ALTERNATIVES FOR TREATMENT, STORAGE AND DISPOSAL OF GREATER-THAN-CLASS C LOW-LEVEL WASTE AT WEST VALLEY, NY

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ABSTRACT

The West Valley Demonstration Project has generated and will continue to generate commercial Greater-Than-Class C Low-Level Waste from both vitrification operations and decommissioning operations. This paper summarizes information on the quantity of wastes, and describes alternatives for interim storage, treatment, and disposal. Waste management systems comprised of treatment, storage, and disposal options are identified, and the first order economics associated with the systems are evaluated.

INTRODUCTION

The West Valley Demonstration Project (WVDP) has been established to solidify the existing High Level Wastes (HLW) that remain from the commercial reprocessing of spent fuel at the West Valley Site in the late 1960's. Along with the HLW, other wastes exist at the site, and additional wastes will be generated during both the solidification operations and the final decontamination and decommissioning of the site. Because of the transuranic content of both the HLW and the spent fuel fragments remaining in the facility, some of these wastes will be TRU waste and will be classed as Greater-Than-Class C Low Level (GTCC) wastes by the NRC definitions of Low- Level wastes (LLW).(1)

This study was undertaken for West Valley Nuclear Services by PNL to aid them in identifying and evaluating the alternatives for treatment, interim storage, and disposal of the GTCC wastes from West Valley. Treatment and disposal of the GTCC wastes will follow vitrification of the HLW. Several years are available for the final selection of waste management options. Therefore the information in this paper is still very preliminary and is not a commitment for the WVDP or DOE to any particular alterative or course of action.

WASTE TYPES AND ESTIMATED VOLUMES

The wastes at West Valley were identified and then categorized as either 1) existing waste, 2) vitrification operations waste, or 3) post-solidification waste, depending on when the wastes would be generated or classified as waste. Many of these wastes can be treated to reduce their volume and contamination levels so that the final volume of GTCC waste material to be disposed of will be greatly reduced from the amounts presented below. Since detailed assay information is not available at this time, we have assumed that all of the wastes are GTCC wastes. Many of the wastes may be reclassified in the future. The existing wastes are those that have already been placed in containers or are otherwise currently available for treatment. The wastes to be generated during vitrification of the high-level waste sludges and materials are the vitrification operations waste. Finally, the wastes to be generated during post-solidification activities (e.g., D&D of the facilities) are the post-solidification wastes. It should be noted that wastes that have already been buried on site have not been included in this study. The wastes have been divided into several categories that are anticipated to be useful in evaluating various treatment and disposal options. The summary of the data is shown in Table I.

DISPOSAL ALTERNATIVES

The NRC has issued guidance on the disposal of wastes and directed that the GTCC wastes should go a high-level waste repository unless DOE can demonstrate that there is an acceptable alternative (2). Congress in addressing the GTCC wastes has indicated that they should go to an NRC licensed facility. These directives then provide two alternatives. The first is the Yucca Mountain Repository, and the second is a new facility yet to be developed. The Waste Isolation Pilot Plant is not a viable political alternative since it is not a licensed facility.

Yucca Mountain Repository

The Yucca Mountain repository is being developed by the Office of Civilian Radioactive Waste Management (OCRWM) for the disposal of high-level radioactive wastes. Acceptance requirements for wastes other than spent fuel and HLW have not been considered. Current schedules would not allow receipt of the GTCC wastes for disposal before about 2015.

New GTCC Disposal Facility

DOE began considering the establishment of a new disposal facility in 1989. Preliminary evaluations are being conducted on the ability of intermediate depth disposal to provide sufficient disposal isolation for the commercial GTCC wastes. The major advantages anticipated for a new disposal facility are simpler requirements for the waste form and lower disposal costs. Obviously, no requirements have been established for this type of disposal, but requirements similar to those for Class C LLW are considered likely. One major problem with the establishment of a new facility would be the not-in-my-backyard attitude of the states and populations affected by the location.

TABLE I

Summary of Estimated Volumes of Wastes from West Valley Which May be Classed at GTCC (m^3)

Waste	Existing	Operational	Future D&D	TOTAL
Surface-Contaminated Metals	246	47	444	737
Activated Metals	0	0	1	1
Organic-Bearing Materials	83	11	150	244
Sludges	3	0	1	4
Cement/Ceramics/DE	5	1	19	25
Debris	1	0	0	1
Miscellaneous TRU Waste	62	0	0	62
TOTAL (m^3)	400	59	615	1074

Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP) is being developed by DOE for disposal of defense TRU wastes. Because of the current limitations to the operation of the repository (which were established by Congress and are monitored by the State of New Mexico), it seems likely that inclusion of the West Valley wastes into the repository would require Congressional action to modify the current laws.

INTERIM STORAGE

Processing of the high-level waste at West Valley and decommissioning of the site will most likely occur before the Yucca Mountain repository or any other disposal site (except possibly the WIPP) is available for receipt of the wastes. Therefore, interim storage of the wastes is likely to be necessary. Three general alternatives are discussed below.

Storage At West Valley

All of the previously generated low-level wastes, including GTCC-type wastes, are in temporary storage in storage buildings or domes at West Valley. These facilities were built for a few years of temporary storage, not the two or three decades that may be necessary if storage is required until the Yucca Mountain repository is available for the West Valley GTCC wastes. One benefit of continued storage at West Valley is that only minimal treatment may be necessary. If the wastes were to be given an initial treatment using current technology, they may not be acceptable for disposal in the future since waste disposal requirements continue to become more severe with time.

Storage at the Monitored Retrievable Storage Facility

The MRS would have storage casks available that should safely contain the GTCC wastes until disposal could be accomplished. Since the West Valley wastes are likely to be considered commercial wastes, and since some scenarios for the MRS include storage of the West Valley high-level waste(3), it seems appropriate to also store the GTCC wastes at the MRS.

Storage at a DOE Site

Several DOE sites, including Savannah River, Oak Ridge, Idaho Falls, and Hanford, have established capability for storage of GTCC-type wastes. These have been intended for DOE wastes that are being stored until the WIPP or some other suitable disposal facility is available to receive the wastes. Most of the wastes are CH; however, RH-wastes are also being generated. It is recognized that it has become increasingly difficult to store wastes from outside the respective states at the DOE sites.

TREATMENT LOCATIONS

The waste acceptance requirements at all the potential disposal sites require that the wastes be reduced in size and packaged to conform to the respective disposal and storage requirements. This study assumes that the wastes will need some form of treatment. The need for treatment raises the question of where the treatment should occur. Four major alternatives are considered. However, it may be difficult to get acceptance for the shipment of the wastes in an untreated form.

Treatment at West Valley

Treatment facilities have already been established at West Valley for volume reduction, cementation of low-level waste, decontamination of waste, and vitrification capability is currently being developed for the high-level waste. Therefore, West Valley has capabilities to treat many of the CH-wastes and some RH-wastes that will exist at the site. One proposal for treatment at West Valley calls for

preparing the most radioactive wastes as slurries, and feeding the slurry to the ceramic melter following the vitrification campaign. This treatment seems desirable for the existing wastes on the site and other wastes that can be generated before decommissioning the melter and the other waste treatment facilities.

The problem with total waste treatment in the existing operating facilities at West Valley is that the current and future treatment facilities will need to be decontaminated and decommissioned during the final site closure. However, it may be possible to provide treatment using mobile facilities.

Treatment At The MRS

The MRS, as part of its capability, will treat site-generated GTCC and low-level wastes that are principally the non-fuel bearing hardware and other low-level wastes. The extent of the capabilities to treat GTCC wastes will depend on the final mission of the MRS, which is to be decided by Congress. The MRS offers the advantages of having a central facility which also provides interim storage in conjunction with treatment. The treatment capabilities would also be compatible with the commercial repository and would be able to meet the applicable waste acceptance requirements. The major uncertainties with the MRS are its location and the schedule for receipt of wastes.

Treatment At The Yucca Mountain Repository

The Yucca Mountain repository will receive and handle spent fuel. Therefore, it will generate both remote-handled low-level waste and GTCC waste that will need to be prepared for disposal. The volume of waste will be about 1500 m^3 annually(4). The total volume from West Valley would only be about 67% of the annual site waste. If processed over several years, the West Valley wastes could be processed without a major increase in the treatment system capacity. The repository treatment system should also produce a waste form that will be acceptable for disposal at the site. The major concern with treatment at the repository would be the time when the treatment facilities would be available.

Treatment At A DOE Site

Many of the DOE sites will have RH-TRU and special-case wastes that must be stored until the waste can be sent to a disposal facility. The emphasis on treatment will be to prepare the wastes for receipt at WIPP. However, the requirements at the Yucca Mountain Repository may be more restrictive than those for WIPP. Therefore, treatment through a defense facility at other DOE sites may not provide a waste form that is suitable for disposal at Yucca Mountain. Treatment at a defense facility may also be difficult because of the defense mission of these facilities, and the rules barring the intermixing of commercial and defense activities.

Treatment In A Commercial Facility

Several commercial facilities have been established to take low-level waste from reactors, process the wastes to reduce their volume, and ship the wastes to the low-level waste disposal site. Typical capabilities include decontamination, supercompaction, incineration, and some immobilization of residues. Commercial facilities currently do not have the capability to treat RH materials.

IMPLICATIONS OF DISPOSAL, INTERIM STORAGE, AND TREATMENT LOCATIONS ON TREATMENT REQUIREMENTS

The review of disposal, interim storage, and treatment locations discussed previously provides some perspectives for early planning of eventual disposal of the GTCC wastes. In this section of the report, we will identify the potential requirements for waste products, transportation, and timing.

Waste Product Requirements

The most likely alternatives for disposal of the GTCC wastes will be either the Yucca Mountain Repository or a new GTCC disposal facility. The requirements for either facility will likely prohibit explosives, pyrophorics, pressurized gas, and liquids. The wastes will also have to demonstrate some level of stability in the disposal environment. For conservative planning at this time, it would be advisable to plan to eliminate organic materials and to produce a waste form with good durability. However, both requirements have very significant effects on the treatment requirements and on the processes that should be included in a treatment facility.

The handling and treatment of concrete wastes is also of importance. It is recognized that radiolysis of the chemically bound water in the cement structure occurs during storage and results in the generation of hydrogen gas. Discussions with the OCRWM staff on the acceptance of cements in the repository have indicated that cement will not likely be an acceptable form since it has major impacts on the pH of the repository ground water, and is not part of the current experimental program to determine the release of activity from high-level waste glass and spent fuel.

One additional consideration for disposal will be the final size of the package. Both the Yucca Mountain Repository and the WIPP have requirements on the maximum diameter of the RH package. These requirements, if applied to the GTCC waste, would require size reduction of many existing pieces of excess equipment so they can fit within the approximately 2-ft-diameter canisters. This implies the need for a size reduction facility or a facility that can

decontaminate large pieces of equipment to remove them from the GTCC classification.

A final consideration is that the wastes will require certification. Certification will require characterization of the waste materials, and characterization data on the waste package along with its identification. Consequently, facilities to decontaminate and assay the packages will be needed.

Transportation Requirements

The GTCC wastes will be transported from West Valley either for treatment, interim storage, or disposal. The West Valley site has the capability for rail or truck transport of shipping casks. At the time of shipment, the wastes must be packaged in a manner that is acceptable to the NRC. Remote-handled wastes will generally require shipment in either a shielded cask, shielded boxes in the TRUPAC-II, or liners in a Type B shipping container.

Timing Of Interim Storage Or Disposal Capability

Table II summarizes potential operation dates for the various disposal, storage, and treatment alternatives, along with the current West Valley schedule. All dates are subject to extension as projects change. The table shows that for near-term treatment the major options are West Valley, a commercial LLW treatment center, and possibly a DOE site, if adequate treatment technologies are available. For interim storage of the wastes, the near-term options are West Valley and a DOE site. The only near-term disposal alternative would be the WIPP site. Use of the WIPP site would eliminate the need for interim storage. Disposal in either Yucca Mountain or the GTCC engineered storage facility would be at least 16 years away, and would require a minimum of 6 to 10 years of interim storage.

TREATMENT TECHNOLOGIES

This section briefly discusses the technologies that have been considered for GTCC LLW treatment. A good review of most of the technologies is given in DOE-LLW-60T (5). The treatment technologies discussed here include pretreatment/sorting, size reduction, compaction/supercompaction, decontamination, incineration, metal melting, vitrification, and cementation. No single technology is capable of treating all of the wastes. Therefore, several processes must be integrated into a total system. The overall generic process is illustrated in Fig. 1. The wastes are first assayed, and non-GTCC wastes are sent directly to low-level waste treatment or disposal facilities. The GTCC wastes are pretreated, sorted, and prepared for subsequent treatment. The general treatments are shown as decontamination, organic removal, and immobilization. Decontamination would remove contamination to the point that the wastes could be classified as low-level waste. The residues would then be immobilized along with other wastes. Organic removal is considered necessary and can occur by several processes. Residues (e.g. ash and off-gas scrubber residue from an incinerator) are sent to the final immobilization step. Immobilization can occur by several technologies, including cementation, direct melting, and vitrification. The immobilization process then produces a product that would go to the final repository or disposal site.

It is possible to generate a very large number of treatment alternatives based on different combinations of treatment. However, for this upper level analysis we have selected three alternatives to include in the overall evaluation.

No-Treatment Alternative

This treatment alternative involves packaging the waste and storing it until it can be sent for disposal. Some size

TABLE II

Summary of Current Schedules for Waste Management Facilities

Facility	Treatment	Interim Storage	Disposal
West Valley	Begin 1996	Current	N/A
MRS	2000	2006	N/A
Yucca Mountain	2010	N/A	2015
DOE Sites	1998	Current	N/A
WIPP	N/A	N/A	1998
Commercial Treatment	1995?	N/A	N/A
GTCC Disposal Site	2006?	N/A	2006?

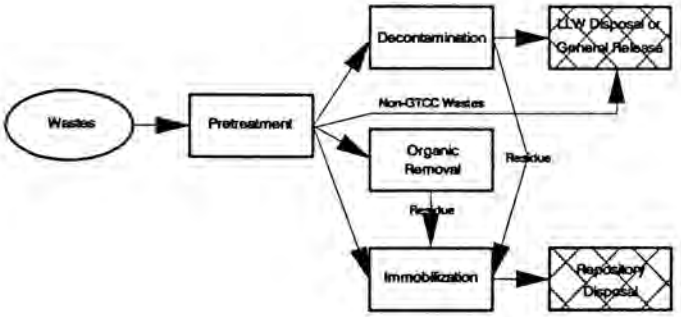

Fig. 1. Generic process flowsheet.

reduction would be needed for the larger components to allow the wastes to fit within the respective disposal containers. The GTCC disposal containers for the Yucca Mountain or WIPP repositories are expected to be very similar to the HLW canister -- 2 ft in diameter and 10 ft in length. There is no significant volume reduction in this alternative with the wastes being packaged as generated. It is unlikely that the wastes would be acceptable for disposal at the Yucca Mountain repository, but they may be technically acceptable at WIPP or at the GTCC facility. For the GTCC facility, it also may be possible to place the wastes in a larger container.

Melter-Incinerator Alternative

This alternative treats all of the wastes and provides the lowest volume of waste since the wastes are densified to near their theoretical density. The primary process is envisioned to be a plasma melter-incinerator. The wastes are first size reduced to fit within the feed hopper of the process unit. The material is then fed slowly into a plasma furnace where the plasma torch is directed onto the waste materials. The plasma torch produces a very high temperature (>3000°C) and will melt any material. The torch will also pyrolize organic materials and allow for their destruction. The melted materials are cast directly into the canister for further handling and disposal.

Decontamination and Vitrification Alternative

The objective of this alternative is to reduce the mass and volume of wastes requiring GTCC disposal. The major volume reduction is accomplished by decontamination, where the surface contamination on process equipment and vessels is removed for vitrification as a residue. Some large items may need to be size reduced before decontamination, while other large tanks and some piping can be decontaminated in place with the equipment serving as its own decontamination tank. The major waste volumes are from surface-contaminated process equipment. This treatment alternative produces a volume of LLW that is considered equivalent to the volume of GTCC waste, and a small volume of concentrated surface contamination considered to be 5% of the initial volume and GTCC waste. Higher volume reductions are possible. The decontamination residues and all of the other waste residues are vitrified into a high-quality waste form. The standard HLW canister is used for the vitrified form. It is expected that this alternative will produce the smallest final GTCC waste volume for interim storage and disposal.

WASTE MANAGEMENT SYSTEM OPTIONS

This section addresses the potential options for waste management systems that can be envisioned from the alternatives previously identified. Three disposal alternatives were identified, three interim storage alternatives were identified, five treatment locations were identified, and three treatment methods were identified. If all combinations of these alternatives are considered, a total of 180 possible waste management systems would exist. For simplicity, we have selected 14 waste management systems for this initial economic and system analysis. The 14 systems have been grouped into four groups. Each of the four groups is focused on either disposal, interim storage, treatment location, or treatment method to further evaluate the economics and implications of these major choices.

Group 1 Systems - Differences In Treatment Location

This group of systems looks at the five different treatment locations. Wastes to be treated at West Valley will not require an initial size reduction, although size reduction may be a part of the treatment system. However, to ship the wastes to an off-site facility for treatment, some minimal size reduction will be required to package the wastes in the

shipping containers. All options within this group consider the MRS as the interim storage location for the treated wastes. Treatment facilities at the Yucca Mountain repository will not be available until the repository is operational. Therefore, for the waste management system with treatment at Yucca Mountain, the wastes must be put into interim storage and shipped as untreated waste. The commercial treatment system was assumed to be located near ORNL.

Group 2 Systems - Differences In Type Of Treatment

This group looks at the three treatment options. The wastes are initially size reduced at West Valley to allow packaging in a large shielded cask or transporter for shipment to the MRS, where the various treatments are to occur. Option A is the melter-incinerator system, Option B is the decontamination-vitrification system, and Option C is the no-treatment option. The MRS is considered to have an existing facility for treatment of the wastes as discussed. After treatment, the wastes are stored at the MRS until the Yucca Mountain repository is available to accept the wastes.

Group 3 Systems - Differences In Interim Storage Location

The potential interim storage locations are evaluated in this group of systems. It assumes no treatment of the wastes, which should show the greatest effect of the differences in system costs. It also uses the new GTCC facility as the disposal option, since untreated wastes would most likely be acceptable at this facility. As noted previously, the three interim storage locations are West Valley, the MRS facility, and a DOE site, taken to be a western location for this study.

Group 4 Systems - Differences In Disposal System

This group of systems looks at the differences in final disposal alternatives for GTCC wastes, and includes the alternatives of Yucca Mountain, WIPP, and a new GTCC facility. The wastes are size reduced at West Valley and shipped to a commercial waste treatment site for decontamination and vitrification of the residues. The wastes are all stored on a DOE site, assumed to be in the west for the evaluation.

ECONOMIC EVALUATION OF MAJOR ALTERNATIVES

The following assumptions were used to develop costs for the 14 options discussed above.

The cost of initial size reduction and packaging was estimated to be \$5,000/m^3. This cost includes the operational costs and the purchase of cask liners (\$10,000 each).

The cost of treatment includes capital costs, facility costs, operating costs (assumed four years of operation), and package costs. The package (canister) costs were assumed to be equal to that for HLW glass canisters (\$8000 each).

The LLW disposal cost was assumed to range from \$1000 to \$10,000/m^3. It was assumed that the cask liners used to ship the wastes to the treatment location were reused for disposal containers. Since the LLW probably would remain in New York State, no shipping costs were included.

The volume of GTCC wastes after treatment was estimated as follows: 1) The decontamination wastes would be vitrified, resulting in a volume of GTCC waste that is 5% of the original GTCC volume; 2) Sludges, cements, ceramics, DE, and debris would form a GTCC glass volume that is 65% of the original volume; and 3) Metals could be melted to a volume 10% of the original volume.

Other major assumptions include: 1) The storage costs at the MRS range from \$12,000 to \$40,000/m^3; 2) The disposal costs at Yucca Mountain range from \$58,000 to \$300,000/m^3; 3) The storage costs at the DOE site for GTCC waste range from \$7,000 to \$53,000/m^3; 4)The disposal costs at WIPP range from \$2,000 to \$50,000/m^3; and 5) The disposal costs at the new facility range from \$2,500 to \$170,000/m^3.

Interim storage of wastes at West Valley probably would involve a storage period of at least 6 years and possibly 19 years after completion of the vitrification operations. Therefore, the \$5M to \$50M per year site cost was attached to the storage of the GTCC waste.

The results of the economic evaluation are discussed in the following sections.

Group 1 (Treatment Location) System Cost Estimates

Waste management system cost estimates for the Group 1 range from \$18M to \$110M for the various options. Treatment at West Valley has the lowest system cost estimate at \$18M. The lower costs result from the lack of a need for a size reduction and shipping capability requirement for treatment, and from the existing and available vitrification facility. It should be noted that this is not a realistic option since the vitrification system itself is a major fraction of the wastes to be treated. The differences in cost for the other alternatives except Yucca Mountain are very similar, and, with the level of accuracy of the analysis, are essentially the same.

Group 2 (Treatment Methods) System Cost Estimates

Waste management system cost estimates for the Group 2 systems range from \$34M to \$400M. The cost for either a melter-incinerator system or

decontamination-vitrification are essentially identical. The costs for the no-treatment options are very high in comparison to the high volume reduction options. This implies that future plans should include volume reduction.

Group 3 (Interim Storage Locations) System Cost Estimates

Waste management system cost estimates for the Group 3 systems range from $42M to $1150M. The costs are more sensitive to the range of costs for each alternative than they are for the various alternatives. The results also indicated that interim storage at West Valley could be the highest cost alternative due to the continued DOE presence on the site. This implies that further cost work should be directed at reducing the uncertainty in interim storage costs for each of the alternatives.

Group 4 (Disposal Locations) System Cost Estimates

Waste management system cost estimates for the Group 4 systems ranged from $36M to $119M. Again the variations in costs between the three disposal alternatives is less than the potential range of costs at each of the three alternatives. Generally, the costs for disposal at WIPP are the lowest, with a $4M to $19M savings compared to Yucca Mountain. Additional cost work for disposal would be warranted and may result in a more clear decision. Without major cost differences it may be well to plan for disposal in the Yucca Mountain Repository.

CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions and recommended directions for further development of treatment capability for GTCC wastes at WVNS.

The total volume of suspect GTCC waste that exists and will be generated at the West Valley site from operation and decommission of the vitrification facility will total about 1100 m^3.

The majority of the wastes will be generated from the final D&D of the vitrification facility and other supporting facilities. Mobile facilities should be identified to perform the final treatment of the wastes.

The treatment processes selected should focus on volume reduction of the treated wastes. There was little economic difference between volume reduction by melting versus volume reduction by decontamination.

Based on future flexibility and further increases in waste form quality currently evident at WIPP, the treatment technology should focus on technology that will provide an organic-free, high-durability waste form.

The treatment locations, other than West Valley, to further consider include the MRS, commercial facilities, and DOE sites. Commercial facilities should be further evaluated based on potential delays in the MRS and on the limited treatment capability currently planned at DOE sites.

The cost estimates of treatment, interim storage, and disposal of the GTCC-LLW from West Valley ranged from $18M to $1150M and show the importance of continued system evaluation and development.

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REFERENCES

1. USNRC. 1982. "Licensing Requirements for Land Disposal of Radioactive Wastes." 10CFR61.
2. 10 CFR 61 (amendment to). May 25, 1989. U.S. Nuclear Regulatory Commission, "Disposal of Radioactive Wastes." U.S. Code of Federal Regulations. Vol. 54. No. 100.
3. Woods, W.D., et al. 1988. "MRS Action Plan Task B Report: Analyses of Alternative Designs and Operating Approaches for a Monitored Retrievable Storage Facility." PNL-6770, Pacific Northwest Laboratory, Richland, Washington.
4. Jardine, L.J., D.J. Lipps, and D.D. Miller. 1987. "Nevada Nuclear Waste Storage Investigations, Project - Site-Generated Waste Treatment and Disposal Study." SAND86-7136. Bechtel National, Inc., San Francisco, California.
5. DOE-LLW-60T. 1988. "Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies Resource Manual." EG&G Idaho, Idaho Falls, Idaho.