RADIOACTIVE WASTE MANAGEMENT CENTERS — AN APPROACH*

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ABSTRACT

Radioactive waste management centers would satisfy the need for a cost-effective, sound management system for nuclear wastes by the industry and would provide a well integrated solution which could be understood by the public. The future demands for nuclear waste processing and disposal by industry and institutions outside the United States Government are such that a number of such facilities are required between now and the year 2000. Waste management centers can be organized around two general needs in the commercial sector: (1) the need for management of low-level waste generated by nuclear power plants, the once-through nuclear fuel cycle production facilities, from hospitals, and other institutions; and (2) more comprehensive centers handling all categories of nuclear wastes that would be generated by a nuclear fuel recycle industry. The basic technology for radioactive waste management will be available by the time such facilities can be deployed. This paper discusses the technical, economic, and social aspects of organizing radioactive waste management centers and presents a strategy for stimulating their development.

1. INTRODUCTION

Although this session of the American Nuclear Society meeting is focused on international fuel cycle centers, I have chosen to address the general concept of radioactive waste management centers, using as a model the needs of the United States. The general analysis is, of course, applicable to the international scene. Technologically, international radioactive waste management centers would probably not be different from those that might be employed in the United States, except for various refinements of flowsheets and applications and for different shipping requirements. However, another set of political attributes is involved. One can readily see that for certain regions and combinations of countries there are advantages to fuel cycle centers with associated waste management facilities. In addition, much has been written and said concerning the safeguards advantages that such facilities might have. The principal barriers to their development are political and institutional.

Waste management centers must be developed within the context of their being service facilities for other primary components of the nuclear industry; thus, such centers would serve reactors, industrial needs, and institutions. More comprehensive facilities can be envisioned for fuel cycle centers that reprocess and recycle fuel. Thus, where any suitable regional service area can be identified, then the approaches suggested in this paper would apply. The United States government sources are excluded in the discussion of this paper although inclusion would make no difference in conceptual terms.

2. BACKGROUND

Virtually every study that has examined the subject of nuclear energy and fuel cycle centers has concluded that such centers are advantageous when there are suitable regional service areas for them.[1–6] These advantages have been recognized by many countries as attested by the fact that the majority of government-owned nuclear fuel cycle facilities, including waste management facilities, have been organized into large integrated complexes, and in planning for future facilities, other countries have adopted such an approach. For example, the Federal Republic of Germany has developed regional centers for the management of low-level wastes throughout Germany. In addition, until the program was deferred, the Federal Republic of Germany had plans to develop an integral fuel recycle plant and repository complex at the Gorleben site. In fact, commercial burial grounds that have been opened (and some subsequently closed) could be considered to be the precursors for low-level waste management centers. However, even the ones now open may be closed unless socially and politically acceptable terms are reached.

Waste management centers would offer the means for cost-effective application of sound waste management technology. Centers offering comprehensive services would have the best opportunity for possessing the necessary technical and management expertise to process and dispose of nuclear wastes. Development of centers would seem to be a more effective technical approach than for each state to take care of its own wastes or for each reactor to end up storing all of its wastes on site. Nuclear waste management centers should also provide for a well integrated solution to waste management problems which might be better understood by the public than a more dispersed, non-uniform system.

Disadvantages of the approach include the political issues — for example, the necessity for entering into regional compacts or agreements to overcome the "you can't put it here" syndrome. Thus, institutional changes may be required in order to bring about the effective application of nuclear waste centers. In addition, changes in the law may be required; for example, statutory changes may be required to establish regional waste management centers, or for private industry to operate such centers on government or private land. Also, as the operations proposed become larger in size and more comprehensive there will be greater visibility and interest (both positive and negative); therefore, the very suggestion of a center may evoke reactions.

To assess the magnitude of the problem of applying waste management technology and extending it to a comprehensive solution, it would be good to review the present approach to development of a solution. The Federal government is undertaking the major role. It alone is looking for a location for one or more repositories and has undertaken the burden of obtaining acceptance of such repositories. The Federal government has this singular involvement in the management of spent fuel, transuranic, and high-level wastes. On the other hand, the states have been delegated the role of conducting the major effort in managing low-level radioactive waste. Some states are studying the problem individually; others have sought to enter group efforts to see if regional compacts would make sense for them. The states are also consulting and acting in a concurrence role on waste management approaches. The states do not at present have a statutory veto power for such approaches; but, as a practical effect, they have had such a power to date. Industry, which is applying interim solutions, has little power to intervene in the process. Owners of nuclear reactors are implementing additional storage capability for spent fuel and for the wastes generated at nuclear reactors. Meanwhile to a great extent, the public is being led to believe that there is no technical solution to management of radioactive wastes.

Establishment of an adequate service industry is not limited by technology; in fact, the basic technology existing today is probably fully adequate, if properly applied. And, if that is not enough, the Department of Energy (DOE) has a comprehensive technology program that will provide adequate options for the future. What is missing is a coherent plan for the required service facilities for the nuclear commercial sector. It is difficult to develop an exact plan for the required services, but the legal and institutional structures can be changed so that service facilities are easily developed by private sources. A methodology for obtaining acceptance of facilities by the public must be developed. At present, the plans are not completely adequate because there are not sufficient means for determining compensation for impact nor for obtaining agreement on what such compensation should be. Although one can explore the technical alternatives, locate tentative sites, and do all the necessary work for deploying a facility for waste processing or disposal, the fact remains that the institutions and procedures for deciding the tough issues regarding siting are just not adequate to do it.

This paper scopes the needs for radioactive waste management centers and the actions that could be taken to improve the prospect of developing such centers. The paper projects wastes to be generated by nuclear power reactors and by other parts of the commercial sector such as industry and medical institutions, describes a waste management center approach, and summarizes the technical feasibility of waste management centers. The paper suggests methods of obtaining acceptance of radioactive waste management centers by the public, and lastly, suggests a plan of action that could be undertaken to expedite the process. This paper is not intended to delineate a well researched and documented approach since not enough information is available to do that. Rather, it is intended to serve as a basis for discussion so that an approach can be developed.

3. BASIS OF PAPER

Two broad possible scenarios are considered in setting up the suggested radioactive waste management center approach: (1) the case of no recycle of reactor fuel; and (2) the case of recycle of reactor fuel if that would be allowed in the future. The approach is based on nuclear power reactor deployment schedules and power projections contained in the document on the position of the United States DOE on rulemaking on the storage and disposal of nuclear wastes.[7]

For the case of no recycle, the analysis assumes extensive reactor storage of spent fuel. Storage beyond that provided at the reactors would be provided in away-from-reactor (AFR) storage facilities. Geologic repositories are established on the schedules presented in the DOE statement of position, and later spent fuel would be stored in these repositories. Regional low-level waste management service facilities providing the needs for commercial waste are assumed.

For the recycle case, the schedules and power projections are the same as for the no-recycle case, thus the basis is the same except that fuel recycle plants are phased to enable loading the first repository with high-level wastes, not with spent fuel. In other words, AFRs are employed, thus unreprocessed spent fuel is never placed in a geologic repository.

The assumed nuclear capacity projections are presented in Fig. 1. For the analysis, the DOE/NE-0007 base case[7] has been used in this paper. Also presented in Fig. 1 for comparison are the current median and low estimates of nuclear capacity by the Energy Information Administration (EIA). Reduction of nuclear capacity to the levels of the EIA median and EIA low would, as a first approximation, reduce the waste processing and disposal system needs by approximately 50% from the levels presented in this paper. It could also substantially alter the dates at which various facilities are needed. The sensitivity of various needs and schedules to the EIA projection has not been analyzed.

4. THE SCENARIO FOR NO FUEL RECYCLE

The cumulative fuel discharges from the nuclear capacity represented as a base case in Fig. 1 are presented in Fig. 2. The fuel held at reactors is represented by the bottom curve, and the amount shown represents a case in which it is assumed that the utilities expand their reactor storage pools to the maximum capacity they have estimated.[7] It does not assume trans-shipment between reactors; thus, some cushion may be provided by this assumption since trans-shipment may be possible. The difference between the total discharge and the amount at the reactors, of course, is the amount of fuel to be placed in AFRs or in repositories.

4.1 Spent Fuel Storage Facilities

To determine the number of locations of AFRs or repositories that might be needed for optimum deployment from a transportation standpoint, it is necessary to examine transportation costs as a function of the number of repositories or AFRs. Results of an analysis by Joy and Hudson[8] are presented in Fig. 3. The relative costs of transportation versus the number of repositories in the United States are shown. The analysis shows that transportation costs will decrease significantly as the number of storage sites increase. Maximum costs were obtained with the assumption of one western site initially for location of a repository. This is because the larger proportion of fuel is located in the eastern part of the United States. Minimum costs are obtained by distributing the sites optimally. Diminishing returns on increasing the number of repositories is approached at five repositories. Thus, for purposes of the analysis in this paper, it was assumed that a target of three would be acceptable if the sizes of the facilities required turned out to be appropriate. Of course, the judgment on what is appropriate is subjective when complete system studies on the effect of scale have not been accomplished.

The required central storage capacity is presented in Fig. 4. The repositories are sized and scheduled according to the DOE position on rulemaking; that is, the first repository has the capacity of 40,000 metric tons of uranium and the second and third repositories have capacities each of 70,000 metric tons of uranium. The graph also indicates the cumulative off-site storage required. It can be observed that the maximum requirement is in the year 2000, and a storage capacity of 20,000 metric tons of uranium is required. After opening of the repositories, fuel would be placed in the repositories according to the schedules presented in Fig. 4. Figure 5 examines the away-from-reactor storage requirements in more detail. The requirements for AFR storage are based on the assumption that the GE-Morris, the AGNS, and the NFS facilities can be used and that the fuel can be reracked to obtain maximum loading. Under these assumptions, the GE-Morris facility would contain 750 metric tons of uranium, the AGNS facility 1750 metric tons, and NFS 1500 metric tons. AFRs were assumed to be designed for a capacity of 5000 metric tons of uranium. All of these assumptions are consistent with the DOE position statement.[7] As can be seen in Fig. 5, the first AFR is required to be on line in 1990, the second in 1994, and the third in 1996. Optimum boundaries for the establishment of either AFRs or repositories were established by a three-region transportation study based on the requirements in year 2000; this information is presented in Fig. 6. As can be seen, optimum establishment of such facilities results in one in the midwest-east region, one in the southeast, and one in the west. This optimum is based solely on analysis of transportation costs and the distribution of spent fuel that will be discharged. Final establishment of such facilities will depend upon environmental acceptability for the various areas as well as upon finding suitable geologies for the repositories.

4.2 Centers for Processing and Disposal of Low-Level Radioactive Waste

Using the nuclear capacity projections presented as the base case in Fig. 1, the quantities of low-level wastes were estimated. The basis for the estimates were waste inventories and projections recently published by DOE.[9] Institutional and industrial wastes were also based on the same projections. The projections estimate that reactor operations and the associated once-through fuel cycle will produce 900 m^3/GW(e)-year. All of this information is presented graphically in Fig. 7. One of the principal observations is that nuclear power reactors will contribute an increasing proportion of low-level radioactive waste. It would appear also that the institutional and industrial low-level radioactive wastes are underestimated for the future since one would ordinarily expect these to expand also; however, they would not be expected to scale as a direct ratio to the application of nuclear energy. It is more likely that such wastes would be based upon advances in the industrial and, particularly, the medical sectors. The waste quantities presented are for volumes as generated; they do not take into account volume reduction. Volume reduction impact, however, is indicated schematically in Fig. 7, showing the effect of achievement of 4:1 volume reduction of all low-level radioactive waste generated by 1990.

The present technique primarily used for disposal of low-level radioactive waste is shallow land burial. Figure 8 gives the cumulative commitment of land required when the land can be loaded at a value of 20,000 m^3/hectare. Only 200 hectares are required by the year 2000, which is not an extraordinary commitment of land. The required land commitment can be reduced. The volume reduction in Fig. 8 indicates the commitment required when a 4:1 volume reduction is assumed. It should be noted in the context of presenting Fig. 8 that future disposal requirements for low-level waste may necessitate isolation that is improved over present shallow land burial practice — for example, deeper burial and mined cavities might be employed. The type of isolation required might also depend upon the amount of waste fixation that is practiced.

In determining what a low-level waste processing and disposal facility should do, one is confronted with the complex matter of estimating and categorizing the wastes generated, especially when it is derived from diverse, unrelated sources. Through consideration of our own data at Oak Ridge National Laboratory as well as review of the literature,[10–12] the waste categories presented in Table 1 were estimated. The sources of the waste are the nuclear fuel cycle, reactor operations, and institutional and industrial organizations. The once-through fuel cycle wastes are usually characterized as combustible and noncombustible trash, protective clothing, failed equipment, resins, filter sludges, filter cartridges, and process liquids. Reactor operations produce similar wastes although with a different distribution. Institutional wastes include biological, a large quantity of scintillation vials, solidified and absorbed liquids, and dry trash.

To select basic processes, it was assumed that maximum volume reduction and a high degree of waste fixation would be desirable. Of course, other approaches could be taken. For purposes of simplification, it was assumed that all of the materials could be processed in lightly shielded facilities and that the equipment could be maintained by contact means. It should be noted that some of the wastes, however, cannot be processed in this manner, either because they are too radioactive or not amenable to one of the processes. Concerning the basic process unit scale, it was assumed that two to three furnaces of different designs would be required to handle the distribution of metals. Units are readily available which can process up to

10 metric tons per day; accordingly, a basic unit scale of 20 metric tons per day is appropriate. Concerning combustibles, the medium-scale incinerator was chosen, having a capacity of 100 m^3/day. For glass and ceramic materials, 20 m^3/day can be easily processed through crushing equipment. In Table 1 these scales are compared with the requirements for a 1000 MW(e) reactor for each day of its operation. For purposes of analysis, wastes from industrial and institutional sources were prorated to the reactor. At the basic unit scales chosen, a number of reactors together with their supporting fuel cycle sources and contributions from industrial and institutional sources can be handled by each basic unit.

The question then becomes: How might such low-level waste processing and disposal centers be deployed? A good choice might be to base the selection on the nine regions of the National Electric Reliability Council (NERC). These regions are depicted in Fig. 9. They vary considerably in size of projected nuclear capacity. As can be seen in Fig. 10, demand for most of these regions can be met with not more than two unit processes in most cases in the year 2000. The exception in Fig. 10, in the case of both metal and combustibles, is the southeastern region.

The average regional plant, serving 50 GW(e) at 80% load factor, would convert 120 m^3/day of low-level radioactive waste to 46 m^3/day of fixed low-level waste. Figure 11 shows a schematic flowsheet for the operations. It was assumed that the method of fixation would be in either concrete or polymer, all placed in a container. Based on the average plant size, four such plants would be needed in 1985 and nine in the year 2000. Obviously, such regional centers could offer, as they do now to an extent, additional services such as for decontamination, decommissioning, and for emergency response.

Regional low-level waste management centers could be designed now to offer comprehensive services. Concerning the illustrated approach of maximum volume reduction and fixation, most of the technologies are known for accomplishing the processing. The technology of metal melting is established, although not applied fully in such facilities. There are many operating facilities for incineration. Glass and ceramic crushing should be a straightforward technological application. Fixation by concrete and polymers are both highly developed and are improving. For burial or storage, pathways analyses must be accomplished to determine the suitability of any particular site. Regarding the design of processing facilities, most of the technology required is well known. It should be noted that many other approaches could be taken to the disposal of low-level wastes. The many alternatives need to be subjected to systems analyses to optimize the variables that must be considered relative to waste form and method of disposal as well as the processes required. However, the one depicted in this paper is a technologically feasible solution.

4.3 Other Aspects of the No-Recycle Case

In this paper the assumptions of the DOE position document regarding reactor on-site spent fuel storage and the dates for bringing repositories on line were adopted. It is possible, of course, to reduce the amount of on-site storage, in which case the construction of AFRs would be required at an earlier date, and it should be possible to construct such facilities by 1985. If there is to be no fuel recycle, the AFR requirement can be reduced through earlier resolution of the problem of repository siting. The siting of low-level radioactive waste management centers is not constrained by the assumptions, but the earliest that such comprehensive facilities could be provided would be about 1985. Other problems regarding siting are presented later in this paper.

5. WASTE MANAGEMENT CENTERS FOR THE FUEL RECYCLE CASE

For this analysis, to develop a schedule it was assumed that fuel recycle plants should be placed into operation on a schedule which would obviate the placement of spent fuel in a geologic repository. In accord with this assumption and the storage requirements presented in Fig. 4, recycle plants would be required to start production in 1997, 2002, and 2006. Each plant would have a production capacity of 3000 metric tons of uranium per year (10 metric tons of uranium per day). The cumulative fuel storage requirements and cumulative recycle capacities with these assumptions are presented in Fig. 12. Obviously, in this case, it is technically possible to advance the start date for the first recycle plant and thus minimize AFR storage requirements.

5.1 Waste Processing in the Fuel Cycle Center

Waste processing should be an integral part of the fuel cycle center since significant quantities of transuranic wastes, low-level wastes, and high-level wastes are produced in the fuel reprocessing and fuel refabrication operations. While it is possible that the fuel cycle center would also process low-level waste generated from outside the fuel cycle center, this case has not been treated analytically. It would be necessary only to increase the capacity of the operations.

The wastes generated in such plants were estimated from review of literature[10,13,14] and from our own experience at ORNL. The recycle plant would require remote and nonremote transuranic waste processing facilities; the quantities estimated are depicted in Fig. 13. Again, it has been assumed that maximum volume reduction is desirable, and this is done through metal processing, incineration, and glass crushing. The sizes of the required operations are somewhat less than were required for the regional facility for low-level waste processing. It was also assumed that the process materials, except for metals, would be placed in concrete or in another suitable waste form. The low-level waste processing requirements are on the order of the requirements for the average region, and the schematic diagram of the processes for volume reduction and encapsulation is shown in Fig. 14.

Concerning the other categories of wastes, these are not treated explicitly; it was simply assumed that a suitable waste form would be developed for high-level wastes, that the cladding hulls could be compacted, and that successful techniques would be developed for containment of radioactive gases, iodine, and tritium.

If it is assumed that the recycle plant would have a design life of 30 years, the repository site required for storage of all wastes produced would amount to approximately 700 hectares. This does not include land for auxiliary facilities nor for the recycle plant itself. Presented in Table 2 are the estimates of the quantities of waste forms that would be produced together with the amount that can be accommodated per hectare. It was assumed that the repository would be multi-level.

Regarding the capability of designing and constructing fuel recycle waste management centers, a vast array of technology will be available for the processing and fixation by the time it is required for such centers. Concerning high-level wastes, many waste forms are being developed and many of the processes are at engineering or larger scale. The same is true in the case of transuranic wastes, for which concrete may be a satisfactory form. The status of technology for low-level waste management has already been discussed. The requirements for low-level waste processing in fuel cycle waste management centers is very similar to the requirements for regional centers and, therefore, design can be based on experience in those centers.

5.2 Scheduling of Facilities

At present, recycle of spent fuel is not allowed; however, to preserve the recycle option in its best form the siting of all facilities should account for the possibility that recycling will be desirable in the future. Therefore, concerning the selection of a site for the first AFR, co-location with any future recycle plant and repository should be considered. This would, in effect, minimize transportation from the AFR should it be necessary to store fuel at a repository site. Since there would be a need to select an AFR site by 1983 in order to have it on line approximately seven years later, a comprehensive effort should be undertaken to locate a site suitable for co-location of an AFR, the recycle plant, and a repository.

The facilities and schedules required by this analysis are given in Fig. 15, which shows the phasing of the AFRs, repositories, and fuel recycle plants. Also presented in Fig. 15 are the probable dates by which the sites must be selected. In addition to the sites indicated by Fig. 15, there is a need for choosing sites for low-level waste regional processing facilities if they are to be employed. If four such plants are to be brought on line by 1985, a substantial effort would need to be underway now to locate the sites. The number and distribution of required waste management facilities is presented in Fig. 16, which gives in more detail the required low-level waste regional facilities. As has been previously noted, schedules and sizes, particularly of AFRs, would change depending on the assumption with respect to on-site reactor storage of spent fuel and on availability of repositories.

From a technical standpoint, it is probably feasible to select several tentative sites now. Regarding just one consideration — that of geologic repositories for high-level waste — actually the technology of salt repositories is quite advanced. Several sites could be identified at the present time. Consideration of other geologic structures is not as well advanced, although it certainly should be possible within a few years to identify a number of potential sites. If this is not possible, one can employ engineered storage facilities, which are certainly feasible as an interim step. Sites could be chosen now for engineered facilities.

Regarding low-level waste management centers, it is, of course, desirable to site these at the location of disposal. Enough is known to tentatively choose sites throughout the United States suitable for shallow land burial of low-level wastes. In addition, possibilities such as mined repositories could be examined.

6. ACHIEVING SOCIAL AND POLITICAL ACCEPTANCE OF WASTE MANAGEMENT CENTERS

Although most persons who are working in the technical field of waste management consider that the waste disposal problem is not technical, the social perception is that it is a technical problem. Besides, not many of the public can see any advantage to having such facilities located near them.

A number of persons have been examining how one might approach the problem of obtaining public acceptance of such facilities. Abrams and Primack[15] noted that numerous options and lack of understanding of which solution is emerging contribute to public confusion. This is the primary reason for developing a well understood, well conceived strategy involving the waste management center approach. Viable methods have been proposed for siting facilities; for example, Burwell et al.[16] have recommended a gradual approach to development of nuclear power reactor centers in which a large amount of the low-level waste would be stored or buried and decommissioning wastes would be handled in the same centers. Their strategy is to have a policy of designating present reactor sites as having passed the alternative sites test instead of requiring *de novo* consideration of alternative sites. Lee[17] has proposed a siting "jury" which would provide technical review and a forum for all concerned with the site selection process.

More recently, Peelle[18] has proposed that incentive payments be made to communities for acceptance of such facilities. It is important to draw distinction between the compensation for costs that are to be experienced by the community because of the siting and the provision of incentives. Direct costs to a community include those for schools, roads, utilities, and other services. There are also indirect costs for the general government. Incentive payments are payments over direct and indirect costs to a community. Generally, incentives have not been provided in programs such as payments in-lieu-of-taxes. Rather, in some cases, a disincentive has been created because public service costs due to worker immigration increased more rapidly than revenues. This paper does not explore the various means by which incentives can be provided, but assumes that they can be. In fact, if calculations are performed to allocate incentive awards as an incremental power cost, the increment is small. For example, a $0.001/kWh incentive payment would amount to revenue of $21 million/year from an average regional low-level waste management facility to the local community.

Thus, to obtain social acceptance, attitudes must be changed. It is my thesis that this can be done through a compensation proposal that is well understood and presented prior to development of a project. The compensation must be offered for both real and imagined impacts. The major question is: What is the level of compensation that will obtain acceptance of a site for location of a waste management facility? I believe that the most straightforward process to establish the compensation level is to allow communities to bid on the amount of payment they would require for acceptance of given facilities. Under the bidding system, the following are the key steps for obtaining siting acceptance:

1. the proposer designs the generic facility, such as a low-level waste management center or a fuel cycle center incorporating waste management operations;
2. the proposer prepares a cost-benefit analysis;
3. the proposer prepares the potential compensation analysis, which would determine the direct and indirect costs to the community and provide, on top of that, an estimate of the incentive capability of the facility;
4. the proposer selects the region for application of the facility;
5. the proposer offers the generic package together with the relevant analyses to the states in that region (states not allowing geologic exploration would be excluded from the bidding). At this stage, the objective would be to obtain agreement from states which would allow the necessary geologic exploration to lead to the selection of sites;
6. the proposer conducts site explorations;
7. the proposer selects potential sites;

8. the proposer offers the package to the largest governmental unit that encompasses the site;
9. each state and local government combination would then propose what revenue is required for acceptance of the facility; and
10. the proposer evaluates the proposals of the state and local governments.

Throughout this whole process it would be necessary to conduct a very thorough public information program to acquaint the public with the benefits of the facility as well as to communicate to them exactly what will be done in the facility and what will be done to mitigate the environmental and health impacts.

Development of regional waste management centers requires a cooperative approach by the various states in the service area. One of the problems, however, is the lack of a body that is perceived by the public to be sufficiently objective and knowledgeable to be trusted to evaluate various aspects of any proposed facility and site. Such a body can be organized by the states, which are taking significant initial steps in arranging for proper handling of low-level radioactive wastes. I would propose that the states organize siting juries that would determine the acceptability of candidate sites, the facilities, and the technical, economic, and impact assessments associated with them. A jury would have the following charter: it would make key decisions in the siting process, evaluate the technical and economic matters associated with the site and the facilities, and would finally determine the acceptability of all invitations and proposals. The composition of the siting jury would be phased according to the stage at which the proposal is involved. When the siting action is at the stage of determining the states in which geologic exploration will be allowed — that is, steps 1 through 5 under the bidding system — then the composition would be one member from each state of the region; this is termed Stage 1. After the states have determined whether they will accept site evaluations, those states accepting will be allowed membership on the siting jury; states not allowing such evaluations would be dropped. Thus, at this stage — Stage 2 — the composition would be one member from each state allowing site evaluations.

The authority for the juries may have to be obtained through a Congressional act. Establishment of this process has the benefit of removing the decision concerning acceptability from the direct political arena. It also has the advantage of providing regional and state representation. Options could be provided for local representation as the siting process narrows.

7. SUMMARY AND CONCLUSIONS

A definitive strategy for obtaining waste management facilities is required. In this paper it has been proposed that waste management centers are a logical and necessary part of that strategy. Such centers, if fitted properly into an overall strategy, would offer the public a well integrated approach that would result in increased confidence that wastes are manageable. Although the technology has not been examined in depth, waste management centers are technically feasible. Many approaches can be taken, and systems analyses are needed to determine the exact approach that should be undertaken. From this analysis, the following recommendations are made:

1. four regional low-level waste management facilities should be brought on line by 1985 and five more should be added by 2000;
2. at least three AFRs should be opened in the period 1990-1996;
3. to preserve the fuel recycle option in its most cost-effective form, the first site for a co-located AFR, repository, and fuel recycle plant should be chosen by 1983;
4. a bidding system to establish incentives for location of waste management facilities should be implemented; and
5. juries organized by the states should be employed to facilitate selection of sites for waste processing and disposal facilities.

The technology is sufficiently advanced that siting schedules can be met; however, the obstructions are institutional, societal, and political. Waste management centers deserve more analysis, development, and consideration. The nuclear industry and the technical community have tbe greatest incentive for performing both the technical and the social analyses and for developing a more definitive approach to waste management centers.

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ORNL-DWG 80-18977

NUCLEAR CAPACITY PROJECTIONS VARY WIDELY
(DOE/NE-0007 BASE USED IN THIS ANALYSIS)

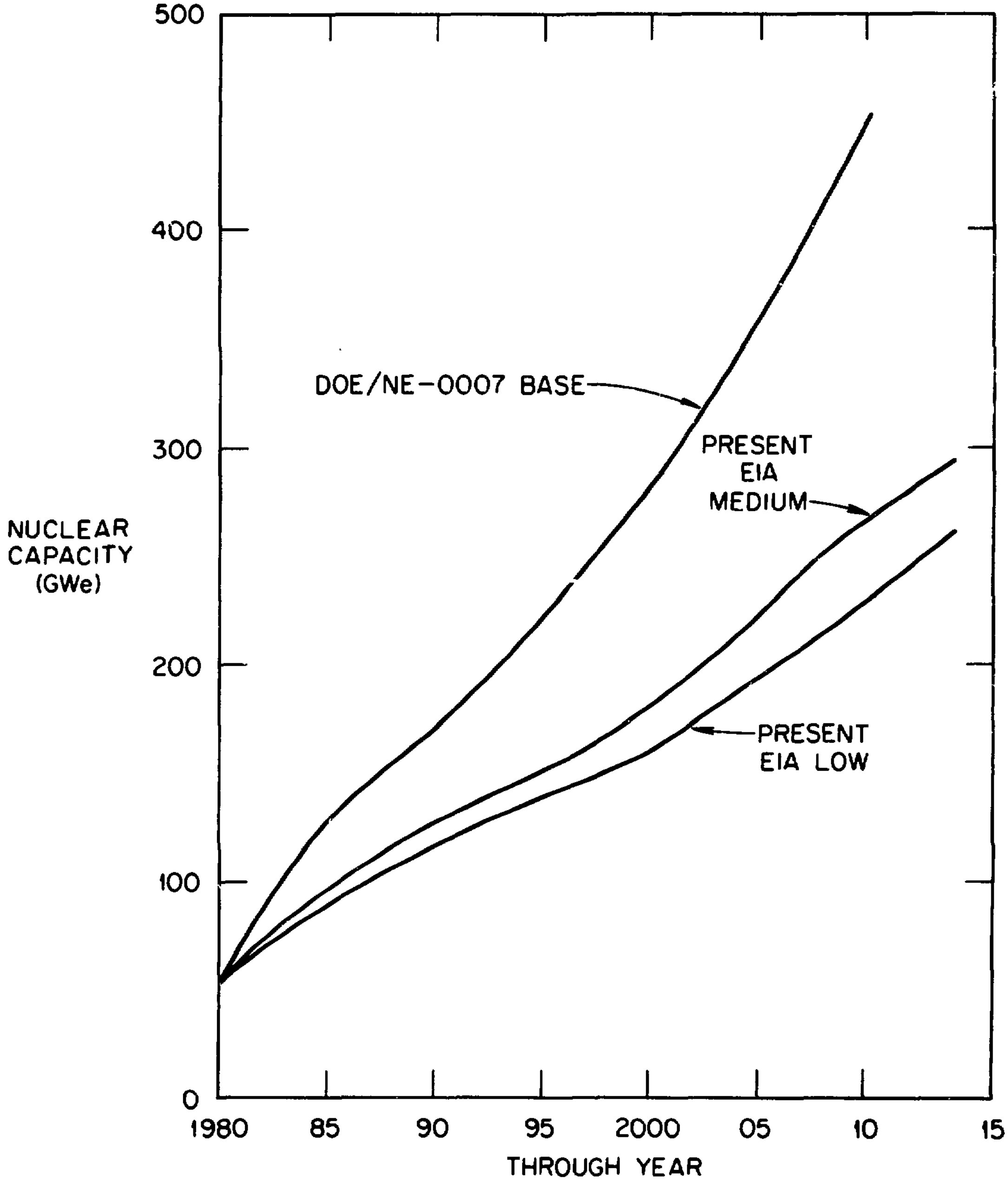


FIGURE 1

ORNL-DWG 80-18976

MAXIMUM EXPANSION OF ON-SITE STORAGE
MINIMIZES CENTRAL STORAGE REQUIREMENTS

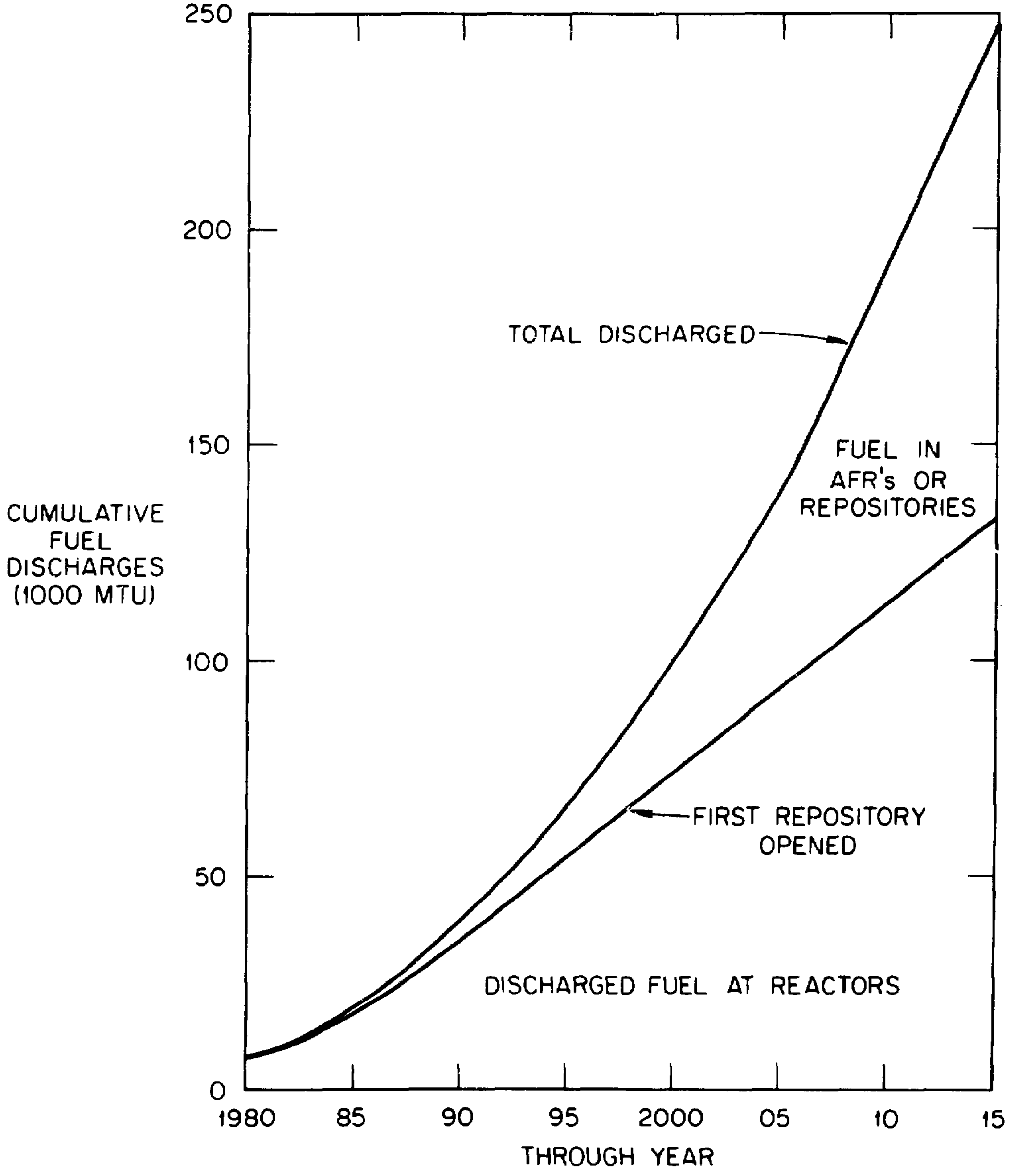


FIGURE 2

ORNL-DWG 80-18971

ANALYSIS SHOWS THAT TRANSPORTATION COSTS WILL DECREASE SIGNIFICANTLY AS NUMBER OF STORAGE SITES INCREASE

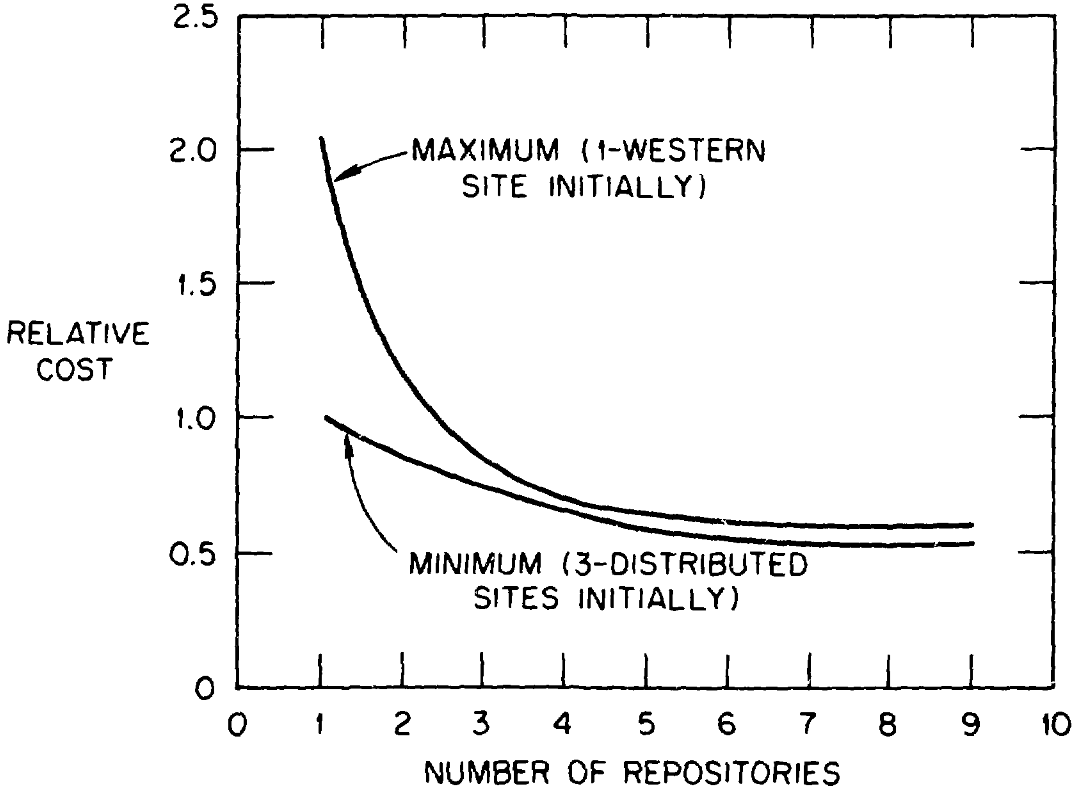


FIGURE 3

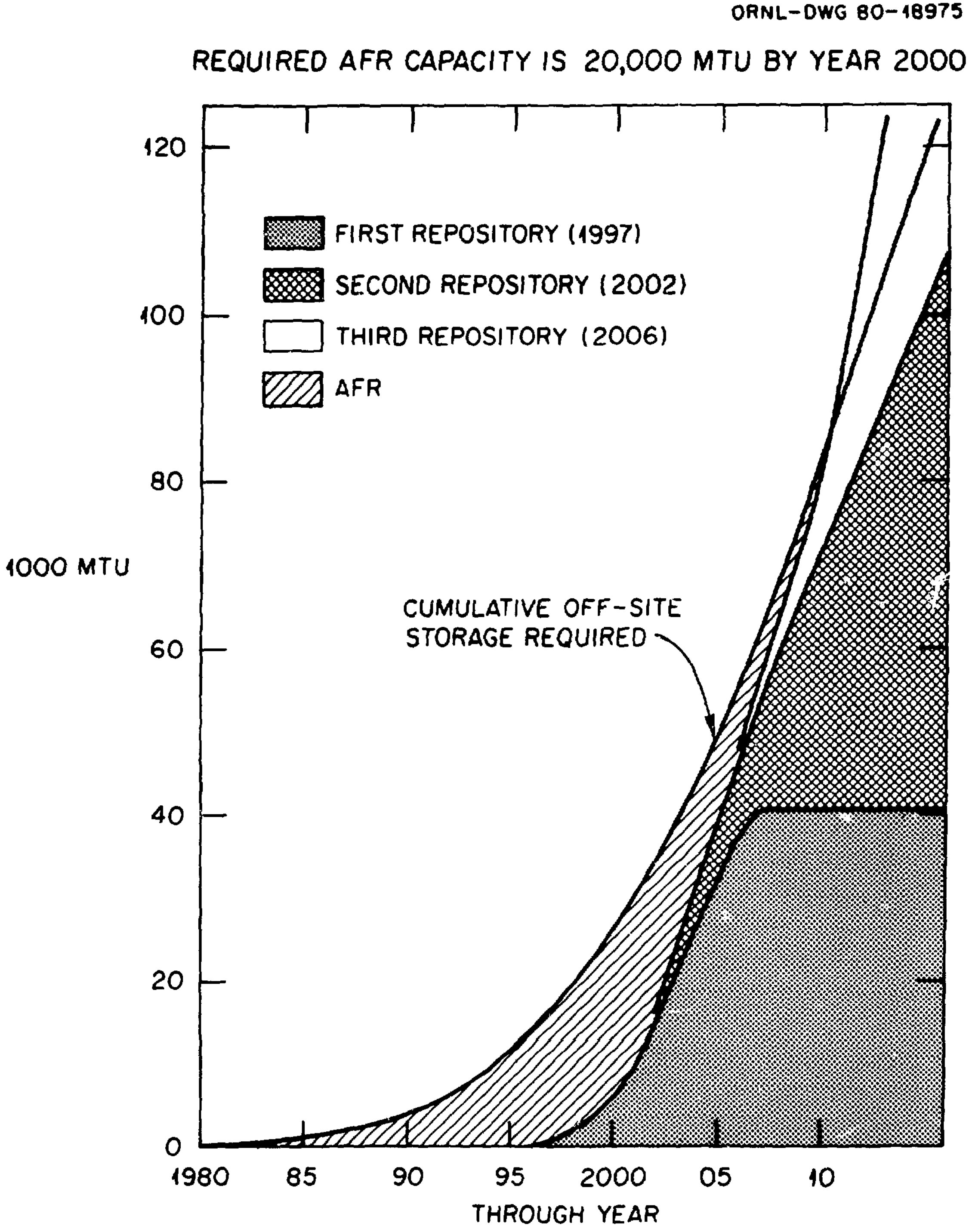

ORNL-DWG 80-18975
REQUIRED AFR CAPACITY IS 20,000 MTU BY YEAR 2000
FIRST REPOSITORY (1997)
SECOND REPOSITORY (2002)
THIRD REPOSITORY (2006)
AFR
CUMULATIVE OFF-SITE STORAGE REQUIRED
1000 MTU
0
20
40
60
80
100
120
1980
85
90
95
2000
05
10
THROUGH YEAR

FIGURE 4

ORNL-DWG 80-18974

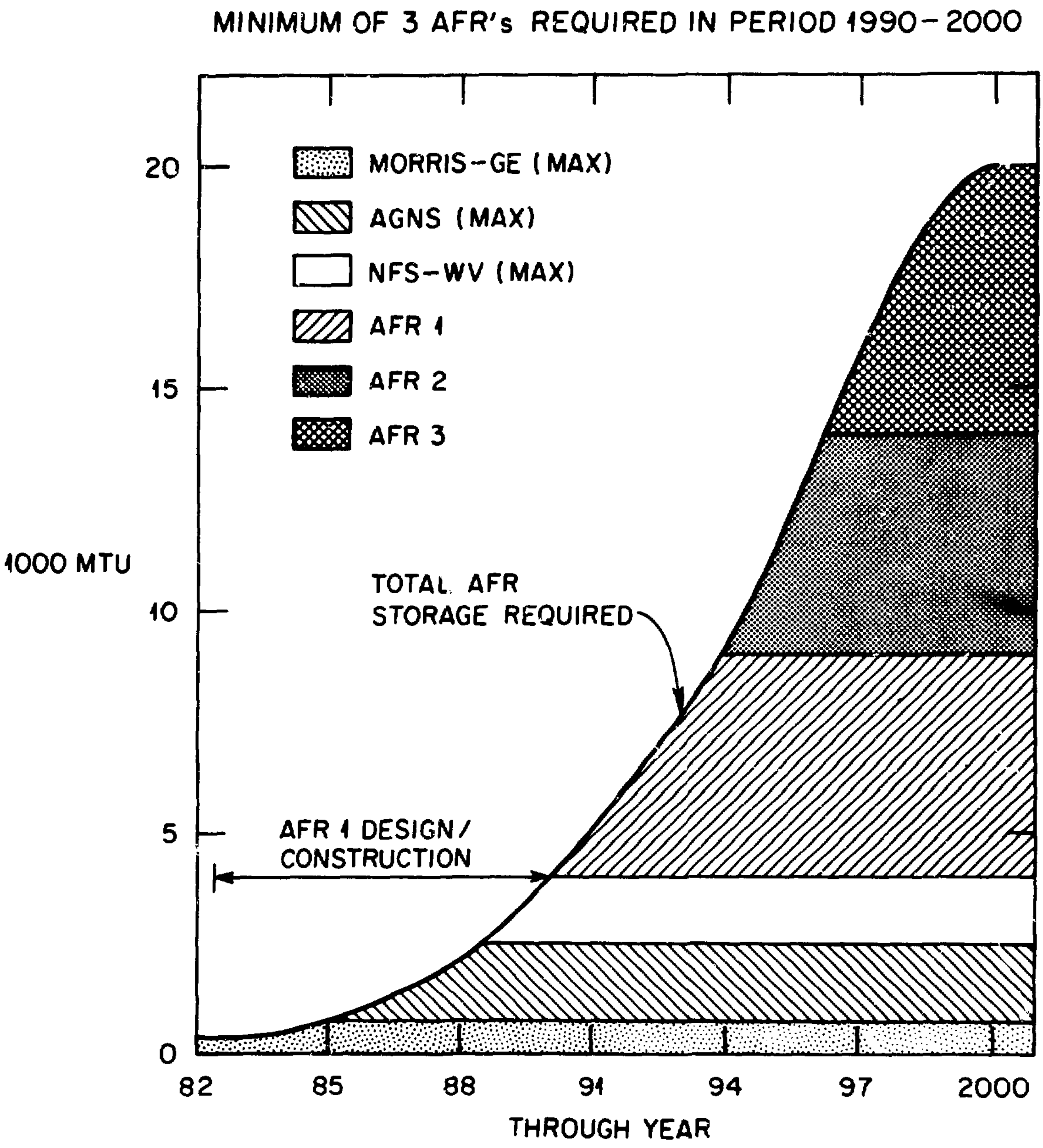


FIGURE 5

ORNL-DWG 80-18970

OPTIMUM BOUNDARIES FOR 3-REGION TRANSPORTATION STUDIES IN YEAR 2000

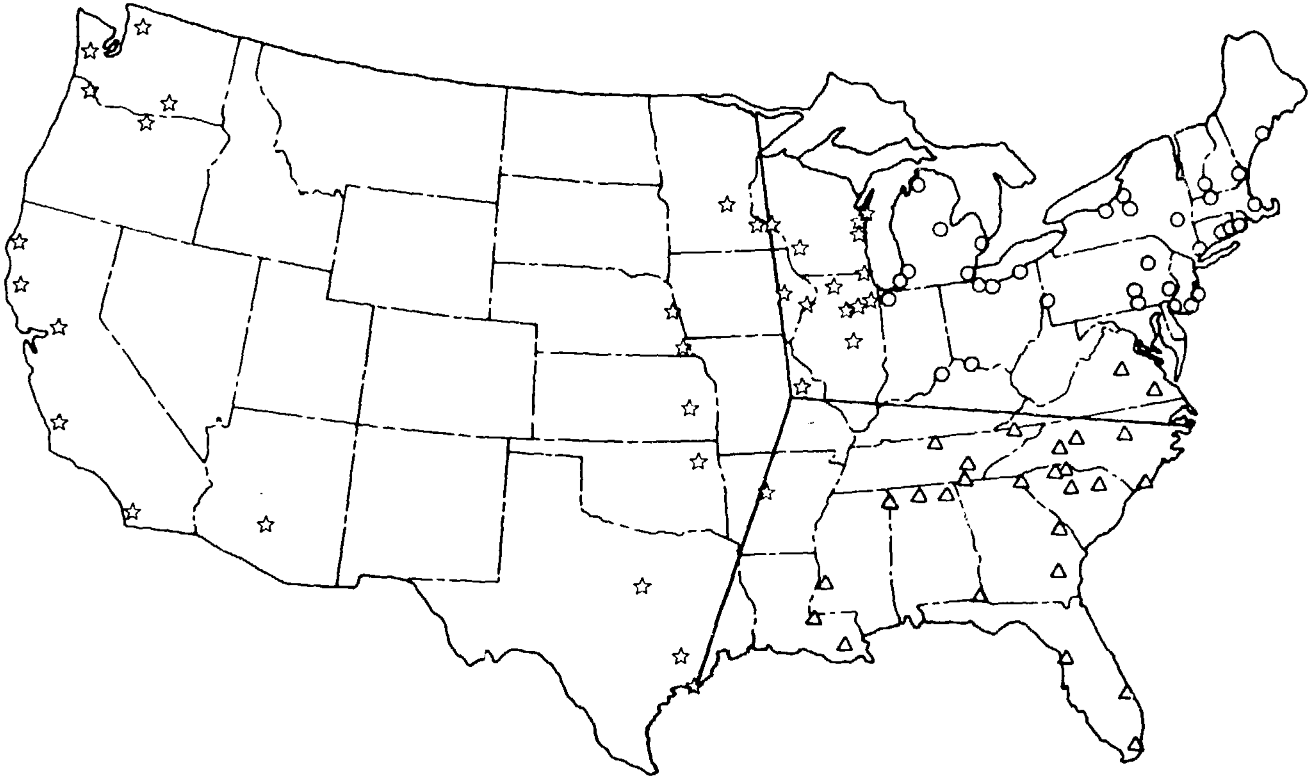


FIGURE 6

ORNL-DWG 80-18973

POWER REACTORS WILL CONTRIBUTE INCREASING PART OF LOW LEVEL WASTES

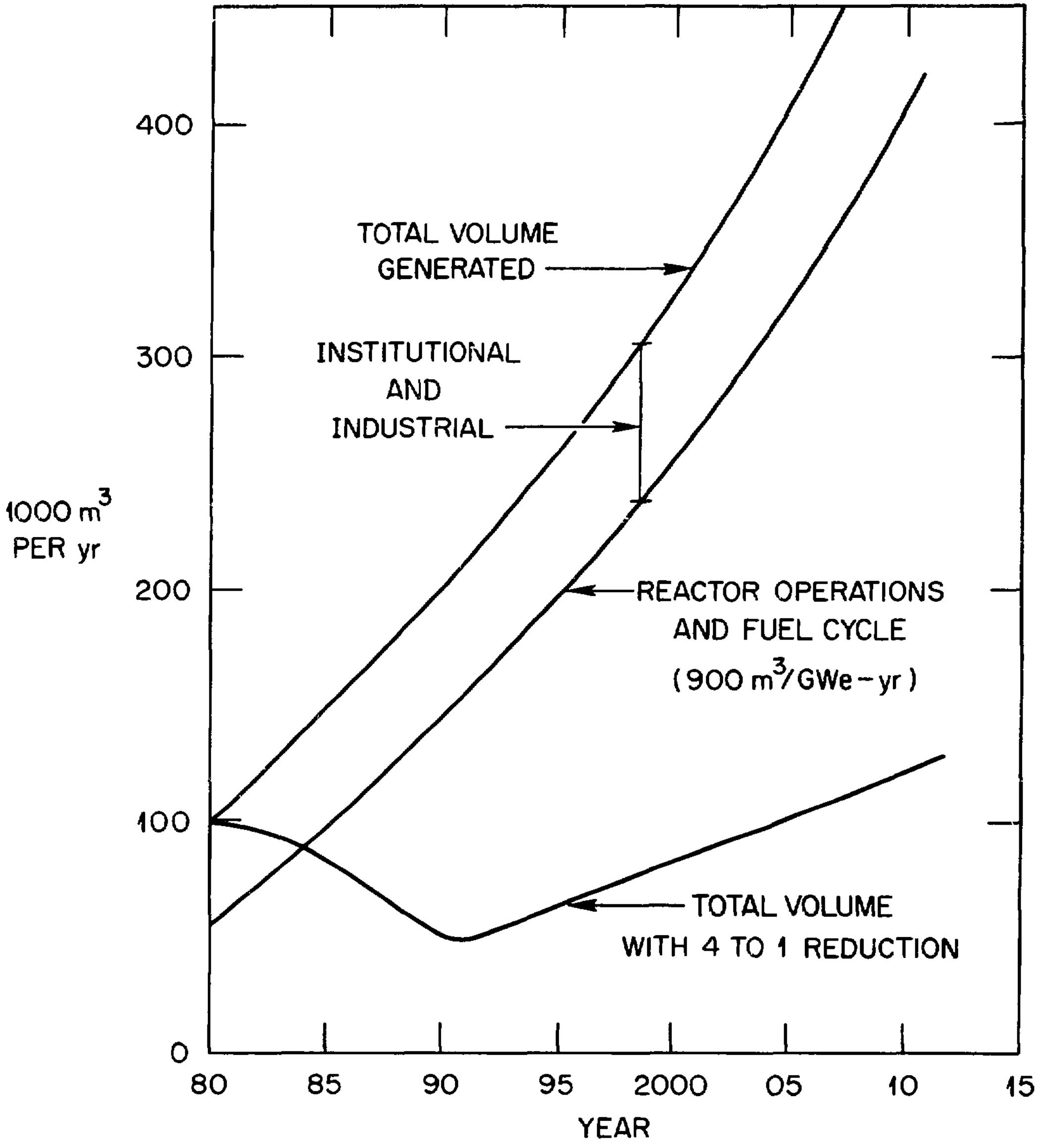


FIGURE 7

ORNL-DWG 80-18972

LAND COMMITMENT TO BURIAL OF LOW LEVEL WASTE IS NOT LARGE IF GREATER REDUCTION IS ACHIEVED

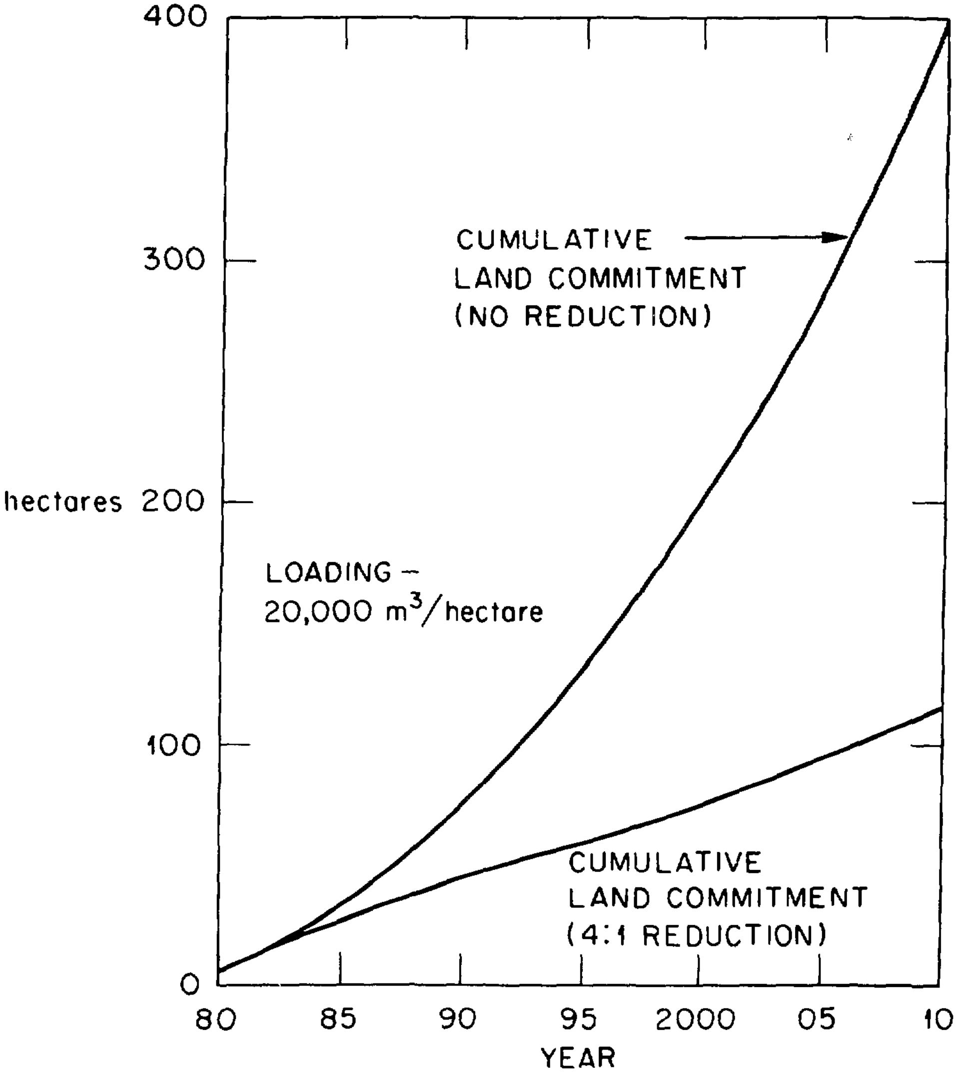


FIGURE 8

TABLE 1

ORNL WS-13763

BASIC SCALE OF UNIT PROCESSES WILL SATISFY DEMAND OF MANY REACTORS

WASTE CATEGORY	BASIC UNIT SCALE	ONE REACTOR*	NUMBER REACTOR PER BASIC UNIT
METAL	20 MT/day	1.4 MT	15
COMBUSTIBLES	100 m^3/day	2 m^3	50
GLASS/CERAMICS	20 m^3/day	0.5 m^3	40
NONCOMPACTIBLE	—	—	—

*INCLUDING 50% PRORATED CONTRIBUTION FROM INDUSTRIAL/INSTITUTIONAL WASTES.

ORNL-DWG 80-19136

NINE REGIONS COULD BE USED AS BASIS
FOR REGIONAL LLW PROCESSING FACILITIES.

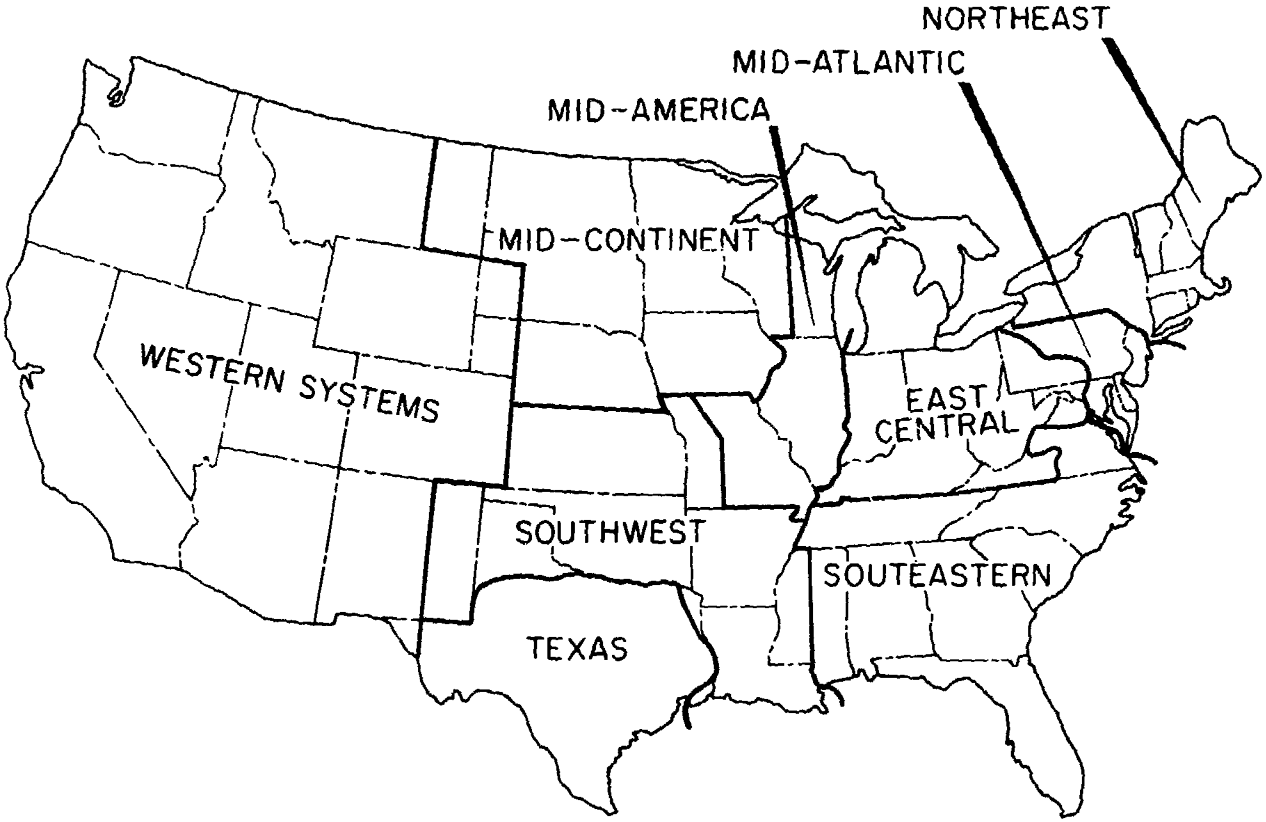


FIGURE 9

ORNL-DWG 80-19138

DEMAND CAN BE MET WITH NOT MORE THAN TWO UNIT PROCESSES IN MOST CASES (YEAR 2000)

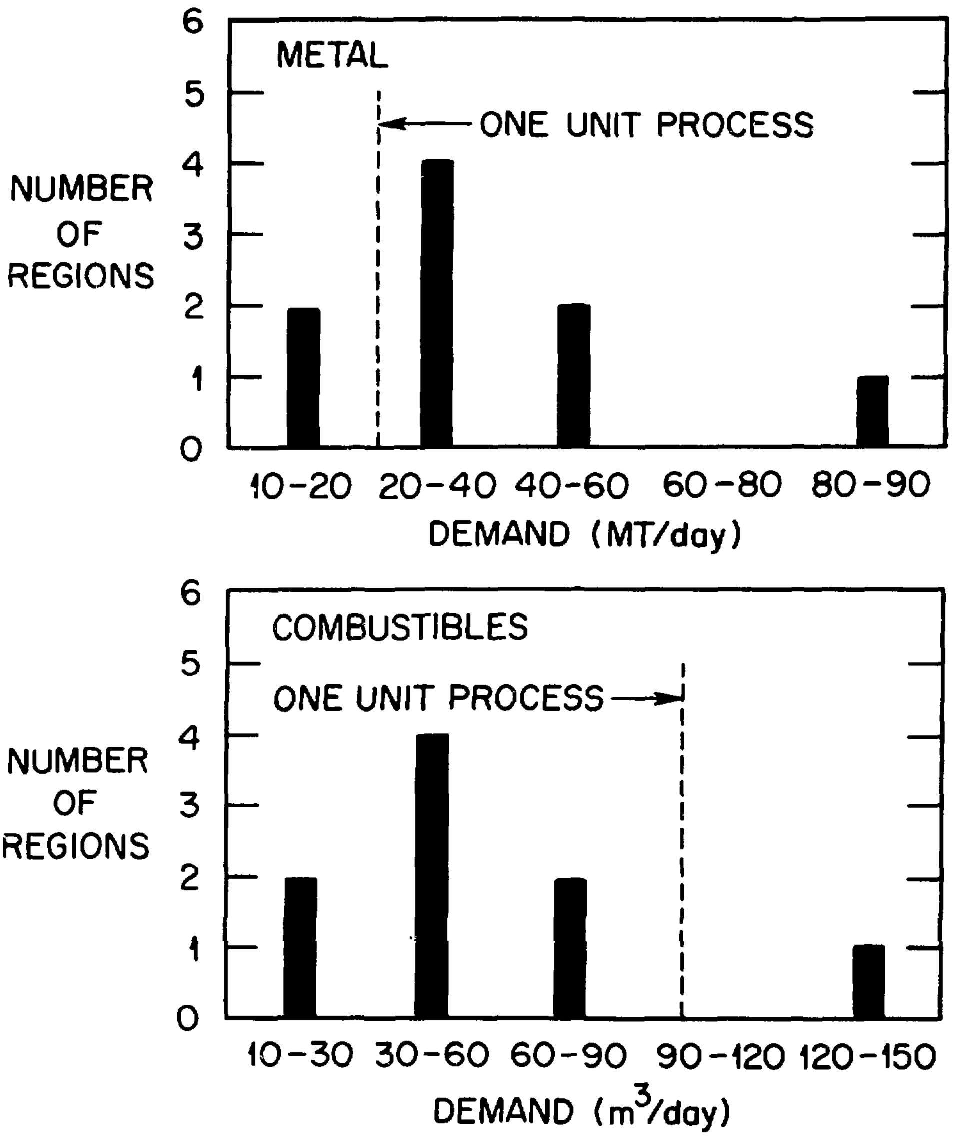
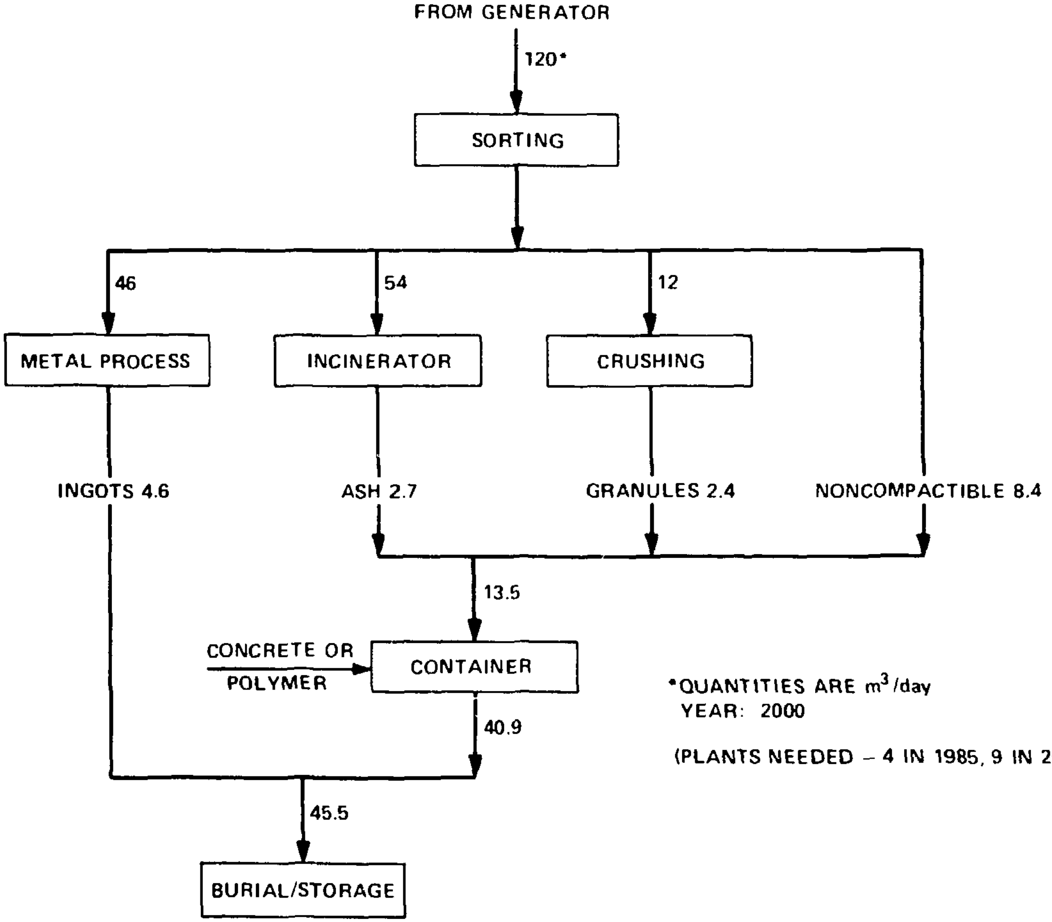


FIGURE 10

ORNL DWG 80 19141

AVERAGE REGIONAL PLANT CONVERTS 120 M³ LLW TO 46 M³ FIXED LLW



*QUANTITIES ARE m^3/day
YEAR: 2000

(PLANTS NEEDED – 4 IN 1985, 9 IN 2000)

FIGURE 11

ORNL-DWG 80-19137

A FUEL RECYCLE PLANT START IN 1997 MINIMIZES AFR CONSTRUCTION AND FUEL IN REPOSITORY

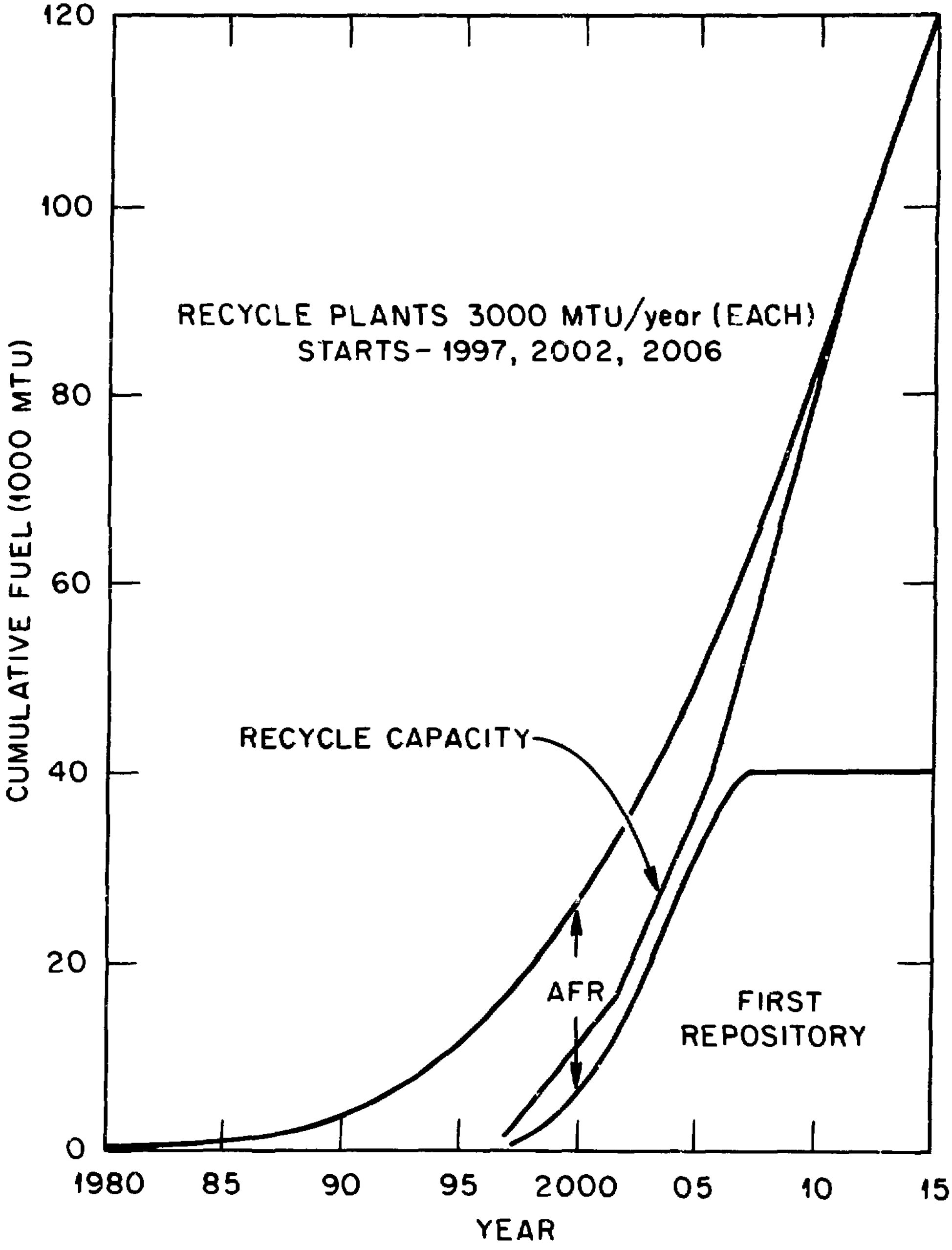


FIGURE 12

ORNL DWG 80 19139

RECYCLE PLANT WOULD REQUIRE REMOTE AND NON-REMOTE TRU WASTE PROCESSING FACILITIES

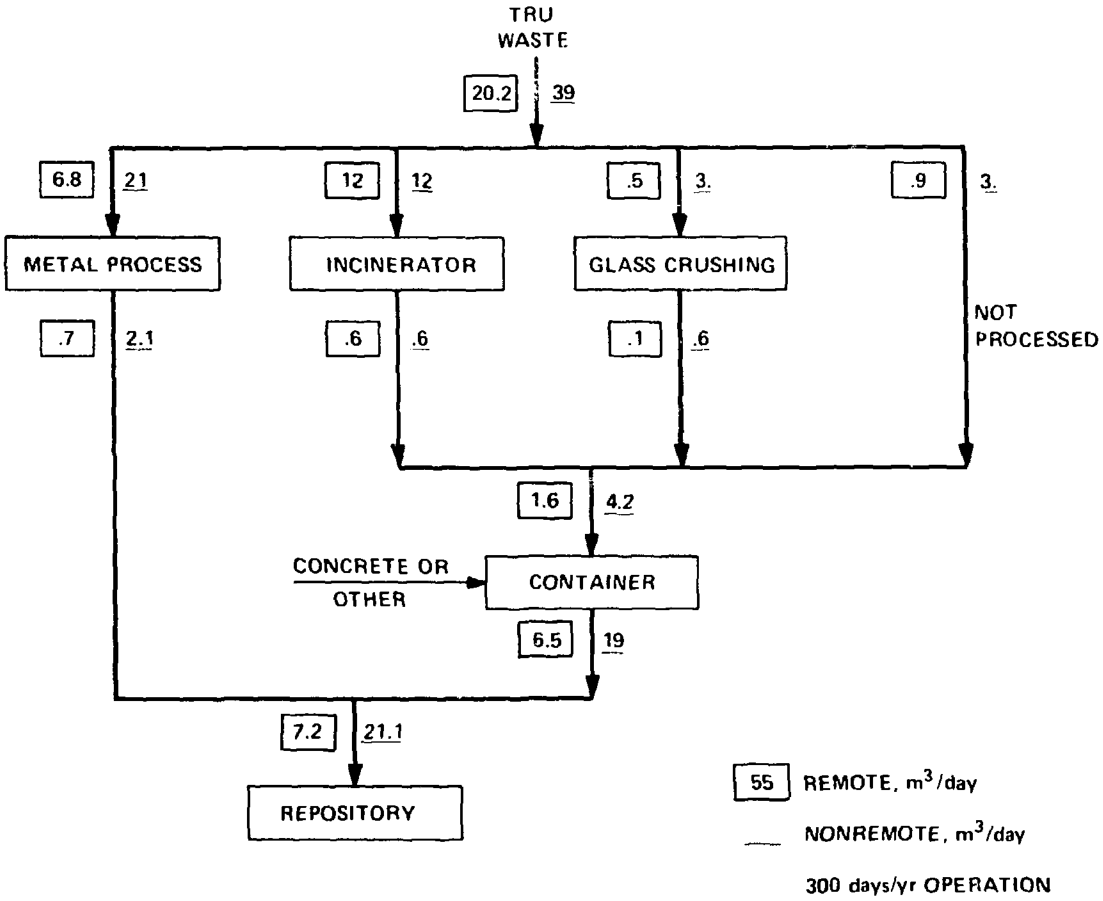


FIGURE 13

ORNL-DWG 80-19140

LLW PROCESSING REQUIREMENTS ARE ON THE ORDER OF REQUIREMENTS FOR AVERAGE REGION

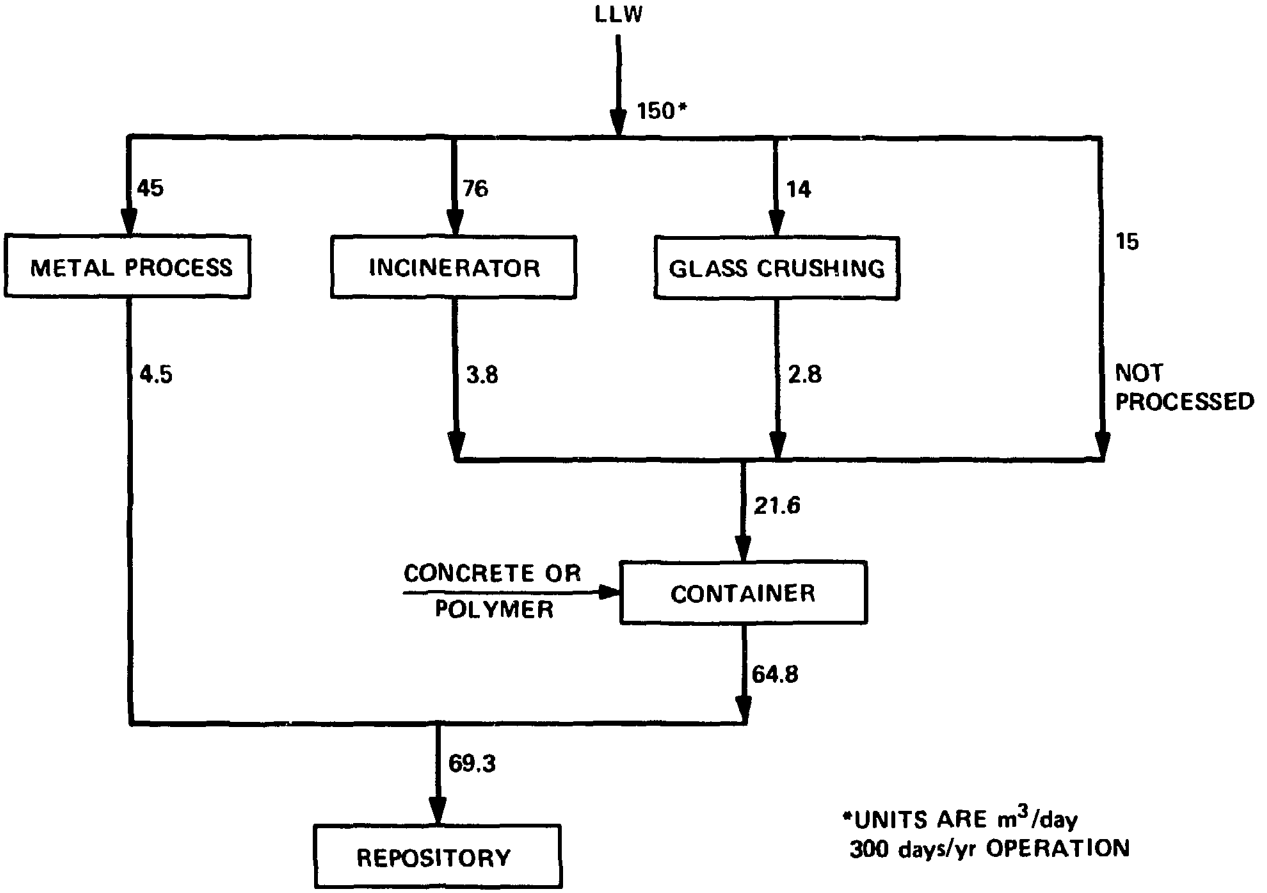


FIGURE 14

TABLE 2

ORNL WS-13764

SITE REQUIRES 700 hectares FOR REPOSITORY FOR 30 years OPERATION OF RECYCLE PLANT

WASTE CATEGORY	m^3 IN 30 years	m^3/hectare
HLW	11,000*	16
HULLS (COMPACTED)	10,000	14
GASES, IODINE, TRITIUM	1,000	1.4
TRU-REMOTE	65,000	93
TRU-LOW LEVEL	190,000	270
LLW	625,000	890

*REPOSITORY SPACE = 700 hectares BASED ON 400 kW/hectare LOADING

THERMAL POWER = 24 kW/m^3 (10-yr COOLED)

ORNL-DWG 80-19142

SITE SELECTION MUST COMMENCE NOW IF SYSTEMS ARE TO BE DEPLOYED OPTIMALLY

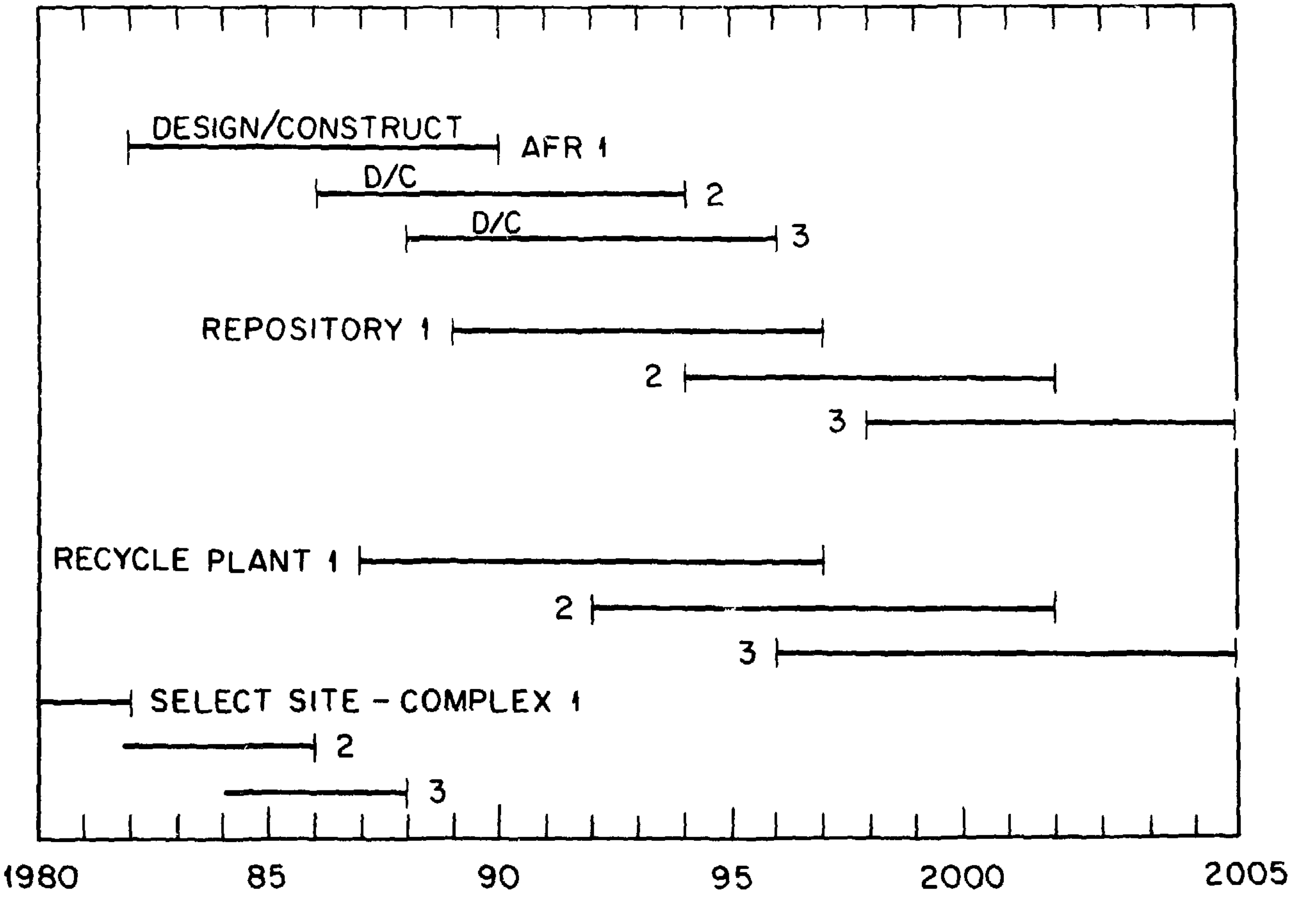


FIGURE 15

ORNL–DWG 80-19143

DISTRIBUTION OF REQUIRED WASTE MANAGEMENT FACILITIES

YEAR	LLW PROCESS PLANTS (36,000 m^3/yr)	AFR's (5000 MTU)	REPOSITORIES (40–100,000 MTU)	RECYCLE PLANTS (3000 MTU/yr)
80				
85	●●●●			
90	●●	●		
95	●●	●		
		●	●	●
2000	●			
			●	●
2005	●●			
			●	●
2010	●●●			

FIGURE 16