Chapter 3
MANAGEMENT OPTIONS

Since some GTCC waste remains potentially dangerous for a few thousand years, it must be safely disposed of in a manner that protects future populations and the environment. The analysis provided in this section indicates that an appropriate disposal facility for GTCC waste will not be available for at least 15 to 20 years. Furthermore, GTCC waste generators cannot prepare their waste for disposal because no disposal technology has been chosen. Instead, they must prepare their waste for storage, and may have to repackage it later for disposal. Until a disposal facility is available, GTCC waste must be safely stored to avoid unnecessary worker exposure and handling accidents that could subsequently contaminate the environment and harm the general population.

Since GTCC waste storage is the most immediate problem now facing waste generators and policy makers, several storage options are analyzed to determine their ability to accommodate GTCC waste over the next two decades. Disposal options for GTCC waste are then analyzed by comparing them with the disposal technologies chosen for other types of radioactive waste. Finally, an integrated approach for managing GTCC waste over the short- and long-term is presented.

The technical and institutional factors listed in Table 4 are used to compare various storage and disposal options in a qualitative manner. The factors within each of the two categories are generally ranked according to their relative importance, but no attempt was made to weight them. These factors are used in somewhat different ways for storage and disposal.

STORAGE: The analysis in the storage discussion indicates that GTCC waste can be safely stored for several decades if it is safely packaged and stored under appropriate conditions. Thus, the major issue for the Federal Government does not involve determining what technologies to use, but <u>which</u> sites to use: a facility constructed and maintained on-site by the waste generator or some other off-site facility. The technical and institutional factors listed in Table 4 are used to qualitatively compare on- and off-site storage facilities.

DISPOSAL: Since the long-term safety associated with GTCC waste disposal depends largely on the disposal technology chosen, technical factors are given primary emphasis and used to evaluate three generic disposal technologies: near-surface disposal, intermediate-depth disposal, and disposal in a deep-geologic repository. Economic and institutional factors are then used to evaluate disposal of GTCC waste either at a separate facility for GTCC waste or at a currently proposed facility (e.g., the deep-geologic repository for spent fuel and defense HLW).

Table 4. Primary Factors for Comparing Waste Management Options

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TECHNICAL FACTORS:

- **Public health and safety risks**
- **Worker** Safety risks
- Environmental risks
- Transportation risks

INSTITUTIONAL FACTORS

- Timeliness in meeting the general intent of LLRWPAA -- having the Federal Government responsible for finding a safe disposal option for all GTCC waste
- Availability of adequate funding and institutional stability to ensure safe storage and disposal
- Ease of facility siting (e.g., acquiring land and finding local support)
- cost

Source: OTA

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There is a rather wide spectrum of facilities having varying levels of protection that can be used to store GTCC waste. The most appropriate storage technology depends primarily on the type and radioactivity of GTCC waste, and the expected storage time.

A. Description of Storage Technologies

The most basic storage facilities for radioactive waste are unshielded prefabricated-fabricated structures or fenced-in outdoor concrete or asphalt pads, which are sometimes covered to shed precipitation. Some companies simply store their GTCC material and waste in the basements of their buildings. Shielded concrete storage modules or bunkers with removable covers may also be located on company property at a distance from workers. The most elaborate storage facilities are permanent steel frame buildings or reinforced concrete structures. To prevent corrosion of the waste containers, some of these facilities are equipped to monitor and strictly control the indoor storage conditions, such as temperature and humidity (Siskind, 1985; Siskind, 1986).

To ensure public health and safety, GTCC waste must be properly prepared for extended storage. In choosing packaging materials, for example, a generator needs to assume that the waste may remain in storage for at least two decades. Like other types of packaged LLW, GTCC waste containers may corrode externally if indoor climatic conditions are not controlled during extended storage. Chemical reactions within the waste can produce liquids that could internally corrode containers; degrading organic wastes can generate pressurized gases, and cause unvented containers to breech or explode. If individual unvented containers are breached, stacked containers could collapse (Siskind, 1985; Siskind, 1986).

While GTCC waste is in extended storage, an adequate monitoring system will be needed to detect packages that may be deteriorating. Once degradation occurs, the GTCC waste will need to be repackaged, which could elevate worker exposures and contaminate the environment.

Inadequate administrative practices during extended storage can also result in contamination problems. For example, a combination of poor record keeping, illegible packaging labels and personnel changes, can result in loss of control over GTCC waste.

Since the controls required for radiation protection and accident prevention tend to increase as the intended storage periods increase, the storage conditions, and monitoring and administrative procedures **now used for most GTCC waste may have to be upgraded to accommodate extended storage. To ensure public health and safety in light of current uncertainties over the availability of a disposal facility the NRC and Agreement States may need to update their packaging guidance and storage regulations assuming several decades of extended storage.**

B. Optional Storage Sites

Options for providing on-site extended storage, off-site extended storage, and limited-access to off-site storage are analyzed in the following discussion. The technical and institutional factors listed in Table 4 are used in this analysis.

1. GTCC waste storage at its generation sites.

At present, GTCC materials **and wastes are being stored on-site by a few thousand users and generators, the majority of which are small companies.** On-site storage places the financial burden and liability for waste storage on the users and waste generators. The main concerns about on-site storage involve human health and safety and the potential for environmental contamination if storage is not conducted properly. This is especially true for the small GTCC material users and waste generators that possess sealed sources.

Surveys mailed to some 14,000 potential GTCC waste generators by a DOE-contractor and an informal telephone survey by OTA indicate that GTCC waste generators will have increasing problems developing on-site storage capacity over the next few decades. Some generators, especially small companies, argue that their present on-site storage capacity cannot be expanded because of costs and limitations on the physical size of their property. Although such claims by waste generators seem reasonable, they are difficult to verify. Some generators may have overestimated their storage problems with the hope that more attention would be focused on their need for a disposal facility. Nonetheless, the availability of unused on-site storage capacity for GTCC waste will decrease as the length of time required to develop a disposal facility increases.

The problem of diminishing on-site storage capacity for GTCC waste may also be much worse than it now appears for several reasons. First, thousands of users of GTCC material and sealed-source were not included in the DOE-contractor survey. Second, some generators that may be nearing the limits of their material licenses may have underreported their projected inventories. Third, some generators, especially small companies, may go out of business over the next few decades before a disposal facility is available to accept their waste. In such a situation, the Federal Government could be left responsible for storing the waste and protecting public health and safety and the environment.

2. Off-site extended storage

Over the next 30 years about 65,000 cubic feet -- equivalent to about 25 tractor trailers -- of GTCC waste is projected to be generated.[17] The DOE-contractor survey indicated that by 2020 generators will posses about 14,000 cubic feet -- equivalent to about 5 tractor trailers -- of packaged GTCC waste that cannot be stored on-site.[18] Since not all generators responded to the survey, and the survey did not include sealed source users, this figure may be low. OTA estimates that the volume of waste that may require off-site storage could be as much as 20,000

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17 M. Knecht, EG&G (DOE contractor), personal communication, September 1988.
18 M. Knecht, EG&G (DOE contractor), personal communication, September 1988.

cubic feet of packaged waste.

For several reasons, it is unlikely that a State or private company would be willing to independently develop an extended-storage facility for GTCC waste. First, given the uncertainty about the availability and timing of the Yucca Mountain repository or an alternative disposal facility for GTCC waste, it is unlikely that any State or private company would be willing to accept the open-ended liability associated with GTCC waste storage. Second, because no decision has been made on which disposal option will be chosen or how much it will cost, no State or private company would know what to charge for storage and the eventual disposal of the waste. Third, if a State or private company decides to wait and charge a second fee when a disposal decision is made, a company whose waste it is holding may go out of business in the meantime, placing all liability on the State or private company hosting the storage facility. Fourth, siting a storage facility for GTCC waste would undoubtedly involve many political difficulties, in addition to current State problems siting facilities for Class A, B, and C wastes. Fifth, the large uncertainties about the needed amount of storage capacity may make such a storage facility a risky investment. Through a notice in the Federal Register, DOE plans to solicit comments on the willingness of any non-Federal entity to provide storage capacity for GTCC waste.

Considering the situation described above, it may be necessary to provide extended storage capacity for some GTCC waste at a Federal facility.[21] In its GTCC waste report (1987a), DOE tentatively committed the Federal Government to accept GTCC waste for storage by 1989. Centrally storing GTCC waste at a well-designed facility would likely enable a more effective and efficient monitoring and enforcement program and minimize the potential for accidents and container failure at scattered GTCC waste generating sites. In the absence of political or legal intervention, the Federal Government, in particular DOE, could quickly expand an existing facility or construct a new facility at one of. its national laboratories.

Political resistance toward a Federal extended-storage facility is likely to come from any State in which the DOE storage facility is located. States have consistently expressed concerns about the added risk of any new radioactive waste management activity to its citizens and the environment. States would be worried that if activities to develop the Yucca Mountain repository or an alternative disposal option were to stall, any storage facility could evolve into a de facto disposal facility. Public trust in DOE programs has been severely eroded during past Federal efforts to site a deep-geologic repository. These State concerns may be tempered by appropriate Federal legislation (e.g., mandating that the facility only be used for GTCC storage and limiting the volume and duration of stored waste).

There is some question as to whether a Federal extended-storage facility would have to be

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19 This figure assumes that most decommissioned nuclear power plants will be placed in storage for 30 to 50 years. Under this scenario, decommissioning waste will not be generated until the middle of the 21st century. (See Appendix C.)

20 A commercial waste service company accepts GTCC sealed sources for extended storage. If it accepts the responsibility of eventually disposing of the waste, the company charges rates generally above those for Class C waste disposal. For example, one-half curie of americium-241 would cost $23,000 for storage and disposal. This company receives many inquiries about GTCC waste disposal, but few customers because of the high costs.

21 To ensure that such a facility would be used by generators with on-site storage problems, the Federal Government may need to decide whether such storage should be in some way subsidized.

licensed by the NRC.[22] All storage and disposal facilities for commercial LLW are today licensed by NRC or Agreement States. Furthermore, the LLRWPAA of 1985 already requires licensing of any **disposal** (not storage) facility for GTCC waste. The Senate passed a bill during the IOOth Congress -- that would require any storage facility for GTCC waste to be NRC-licensed.[23] To allay some State concerns and to bolster public Confidence, Congress may decide to require **that any Federal extended-storage facility for commercial GTCC waste be** licensed **by NRC.**

To ease potential problems associated with developing a licensed storage facility, DOE could parcel off a site adjacent to or within one of its national laboratories, such that the activities occurring at the licensed facility would not interfere with unlicensed defense-related activities. Two of the three commercial LLW disposal facilities are located in such a fashion.[24] Even if this made siting easier, it would still require probably several years to select a site, to conduct the required environmental assessments, and to construct a licensed storage facility for GTCC waste.

Due to economics, it is unlikely that all GTCC waste generators would choose to use the extended-storage facility. Generators who have adequate on-site storage capacity (e.g., utilities) would likely not want to pay for off-site storage. Some generators may wish to defer paying disposal costs for their GTCC waste as long as possible. This facility would, therefore, have to be designed in a modular fashion with a great deal of flexibility in its capacity and use storage technologies that would provide several decades of safe isolation. This facility would also have to accommodate a wide variety of GTCC wastes -- 60 to 75 percent of which must be handled remotely even after packaging (Knecht, 1988).

3. Limited access to an off-site storage facility

Before an extended-storage facility is available, some generators of GTCC waste may need limited access to an existing commercial or Federal storage facility. Of particular concern is the fate of the several thousand sealed sources now being used in a wide variety of tools and machines throughout the United States. Some portion of these will become obsolete and will not be returnable to their manufacturers during the period before an extended-storage facility

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22 DOE can legally accept and store commercial radioactive material generated by health and safety emergencies (e.g., accidents) at its unlicensed facilities. In addition, DOE can accept sealed sources containing plutonium, if the plutonium concentrations are economically recoverable. Users of such sources (e.g., universities and the military) pay for packaging and transportation (but not disposal) of the sources, which are donated to DOE. DOE also has accepted transuranic waste from the decommissioning of facilities operated by Monsanto (Dayton, Ohio), Nuclear Fuel Services (Erwin, Tennessee), and Babcox and Wilcox (Lynchberg, Virginia) under research and development contracts. Negotiations have stalled on a fourth contract with Exxon on a fuel fabrication facility in Richland, Washington. It has not been decided where this transuranic waste will be disposed.

23 See Section 303, Title III, entitled the Nuclear Regulation Reorganization and Reform Act of 1988 (H.R. 1315), reported by the Senate Committee on Environment and Public Works' Subcommittee on Nuclear Regulation on February 22, 1988. The Committee feels that this requirement is a logical extension from the LLRWPAA language that requires any GTCC disposal facility to be NRC-licensed. As of September 1988, The House of Representatives had not acted on this amended bill.

24 The commercial facility at Barnwell, South Carolina is adjacent to the DOE Savannah River Laboratory. The commercial site near Richland, Washington, is <u>inside</u> the DOE Hanford Reservation.

would become available.

The theft and improper handling of sealed sources have been responsible for four major accidents and 14 deaths in foreign countries over the last 25 years. In the **United States** the 40 **or so sealed source manufacturers and the thousands of sealed sources users are regulated, but individual sealed sources are not registered. Institutional controls tend to diminish as equipment containing sealed sources is transferred to other users over time.**

The impacts associated with sealed source accidents often go well beyond any immediate deaths and can be difficult to detect. For example, in 1983, a stored radiotherapy machine containing a large sealed source was illegally sold as scrap to a junkyard in Juarez, Mexico. Contaminated scrap metal was subsequently sold to two Mexican foundries, where it was melted down, made into table legs and reinforcing steel, and shipped to the United States. This accident was discovered five weeks later when a truck carrying contaminated reinforcing steel made a wrong turn at the Los Alamos Laboratory in New Mexico and tripped a radiation sensor. By this time, contaminated steel had been shipped to 40 states throughout the United States, and about 200 Mexicans were exposed to very high levels of radiation (West, 1984; Marshall, 1984; Stengel, 1984).

The International Atomic Energy Agency (IAEA) held a meeting in June 1988 on the problems associated with regulating sealed sources. The IAEA acknowledges the potential for accidents occurring if sealed sources are poorly regulated (IAEA, 1988).

Although fatal accidents involving sealed sources have not been recorded in the United States, they would be more likely to occur if tight regulatory control of licensed material and sealed sources is not maintained, especially when on-site storage is unfeasible. Even though the amount of radioactive material in many sealed sources is small, some are highly radioactive. Moreover, there are several thousands in use or in storage. In response to recent accidents involving sealed sources and mishandling of radioactive materials, the NRC issued a Notice in March 1988 to material licensees, alerting them of the need to control the handling and transfer of their licensed material to reduce the risk of an accident or its loss. Specifically, licensees are to periodically inventory and test for leaks in their sealed sources. Furthermore, the NRC encourages licensees to avoid long-term storage of surplus radioactive material.

Until an off-site storage option is available, generators have no choice but to store their GTCC waste on site. **The political repercussions for the Federal Government if a GTCC waste accident were to occur could be especially significant if the accident were linked to the Federal Government's inability to accept this waste for disposal or long-term storage.**

It is possible that a private company would be interested in storing a limited amount of GTCC waste at an existing commercial facility until a Federal extended-storage facility or disposal facility is available. Such a company would most likely only store GTCC waste if acceptance fees were sufficiently high to cover its potential liabilities, which are several. First, the period that GTCC waste would need to remain in storage is presently open-ended. There is no assurance when or if an extended-storage facility will be developed. Second, the availability of a disposal facility for GTCC waste is far from guaranteed. Third, it is unclear who would pay for extended-storage and disposal if a company were to go out of business while its waste was being held at private company's limited-access storage facility. DOE's planned Federal Register notice on the availability of non-Federal storage facility may also solicit comments on limited access to such a facility.

It appears that the most effective option for reducing the potential for GTCC accidents and ensuring adequate storage capacity for GTCC waste is to provide limited access to an

existing, unlicensed DOE storage facility. To ensure that such a facility were used only when necessary, acceptance criteria may need to be developed. Determinations of need would probably be made on a case-by-case basis by the DOE or NRC. OTA estimates that the total storage capacity needed would probably be a few thousand cubic feet -- less than 2 tractor trailers. **Any GTCC waste in limited access storage could be transferred to the licensed, extended-storage facility, once it is available.**[25]

To minimize the amount of GTCC waste requiring limited-access storage, manufacturers of new sealed sources could be required to repossess obsolete sources. Several mechanisms could be emplaced to further help the management of sealed sources. (See section on Funding Mechanisms beginning on page 32.)

AN EVALUATION OF DISPOSAL OPTIONS FOR GTCC WASTE

The goal of disposal is to isolate GTCC waste during the few hundred to few thousand years when its radioactivity poses a risk to humans and the environment. The technology chosen for GTCC waste disposal is critical to ensure long-term safety. The technical factors listed in Table 4 are used to qualitatively evaluate the acceptability of the following disposal technologies:

- near-surface disposal
- intermediate-depth disposal
- disposal in a deep-geologic repository

After this analysis, the economic and institutional factors listed in Table 4 are used to qualitatively evaluate GTCC waste disposal.

A. Description of Disposal Technologies

1. Near-surface disposal

Near-surface disposal is the technology that is presently used for the disposal of Classes A, B, and C LLW. Waste packages are disposed of in near-surface earthen trenches that are generally 20 to 30 feet deep, 20 to 100 feet wide, and several hundred to 1,000 feet long. As the waste is emplaced, the trench is backfilled with dirt and then covered with a compressed earthen cap. To reduce subsidence of the cap, Class B and C LLW must be packaged to remain structurally stable for at least 300 years. Class B and Class C waste are segregated from structurally unstable Class A waste. In addition, Class C waste must be disposed of at least 16 feet below ground or covered with a barrier (usually made of concrete) that will last at least 500 years.[26] The purpose of this barrier ‘ called an intruder barrier -- is to prevent people from digging into the waste once the site is closed and the institutional period has ended. During the institutional period, monitoring and surveillance of the site must be maintained for at least 100 years. This period begins after a site has closed and its license has been transferred to the State or a Federal Custodial agency.

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25 According to Knecht (1988), the unpackaged volume Of obsolete sealed sources that ‘s expected to accumulate by the year 2020 is less than 35 cubic feet. In the several years or so before an extended-storage facility could become available, there will likely be significantly less than 35 cubic feet. How these sources are packaged will determine how much storage capacity will be needed. It is also likely that during the period before an extended-storage facility could become available, some small companies that possess GTCC material could go out of business, requiring their facilities to be decontaminated and decommissioned. This waste could also require limited storage.

26 10 CFR 61.52(a)(2)

Three near-surface disposal sites which were used in the 1960s and 1970s experienced significant problems with subsidence and failure of overlying caps, infiltration of water, and the subsequent migration of radionuclides from the trenches. These sites have subsequently been closed. Although the more stringent 1983 NRC regulations (10 CFR 61) on near-surface disposal have thus far eliminated these kinds of problems, many States and Compact regions are very interested in using structurally enhanced near-surface disposal alternatives for their future LLW disposal sites (DOE, 1987c and NRC, 1984b).

Among the most discussed enhanced disposal alternatives are: concrete-lined trenches, above- and below-ground concrete vaults, and earth-mounded concrete bunkers (which combine several LLW disposal technologies). Concrete would be used in the construction of all of these enhanced facilities. Many other features (e.g., waterproof coatings, internal and external drainage, etc.) can be incorporated into facility designs to minimize the infiltration of surface water and to keep the waste as dry as possible.

It is possible to increase the degree to which GTCC waste can be isolated beyond that provided by near-surface facilities, by disposing of the waste at an intermediate depth of a few hundred feet. At sucha depth, there is greater assurance that humans will not inadvertently come into contact with the waste. If concrete were used at this depth it would have to withstand the pressures of deep burial over the long-term and resist degradation due to the disposal environment. The primary risk of radionuclide migration at this depth would stem from unforeseen ground water movement. Such risks would be minimized if waste were far removed from potential ground water.

2. Intermediate-depth disposal

Several different technologies could be used to place waste at an intermediate depth of between 100 and 500 feet below the earth's surface. The use of augered holes is one such technology. It involves boring a hole, typically measuring 8 or more feet in diameter, into the ground and pouring a concrete foundation in the bottom of the hole. A smaller diameter steel or fiberglass liner is then lowered into the hole until it rests on the concrete foundation. This liner is then surrounded on the outside with a layer of concrete or cement grout, typically measuring about one-foot thick. After the liner has been filled with waste, grout is poured around the waste to form a solid cement-waste matrix inside the liner. A concrete cap is then placed on top of the hole, and any remaining part of the hole is backfilled with soil (Cook, 1987).

Augered holes with depths of 20 to over 100 feet have been used over the last several years at DOE's national laboratories for the disposal of some defense LLW similar in radioactivity to Class B, C, and some GTCC waste. For example, unpackaged reactor fuel cladding and well-packaged tritium have been disposed of at the Nevada Test Site in a few unlined augered holes measuring about 120 feet deep.[27] These holes are unlined because the yearly precipitation is low and ground water is about 800 feet deep.

Another technology that could be used at an intermediate depth (100 to 500 feet deep) is a geologic repository. Repositories are described in the following section, with respect to deep disposal, but could also be constructed at an intermediate depth. Sweden has developed an intermediate-depth repository under the Baltic Sea, about half a mile offshore and 200 feet below the sea floor. The facility, which has been operating since April 1988, is excavated into

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[27] R. Dodge, Reynolds Electric Company (DOE contractor at the Nevada Test Site), Personal communication, June 1988.

granite. It is designed with 4 large rooms to hold LLW and a concrete silo, about 200 feet high and 100 feet in diameter, to contain intermediate-level waste.

3. **Disposal** in a deep-geologic repositorv

Deep-geologic repositories, located at depths of 2,000 to 3,000 feet, are viewed by the scientific community worldwide as generally the most favored technology for disposing of highly radioactive waste. The geologic formations surrounding a repository will provide major natural barriers to the migration of radionuclides by ground water over the long-term. Engineered barriers, such as the waste form and surrounding package, enhance the isolation of the waste during the first few thousand years. During this time, heat from the waste could increase the migration of radionucides if the waste were to contact with any flowing water (OTA, 1985).

According to the Nuclear Waste Policy Act of 1982 and subsequent studies by DOE (1985d and b, 1987d, and 1988), all spent fuel and defense HLW will be permanently isolated in one deep-geologic repository. Yucca Mountain in Nevada is now being evaluated to determine its suitability for such a facility. If this site found to be suitable, waste canisters will be emplaced along a widely spaced grid within the repository beginning in about 20 years. Waste emplacement will continue for about 50 years (DOE, 1987d). The repository may remain accessible for a few decades after the waste has been emplaced to allow for monitoring and continued cooling of the waste. The repository will then be backfilled. About 67 percent of the repository's volume is projected to be used for commercial spent fuel and 33 percent for defense HLW.[28]

Another deep-geologic repository will be used for the disposal of transuranic waste generated by defense activities. Over the last decade DOE has been developing such a facility, called the Waste Isolation Pilot Plant (WIPP). This repository is situated at a depth of about 2,200 feet in a bedded salt formation near Carlsbad, New Mexico. DOE plans to dispose of some defense transuranic waste in WIPP on a demonstration basis in late 1988.[29] If this 5-year demonstration is successful, much of DOE's remaining transuranic waste will be disposed of in this repository over the next 20 years.

Although there are as yet no licensed deep-geologic repositories for radioactive waste in the United States, or elsewhere in the world, decades of extensive scientific study have revealed no insurmountable technical obstacles for developing such repositories, provided suitable sites are found (OTA, 1985).

B. Technical Comparison of Disposal Technologies

Near-surface disposal facilities, which **are licensed by** NRC (under 10 CFR 61) or by Agreement States, can be used for the disposal of Class C LLW which requires isolation for periods of about 500 years. Since the longevity of risk for GTCC waste greatly exceeds this time period, near-surface disposal technologies would generally not be appropriate. Such a position is stated in NRC's Part 61 regulation.

Reinforced concrete is widely used in enhanced near-surface disposal technologies for long-term structural integrity. To evaluate the suitability of concrete for near-surface enhancements, DOE's Brookhaven National Laboratory conducted an in-depth analysis for the

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28 M. Komar, DOE, personal communication, June 1988.

29 C. Fankey, DOE, Personal communication, May 1988. As of September 1988, it appeared that this demonstration phase would not begin until 1989.

NRC on historical and recent experience with concretes throughout the world (NRC, 1986 b). This study found that some ancient concretes have performed adequately for 2,000 years or more. Although modern concretes have not been in use for much more than a century, there are many examples of excellent performance for periods of several decades and a few for periods on the order of 100 years (MacKenzie, 1987).

Considering the lack of deterioration of ancient concretes that have been subjected to harsh conditions and the relatively benign conditions expected at near-surface LLW disposal facilities, it should be possible to formulate concrete with enough durability to perform satisfactorily as a structural material for a few hundred years (MacKenzie, 1987). It is unclear, however, that enhanced near-surface disposal alternatives using concrete would prove adequate for the few thousand years necessary to isolate most GTCC waste.

As mentioned in the background section of this report, GTCC waste characteristics are most similar to defense HLW. Furthermore, by the year 2020 more than half of the activity of GTCC waste will be contributed by radionuclides (primarily nickel-63) with half-lives of 100 years or longer. In accordance with the Nuclear Waste Policy Act of 1982 and its 1987 amendments, defense HLW is planned for disposal in the Yucca Mountain repository; defense transuranic waste is planned for disposal in WIPP. If a **decision about the disposal of GTCC waste were required today, its permanent isolation in a deep-geologic repository would be technically acceptable.**

The NRC staff, in a letter response to DOE's report to Congress on GTCC waste (NRC, 1987), recommended that GTCC waste be disposed of ina deep-geologic repository. In this letter the NRC estimated that roughly 85 percent of GTCC waste had enough long-lived radionuclides to require permanent isolation in a deep-geologic repository (NRC, 1987). As mentioned earlier, the NRC has also published a proposed amendment to 10 CFR 61 in the Federal Register (May 18, 1988) that would require all GTCC waste to be disposed of in a deep-geologic repository, "unless disposal elsewhere has been approved by the Commission."

It is possible that further research and analysis over the next several years could demonstrate the acceptability of non-repository disposal alternatives, such as intermediate-depth augered holes or an intermediate-depth repository. These technologies, if used in areas of low rainfall and deep ground water, might be found acceptable for some GTCC waste, especially the portion of waste composed of short-lived radionuclides. It is unclear, however, whether any disposal alternatives other **than a deep-geologic repository would be acceptable** for isolating the long-lived radionuclide portion of GTCC waste.

C. Preliminary Economic Comparison of Disposal Options

Due to significant economies of scale associated with constructing large facilities, it is possible that waste disposal in a large repository may be less expensive than using a smaller facility only for GTCC waste. In the following discussion, the costs of GTCC waste disposal in the Yucca Mountain repository are analyzed, to the extent possible, before examining possible costs for a smaller, separate disposal facility for GTCC waste only. It must be emphasized that these calculations are preliminary and will have to be verified when more accurate estimates become available.

Disposal costs are calculated below in terms of the volume of disposed waste rather than considering the various factors used for commercial near-surface disposal facilities. Among others, these factors include: concentration of radioactivity (i.e., curie content per unit volume), the half-life of the waste's radionuclides, and the type of radiation emitted by the waste. Site operators use these factors to determine the waste package's longevity of risk and whether it must be handled remotely. Since repository disposal costs will probably be based on waste volumes, **the following analysis uses only waste volumes to estimate disposal costs.**

1. Large , deep-geologic repository

The approximate cost of GTCC waste disposal in a repository is highly dependent on the mode of waste emplacement. One potential mode involves stacking the packaged waste from floor to ceiling in **dedicated rooms excavated specifically for** GTCC waste. If waste packages could be packed tightly together,[e] the total volume of GTCC waste generated by 2020 would fill a room approximately 15 feet wide, 20 feet high, and 570 feet long. This volume -- about 170,000 cubic feet -- would occupy about 0.1 percent of the 115 miles of tunnels and waste emplacement rooms now planned for the Yucca Mountain repository. According to very preliminary DOE estimates, constructing the Yucca Mountain repository is now projected to cost about $15 billion. Constructing ().1 percent of the repository for GTCC waste would cost about $15 million (not including waste repackaging and loading costs), or about $90 per cubic foot of GTCC waste.[=]

A potentially less expensive disposal mode involves using GTCC waste as **backfill material when the repository rooms and/or connecting tunnels are sealed off and the repository is closed. This mode would eliminate the cost of excavating dedicated** rooms. If this second mode were used, GTCC waste disposal would probably not begin for at least a decade after the first (and presumably the coolest) spent fuel was emplaced. In other words, the emplacement of some GTCC waste could begin around 2020.

Although the backfill option is likely to be less expensive than GTCC waste disposal in dedicated rooms, the backfill option has a couple disadvantages. First, if the small section of repository containing GTCC waste were ever reexcavated, the waste in the backfill material could make this operation significantly more difficult due to worker exposure. Second, if the entire repository were left open for about 50 years to allow further cooling and continued monitoring of the spent fuel, disposal of GTCC waste as backfill could not begin until after the middle of the 21st century.

2. Separate GTCC waste disposal facility

The costs associated with developing a separate facility for GTCC waste using intermediate-depth disposal facilities have not been calculated. Cost estimates, however, have been made by DOE for several near-surface disposal technologies for LLW, with near-surface disposal being the least expensive and earth-mounded concrete bunkers being the most (DOE,

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The majority of non-utility GTCC waste and a great deal of utility GTCC waste could be tightly packed into repository rooms. Some utility waste (e.g., core shrouds) may have to be emplaced along a widely spaced grid, like spent fuel, or further cooled by storing the waste for two or three more decades. NRC staff believe that the overall packaging requirements for most GTCC waste need not be more stringent than those provided in 10 CFR Section 61.55 for 300-year stability of Class B and C LLW (NRC, 1988 b).

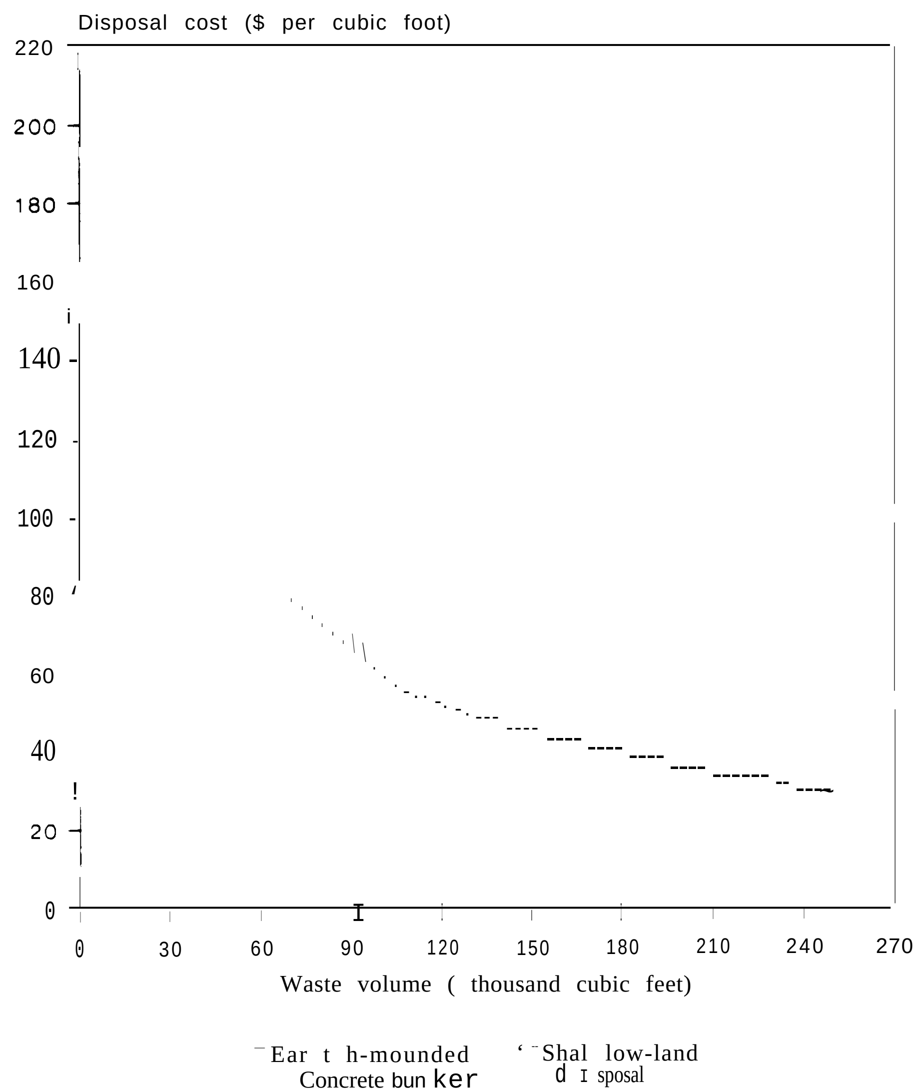
31 M Komar DOE personal communication, June 1988.

32 C. " Conner: DOE: personal communication, May 1988. DOE has already spent several tens of millions of dollars screening sites for a HLW repository and an additional $1 to $2 billion will be required to characterize the presently proposed site at Yucca Mountain in Nevada.

~ This assumes that the cost of space occupied by GTCC waste would include a Proportion of the overall cost of siting and developing the repository. Some people would argue that the repository must be developed anyway, under the Nuclear Waste Policy Act of 1982, and that GTCC costs should be based only on the incremental cost of adding the space used for GTCC waste disposal.

1987c). **Disposal costs fora near-surface facility accepting** about 60,000 cubic feet of waste per year, which was the smallest facility evaluated, were estimated to average $120 per cubic foot (DOE, 1987c). The projected annual rate of GTCC waste generation around the year 2020 is only about 6,000 cubic feet per year. As suggested in Figure 2, the disposal costs for a near-surface facility with a capacity of only 6,000 cubic feet per year could be significantly more than $120 per cubic foot due to its smaller size. These preliminary cost figures are summarized in Table 5.

Figure 2.-Near-Surface Disposal Coats for a Range of LLR Volumes (calculated using the EG&G economic model for a 30-year facility)



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34 **This figure is substantially higher than** the generation **rate today because** of **waste** ‘hat ‘iii come from decommissioning and refurbishing of nuclear power reactors.

Table 5. Preliminary Estimates of GTCC Waste Disposal Costs

Disposal technology	Estimated cost *
Yucca Mountain repository (assuming tight packing of waste)	$ 90/ft^{3} [a]
Separate near-surface facility	$ 120/ft^{3} [b]

* The disposal **costs** for both of these options will probably be higher than those indicated above. Repository disposal costs, which are still being developed by DOE, probably do not include the full range of operating costs. Unit disposal costs for using **a** separate facility for GTCC **waste** could be significantly higher due to its intermediate depth, its small size, and other additional operational costs for handling highly radioactive GTCC waste.

Source:
[a] C. Conner, DOE, personal communication, May 1988.
[b] **EG&G Idaho, Inc., "Costs and** Consequences of **Site** proliferation: per **Unit Disposal Costs,"** Low-Level Radioactive Waste Forum, Toronto, July 1988, unpublished conference notes;

The preliminary calculations provided above indicate that the costs of GTCC waste disposal in the Yucca Mountain repository could be comparable to, or perhaps even less than, costs associated with developing a smaller, separate disposal facility only for GTCC waste. The level of long-term isolation provided by the Yucca Mountain repository would also presumably be as great or greater than the isolation provided by an “intermediate-depth facility.

D. Institutional Considerations in Choosing a Disposal Option

A disposal facility for GTCC waste could, theoretically, either be developed and operated by **a** non-Federal entity or by the Federal Government. For several reasons, it does not appear likely that a non-Federal entity would be interested in developing and operating such a facility. **As** mentioned earlier, DOE plans to issue a notice in the Federal Register to determine whether any such non-Federal interest exists.

It is possible, though unlikely, that a State or regional Compact would accept GTCC waste for disposal. During the Presage of the LLRWpAA, States argued that the Federal Government should take responsibility for GTCC waste because of the long-term risks associated with much of the waste. In fact, one State opposed taking responsibility for Class C LLW.[36] Thus, States would probably not be interested in developing **a** separate disposal facility

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35 The Low-Level Radioactive Waste policy Act of 1980 and the Low-Level Radioactive Wrote Policy Amendments Act of 1985 encouraged States to form multi-state Compacts with each Compact region hosting one disposal facility. States that have not joined **a** Compact may be planning to host a facility only for waste generated in their State. Economically, some States and Compacts may have difficulty supporting their facilities, given the 50 percent decrease in volume of LLW shipped for disposal over the last 7 years. It is, however, unclear whether the economic gain from disposing of such a small amount of waste would outweigh the added risks.

36 Representative Kostmeyer from Pennsylvania introduced an amendment to the Low-Level Radioactive Waste Policy Amendments Act of 1985 to transfer the responsibility of Class C

for GTCC waste. It is unlikely that they would be interested in accepting GTCC waste at an existing or planned near-surface LLW disposal facility, which would probably not provide adequate long-term isolation for much GTCC waste.

Private companies are also unlikely to be interested in independently developing and operating a GTCC waste disposal facility without Federal sponsorship. In addition to the inevitable political difficulties associated with siting and potential delays with licensing such a facility, private industry may have considerable concerns about potential long-term liability of holding title to waste that remains hazardous for a few thousand years. The fact that a commercial waste disposal facility for GTCC waste has never been constructed or licensed would make such a business venture extremely risky.

Given the increasing difficulty in siting nuclear waste facilities, it is unlikely that the Federal Government, presumably DOE, would choose to develop a new, separate facility for GTCC waste. **At this time, the most likely disposal option appears to be the Yucca Mountain repository. Congress, the DOE, and the State of New Mexico have agreed that** the WIPP facility will be only for defense waste, and defense facilities are not licensed by the NRC. The LLRWPAA of 1985 explicitly requires GTCC waste, which is commercial waste, to be disposed of in a NRC-licensed facility.

If DOE decides to dispose of GTCC waste in the Yucca Mountain repository, the State of Nevada will likely object to GTCC waste being funneled into this disposal facility. Furthermore, if fees for GTCC waste disposal in the Yucca Mountain repository are comparable to, or less than, disposal fees for Class C waste at commercial near-surface disposal sites, waste generators would have an incentive to compact Class C waste such that its radioactivity were increased to GTCC levels. In addition, it is still unclear how the country will dispose of GTCC defense waste that is not transuranic. “

It could be argued that the National Environmental Policy Act of 1970 (NEPA) would require an evaluation and comparison of alternatives prior to selecting a disposal option. Such a process normally involves balancing costs and benefits associated with a particular project or a major Federal action. In most cases, environmental and public health and safety risks associated with projects can be decreased by adding features to the project that would increase its development costs. The situation involving GTCC waste disposal, however, appears to be quite different. From a public health and safety standpoint, it is highly unlikely that any disposal alternative would provide more isolation than the Yucca Mountain repository. It also appears unlikely that a small, separate GTCC waste disposal facility of any type would be as economical as the repository.

E. Summary

From a public health and safety standpoint, deep-geologic repositories are likely to provide the greatest isolation of GTCC waste based on information available today. In fact, repository disposal is believed to be sufficient for isolating spent fuel which is many times more dangerous than GTCC waste. Since the projected volume of GTCC waste would probably occupy much less than 1 percent of the planned Yucca Mountain repository, this option would

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waste to the Federal Government.

[37] prior to May 1986, DOE had plans to develop a second repository in the East. DOE Secretary, Herrington, postponed these plans, arguing that volumes of spent fuel and defense HLW were insufficient to justify two repositories. This decision also defused a great deal of political opposition associated with this siting program.

likely be less expensive than developing a small, separate facility for only GTCC waste using ~ technology. Institutionally, using the Yucca Mountain repository would eliminate having to site, develop, and license a new separate disposal facility for GTCC waste.

If a decision about the GTCC waste disposal were required today, permanently isolating GTCC waste in a deep-geologic repository would be an acceptable option. It is possible, however, that further research of alternative disposal technologies could indicate that an intermediate-depth disposal facility used only for GTCC waste (e.g., augered holes) would provide an acceptable level of isolation. DOE could spend the next couple of years evaluating the impacts associated with disposing of GTCC waste in the Yucca Mountain repository on the repository's overall operation and performance. If this disposal option proved to be acceptable from an environmental, economical, and institutional standpoint, DOE could use the Yucca Mountain repository asaba,sis in designing its GTCC waste management approach. If this option proved to be unacceptable, DOE could then evaluate other disposal technologies. Making a disposal decision will help resolve many storage uncertainties and enable necessary guidance and regulations to be developed.