may therefore wish to consider creating a focal point (such as a State advisory council) for presenting State views in the development of MAP and of a design for a waste management agency, and for overseeing the implementation of the program by a waste management agency once Congress approves it.

The State role in the repository development process could be defined in legislation, with explicit limits on States' rights in the first stages of site investigation as well as guaranteed rights at later stages in the process. States may be more willing to allow site exploration to proceed if their rights are clearly specified and guaranteed in law. The explicit limitation on State rights to object in the early survey stages would make it possible to conduct a fair, nonpolitical national site survey based solely on technical criteria. While a great deal of agreement has already been reached by the major participants on measures for State and Indian tribe involvement in the siting of repositories, there is still disagreement about the procedures by which their objections to a particular site could ultimately be overridden by the Federal Government.

Legislation could also contain specific guarantees and commitments that address the substantive concerns of States about the waste management program. State concerns that the first repository may end up being the only one would be addressed by requiring in law that a second licensed site be available within a fixed period after the first. A redundant site evaluation and licensing program would also help reduce concerns that a lack of alternatives could compromise the fairness and integrity of the site selection process. State concerns about the socioeconomic impacts of waste disposal activities could be addressed by requiring in law that the Federal Government make compensation payments to affected communities and States. Funding could also be guaranteed for Federal or State arrangements to monitor storage and disposal efforts for safety—especially to detect releases of radioactivity—and for emergency response measures to deal with such releases. The cost of all such requirements would be covered by the disposal fee in order to increase the credibility of the legislated commitments.

NOTE: Copies of the full report "Managing Commercial High-Level Radioactive Waste" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Assessments in Progress as of April 1982

Alternative Energy Futures
Synthetic Fuels for Transportation
Industrial and Commercial Cogeneration
Strategic Responses to an Extended Oil Disruption
Potential U.S. Natural Gas Availability
An Assessment of Nonnuclear Industrial Hazardous Waste
Wood: The Material, The Resource
Impact of Technology on Competitiveness of U.S. Electronics Industry
Strategic Command, Control, Communications, and Intelligence Systems
Water-Related Technologies for Sustaining Agriculture in U.S. Arid and Semiarid Lands
Technologies for Sustaining Tropical Forest Resources
Evaluation of Veterans Administration Agent Orange Protocol
Strategies for Medical Technology Assessment
Technology and Handicapped People
Health and Safety Control Technologies in the Workplace
Comparative Assessment of the Commercial Development of Biotechnology
Genetic Screening and Cytogenetic Surveillance in the Workplace
The Patent System and Its Impact on New Technological Enterprises
Information Technology and Education
Impacts of Atmospheric Alterations
Assessment of Approaches to Wetlands Use
Impact of Clinical Trials on Medical Practice and Health Policy

ADDENDA

The attached summary was published in April 1982, during the course of congressional deliberations on nuclear waste policy legislation, and focuses heavily on the importance of resolution of major policy issues which had not been decided by Congress at that time. Many of those issues were subsequently resolved by passage of the landmark Nuclear Waste Policy Act of 1982 (Public Law 97-425), which established in law a firm Federal policy for the management and disposal of high-level radioactive waste and spent nuclear fuel. The full text of the law can be found in part II of the *Congressional Record* of December 20, 1982. Key elements of the law include:

- Deadline of January 31, 1998, for initial operation of the first geologic repository for disposal of commercial high-level radioactive waste or spent nuclear fuel.
- "Last resort" program for storage of limited amount of spent fuel at existing Federal facilities.
- Programs to facilitate utilities' efforts to provide their own spent fuel storage.
- Mandatory fee on nuclear-generated electricity to fund waste management programs.
- State/Indian tribe ability to halt repository development unless overridden by both Houses of Congress.
- Financial compensation to States/Indian tribes hosting waste storage or disposal facilities.
- Defense high-level radioactive waste to go into civilian repository unless President finds that separate defense-only repository is needed. States/Indian tribes have same rights with respect to defense or civilian repositories.
- Single-purpose Office of Civilian Radioactive Waste Management in the Department of Energy to implement law.

The full report of OTA's assessment of commerical high-level radioactive waste management, revised to reflect passage of the Nuclear Waste Policy Act, will be published in the spring of 1983.

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