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HANDLING 78,000 DRUMS OF MIXED-WASTE SLUDGE

J. B. Berry
E. S. Harrington
A. J. Mattus

Oak Ridge National Laboratory *
Oak Ridge, TN 37831-6330
United States Of America

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ABSTRACT

The Oak Ridge Gaseous Diffusion Plant (now known as the Oak Ridge K-25 Site) closed two mixed-waste surface impoundments by removing the sludge and contaminated pond-bottom clay and attempting to process it into durable, nonleachable, concrete monoliths. Interim, controlled, above-ground storage included delisting the stabilized sludge from hazardous to nonhazardous and disposing of the delisted monoliths as Class I radioactive waste.

Because of schedule constraints and process design and control deficiencies, ~46,000 drums of material in various stages of solidification and ~32,000 barrels of unprocessed sludge are stored. The abandoned treatment facility still contains ~16,000 gal of raw sludge. Such storage of mixed waste does not comply with the Resource Conservation and Recovery Act (RCRA) guidelines.

This paper describes actions that are under way to bring the storage of ~78,000 drums of mixed waste into compliance with RCRA. Remediation of this problem by treatment to meet regulatory requirements is the focus of the discussion.

PURPOSE

Mixed waste generated from an environmental restoration project is currently stored at the Oak Ridge K-25 Site under conditions that do not comply with Resource Conservation and Recovery Act (RCRA) requirements. A Pond Waste Management Project (PWMP) was formed in December 1990 and is bringing the situation into compliance. Industrial firms will be contracted to demonstrate technology and treat ~78,000 drums of low-level radioactive mixed waste. Waste remediation will be conducted in three phases, as follows: Phase 1, Process Qualification; Phase 2, Full-Scale Waste Treatment Demonstration; and Phase 3, Waste Treatment. Because a disposal site for treated waste has not been identified, an assessment of applicable regulations has been used to determine the criteria that the treated waste must meet. The purpose of this paper is to describe: (1) the background for the situation; (2) an action plan for remediating untreated waste; and (3) an evaluation of regulations.

BACKGROUND

CURRENT SITUATION

Sludge from two settling ponds at the K-25 Site has been placed in ~78,000 carbon steel drums that are primarily stored outside on an asphalt pad. The waste is generally of two types: raw sludge and processed solids. The raw sludge is a mixture of liquids, clay, and sludge materials. The "processed solid" is waste that is in various stages of grout stabilization. Approximately 32,000 drums contain raw sludge, and 46,000 drums contain processed solid material

In addition to drummed raw sludge, a total of ~16,000 gal of raw pond sludge has been stored in holding tanks at the Sludge Treatment Facility (STF). Additional solidified waste is stored in two 6-ft culverts and four B-25 boxes (4 x 4 x 6 ft) on the asphalt storage pad.

The pond sludge is classified as a mixed waste because it is listed as F006 and contains low levels of radionuclides such as technetium and uranium. Further statistical sampling and analyses of both grouted drums and raw sludge are planned for implementation during overpacking operations.

Some drummed raw sludge may contain various amounts of clay and rock from the bottoms of the two ponds. It is also believed that the drummed sludge may have a solids concentration ranging between 15 and 50 wt %. The liquid associated with this sludge has been shown to have an extremely low dissolved solids content due to solubles leaching away from the holding ponds over a number of years. Despite this fact, enough chloride and fluoride are able to be leached from the raw waste into the liquid associated with grouted sludge to promote corrosion and pinhole leaks in the drums. Condensation of atmospheric moisture inside the drums is also believed to contribute to the corrosion problem. Storage is not compliant with RCRA guidelines because (1) free liquid is present in drums that are not doubly contained and (2) the drums are not stored in an inspectable array.

These conditions have resulted in an immediate need to handle all 78,000 drums of grout and/or raw sludge. The drums will be placed in protective overpacks, beginning in October 1991. After the overpack operations are completed, the drums containing raw sludge will be moved to storage buildings, while those containing solidified waste will be stacked in a RCRA-compliant array on asphalt storage pads outside.

HISTORICAL BACKGROUND

From 1955 to 1985, the Oak Ridge Gaseous Diffusion Plant (ORGDP) (which is now known as the Oak Ridge K-25 Site and operated by Martin Marietta Energy Systems, Inc., for the Department of Energy (DOE), utilized two ponds (B and C) as settling/holding basins for neutralized waste streams from the steam plant, metals cleaning facility, plating shop, and sludge generated from the cascade scrubber blowdown treatment system. The primary difference between the sludges in the two ponds is that cascade scrubber blowdown sludge, ion exchange resin, chlorides, and fluorides, were added to the "C Pond" only. Large quantities of sludge from coal pile runoff treatment, sludge for other steam plant activities, and fly ash were added to the "B Pond" only.

In an attempt to meet a RCRA-directed closure of the ponds by November 1988, the pond sludges were excavated and a portion was immobilized in a cement-based grout. Process control and quality assurance for the grout operations were inadequate, resulting in the production of an as-yet-undetermined number of drums of "solidified" waste that were not properly stabilized. The grout-to-waste ratio and the solids content of the feed were inadequately controlled. All of the sludge was not grouted because of time constraints; raw sludge was drummed in order to close out the ponds prior to the deadline. As a result of this activity, ~78,000 drums containing either grouted sludge or raw sludge are now stored at the Oak Ridge K-25 Site.

A cement-based grout formula was developed for use in processing both pond sludges. In the target formula (see Table 1), 25 wt % solids in the sludge was considered to be optimum during all batch operations, which normally produced between 12 to 20 drums per batch. Following the use of this formula with sludge from both ponds, bleed-water problems were encountered with the grouted product. The full extent of these problems and their causes are as yet undetermined, although it is thought that poor process control may have permitted the incorrect ratios of ingredients to be mixed with the waste.

Table 1. Target grout formula

Ingredient	Wt %
Portland cement (Type I)	25
Fly ash (Class F)	25
Sludge (15-30 wt % solids)	50
Admixture (MB-AE 10)	0.125

Analytical data on the sludge from the ponds are limited to pond sampling that occurred in May 1985 and was reported by Shoemaker and Bostick.[1] These data were obtained from core samples of the ponds and the underlying clay bed. Twelve samples of sludge were removed from B Pond, and 15 samples were taken from C Pond. The chemical and radiological results, which are summarized in Tables 2 and 3, are based on the statistical sampling process employed at that time. As can be seen from these tables, the radionuclides of concern are uranium (^{235}U), cesium, neptunium, plutonium, and technetium. Each of the raw sludge samples removed from the ponds was leached using the Extraction Procedure (EP) Toxicity test and easily passed the test for all species of concern. However, high concentrations of nickel (which ranged between 0.010 and 36 ppm) in the leachates are a concern. Even though nickel is not currently listed as a TCLP constituent, nickel data will be reviewed by the Environmental Protection Agency (EPA) as part of the review of any delisting

Table 2. Summary data for K-1407-B pond sampling

Parameter	Mean	Maximum	Minimum	Units
Aluminum	36200.	49000.	19000.	µg/g
Arsenic	162.	250.	5.0	µg/g
Barium	221.	290.	120.	µg/g
Beryllium	2.0	3.1	1.4	µg/g
Boron	110.	190.	77.	µg/g
Cadmium	2.0	5.6	0.30	µg/g
Calcium	58000.	200000.	29000.	µg/g
Chromium	815.	2400.	290.	µg/g
Cobalt	42.	61.	22.	µg/g
Copper	1030.	1600.	420.	µg/g
Iron	75500.	20000.	35000.	µg/g
Lead	121.	180.	66.	µg/g
Lithium	23.	37.	16.	µg/g
Magnesium	6790.	16000.	4700.	µg/g
Manganese	642.	830.	460.	µg/g
Molybdenum	17.	49.	1.0	µg/g
Nickel	4133.	7100.	34.	µg/g
Niobium	≤0.70	≤0.70	≤0.70	µg/g
Phosphorus	12790.	21000.	6200.	µg/g
Potassium	4100.	7300.	2000.	µg/g
PCB	≤0.0010	≤0.0010	≤0.0010	µg/g
Selenium	88.	140.	5.0	µg/g
Sodium	1151.	3100.	390.	µg/g
Strontium	136.	190.	81.	µg/g
Thorium	21.	30.	20.	µg/g
Titanium	363.	460.	220.	µg/g
Vanadium	44.	61.	17.	µg/g
Zinc	607.	810.	480.	µg/g
Cesium	15.	16.	15.	dpm/g
Neptunium	7.2	17.	1.3	dpm/g
Plutonium	7.1	19.	1.9	dpm/g
Technetium	8088.	15000.	2500.	dpm/g
Density	1.1	1.2	1.1	g/mL
pH	7.0	7.4	6.7	
Uranium	516.	1044.	69.	µg/g
Uranium-235	1.2	1.3	1.1	wt %
Acetone	≤0.0010	≤0.0010	≤0.0010	µg/g
Fluorocarbons	≤0.0010	≤0.0010	≤0.0010	µg/g
Trans-1,2-dichloroethylene	≤0.0030	≤0.0030	≤0.0030	µg/g
Phosphate (total)	38370.	63000.	18600.	µg/g

Table 3. Summary data for K-1407-C pond sampling

Parameter	Mean	Maximum	Minimum	Units
pH	10.	11.	8.1	
Aluminum	25392.	42000.	8500.	µg/g
Arsenic	20.	97.	5.0	µg/g
Barium	89.	150.	13.	µg/g
Beryllium	≤0.030	≤0.030	≤0.030	µg/g
Boron	4252.	11000.	85.	µg/g
Cadmium	0.65	1.8	0.30	µg/g
Calcium	35000.	90000.	30000.	µg/g
Chromium	601.	2400.	30.	µg/g
Cobalt	51.	210.	2.0	µg/g
Copper	583.	2000.	120.	µg/g
Iron	25185.	73000.	2500.	µg/g
Lead	42.	140.	6.0	µg/g
Lithium	16.	31.	2.9	µg/g
Magnesium	7885.	11000.	5500.	µg/g
Manganese	383.	1000.	73.	µg/g
Molybdenum	≤1.0	≤1.0	≤1.0	µg/g
Nickel	5667.	21000.	240.	µg/g
Niobium	2.7	5.3	0.70	µg/g
Phosphorus	5016.	18000.	320.	µg/g
Potassium	9507.	15000.	2600.	µg/g
PCB	≤0.0010	≤0.0010	≤0.0010	µg/g
Selenium	6.0	13	5.0	µg/g
Sodium	7388.	15000.	740.	µg/g
Strontium	111.	150.	95.	µg/g
Thorium	37.	52.	20.	µg/g
Titanium	361.	770.	110.	µg/g
Vanadium	23.	45.	11.	µg/g
Zinc	221.	660.	68.	µg/g
Cesium	119.	511.	15.	dpm/g
Neptunium	45.	183.	1.5	dpm/g
Plutonium	62.	241.	1.0	dpm/g
Technetium	3476.	13600.	293.	dpm/g
Density	1.4	1.7	1.1	g/mL
Acetone	0.32	1.0	0.10	µg/g
Benzene	≤0.040	≤0.040	≤0.040	µg/g
Bromodichloromethane	≤0.020	≤0.020	≤0.020	µg/g
Bromoform	≤0.050	≤0.050	≤0.050	µg/g
Carbon tetrachloride	≤0.030	≤0.030	≤0.030	µg/g
Chlorobenzene	≤0.060	≤0.060	≤0.060	µg/g
Chloroform	≤0.020	≤0.020	≤0.020	µg/g
Cis-1,3-dichloropropene	≤0.050	≤0.050	≤0.050	µg/g
Dibromochloromethane	≤0.030	≤0.030	≤0.030	µg/g
Ethyl benzene	≤0.070	≤0.070	≤0.070	µg/g
Freon-113	0.11	0.27	0.10	µg/g
Freon-114	≤0.10	≤0.10	≤0.10	µg/g
Freon-123	≤0.10	≤0.10	≤0.10	µg/g
Methyl ethyl ketone	≤0.10	≤0.10	≤0.10	µg/g
Methylene chloride	0.030	0.040	0.030	µg/g
Other halomethanes	≤0.10	≤0.10	≤0.10	µg/g
Permethylated cyclosiloxane	≤2.4	≤2.4	≤2.4	µg/g
Tetrachloroethylene	≤0.040	≤0.040	≤0.040	µg/g
Toluene	0.062	0.090	0.060	µg/g
Trans-1,2-dichloroethylene	≤0.020	≤0.020	≤0.020	µg/g
Trans-1,3-dichloropropene	≤0.050	≤0.050	≤0.050	µg/g
Trichloroethylene	≤0.020	≤0.020	≤0.020	µg/g
Trichlorofluoromethane	≤0.10	≤0.10	≤0.10	µg/g
Uranium	515.	1841.	58.	µg/g
1,1-Dichloroethane	≤0.050	≤0.050	≤0.050	µg/g
1,1-Dichloroethylene	≤0.030	≤0.030	≤0.030	µg/g
1,1,2-Trichloroethane	≤0.050	≤0.050	≤0.050	µg/g
1,1,2,2-Tetrachloroethane	≤0.070	≤0.070	≤0.070	µg/g
1,2-Dichloroethane	≤0.030	≤0.030	≤0.030	µg/g
1,2-Dichloropropane	≤0.060	≤0.060	≤0.060	µg/g
Uranium-235	1.6	2.6	1.3	wt %

petition and may cause the waste to be regulated under the California list specified by the RCRA Land Disposal Restrictions.

During solidification operations, "grab" samples of grout slurry were removed from 40 batches and were cast into cubes for the unconfined compressive strength and EP-Toxicity testing, Multiple Extraction Procedure (MEP) testing, and analyses for total constituents, organics, and oil and grease. The unconfined compressive strengths were found to range between 1000 and 1500 psi (ASTM C-109), and the leachates easily passed the EP-Toxicity test as well as the primary and secondary drinking water standards when applied directly. However, because of a suspected loss of process control during grouting operations, these data are considered to be representative only of the 40 batches sampled--and not of the entire process.

PLANS FOR REMEDIATION OF UNTREATED WASTE

TECHNICAL APPROACH

Criteria for Waste Treatment. Untreated waste, including raw waste and ~10,000 drums of "solidified" waste that was not properly stabilized, will be remediated. Industrial firms have been contacted and will propose processes to treat the waste to meet waste-form criteria. In this way, a wide range of processes can be evaluated. At this stage of evaluation, neither the treatment options nor the final product forms are limited. Proposed treatment processes may include (or be a combination of) either solidification/stabilization or some other, unspecified treatment to ensure that performance requirements are met.

Performance criteria originating from various regulatory agencies such as the Department of Energy (DOE), Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency (EPA) must be met by the chosen process and any final resulting waste form. Industrial firms will attempt not only to meet the minimum performance criteria put forth in the referenced regulatory documents, but will also strive to obtain performance goals above regulatory minimums. During the treatment process, the insult to human health and the environment shall be minimized in accordance with the principle of As Low As Reasonably Achievable (ALARA) in all phases of processing. In addition to abiding by the ALARA principle, it shall be an objective of any treatment scheme to minimize the volume increase of the waste at the conclusion of treatment while, at the same time, minimizing or not co-producing new secondary products that may be classified as new waste.

Performance criteria for final waste forms, as well as requirements for the treatment of wastes, are outlined in DOE Order 5820.2A, dated September 1988. The only exception to the guidance in this document will be that the final waste form shall have 0% free water after a period of 24 h and beyond in accordance with DOE-Oak Ridge Operations guidance.

Stabilization/solidification. The regulation, "Licensing Requirements for Land Disposal of Radioactive Waste" (also known as 10 CFR Part 61), has contained the most comprehensive guidance on waste forms under NRC since its issuance in 1983. This document, entitled "Technical Position on Waste Form, Revision 1," was revised and issued as draft guidance in January 1991. Because of the comprehensive nature of the newer technical position compared with the old version, all treatment process-related activities will conform to the requirements outlined in this NRC position if stabilization/solidification is chosen. Under guidance from this document, the treatment process implementation and the final product performance will meet all the requirements put forth in this new NRC Technical Position Paper (TPP) if a stabilization process is selected.

All test methods proposed in the TTP will be used to show that the waste form performance criteria can be met within the confines of the expected variation in process equipment operating control. Guidance on laboratory testing and Process Control Programs (PCP), as set forth in the TPP, will be followed. The appendix of the new TPP is written with cement-based products in mind; however, the same performance and process requirements will be required of any other matrix material. Other matrix materials, such as thermoplastics, are covered under the new TPP. In addition to the waste form performance criteria required under the new NRC TPP, the following criteria will be met: (1) 0% free water must be obtained after 24 h and beyond, and (2) thermal cycling tests as described in the TPP must be successful. Additionally, a newly proposed mean unconfined compressive strength of 500 psi must be demonstrated after 28 d in the case of cement-based matrices and a minimum of 60 psi for other non-cement-based materials.

The treatment technology employed must yield a product that does not exhibit any of the hazardous waste characteristics. MEP and total constituent analysis will be conducted on the treated waste form. Both laboratory and field process samples of statistically representative product must be capable of passing the TCLP test in support of a Land Disposal Restrictions (LDR) determination and a delisting petition to both the EPA and the state of Tennessee.

The pond sludge is listed as RCRA hazardous, and liquid in contact with the grout has a high pH, making it characteristically hazardous. Therefore, the waste must be regulated under LDR stemming from the Hazardous and Solid Waste Amendments (HSWA) passed by Congress in 1984. The LDR requires that the wastes be treated using the best demonstrated available technology (BDAT) for this type of waste. Therefore, the waste will be treated using the recommended BDAT technology under LDR or a technology that will permit the treated product, or any residues resulting from the production of the treated product, to meet all LDR requirements promulgated under these restrictions.

Treatment Other Than Stabilization/Solidification. Processes that are proposed as an alternative to solidification will be required to meet the waste form requirements for a stabilized waste. Potential treatment scenarios were considered, and concentration limits of radionuclides were identified; however, the tabulated concentrations are based on proposed limits and are not final. Concentrations will, undoubtedly, be changed prior to implementation of an actual treatment process.

Scenario 1: Treatment of waste to allow a portion of the waste to be handled as "non-radioactive," hazardous waste. Treated wastes may be considered to be hazardous only (nonradioactive) if the concentrations of the radionuclides meet the limits shown in Table 4.

Scenario 2: Treatment of the radioactive fraction of the waste so that the bulk of the material will meet proposed on-site disposal concentrations as specified in the appendix. The pond waste cannot qualify as Class II waste because it contains radionuclides (e.g., uranium) with half-lives >30 years. Therefore, the goal of treatment is to qualify a fraction of the waste for designation as Class I.

Treatment of Used Containers. A method must be devised for handling used carbon-steel drums in which the raw and solid waste was stored before processing. Handling includes removal of drummed raw waste from the overpack container, removal of the raw waste and solid waste from carbon-steel drums, treatment of carbon-steel drums to meet waste acceptance criteria, and cleaning of overpack containers for reuse.

Waste acceptance criteria for decontaminated used drums fall into four categories: (1) RCRA; (2) radioactively contaminated scrap metal; (3) clean scrap metal, and (4) Department of Transportation (DOT).

Table 4. Limits for selected radionuclides in solids to be considered for disposal as hazardous waste*

Radionuclide	Limit
Gross alpha	≤ 2.0 pCi/g
Gross beta	≤ 4.0 pCi/g
Tc-99	≤ 8.0 pCi/g
Np-237	≤0.5 pCi/g
Pu-238	≤0.5 pCi/g
Pu-239/240	≤0.5 pCi/g
Th-228	≤0.5 pCi/g
Th-230	≤0.5 pCi/g
Th-234	≤7.0 pCi/g
Cs-137	≤16.0 pCi/g
Pa-234m	≤55.0 pCi/g
U	≤1.0 µg/g

*Detection limits are quoted based on analyses of soil samples by K-25 analytical chemistry staff.

1. RCRA (mandatory). The used drum must meet criteria for "residues of hazardous waste in empty containers," as defined by RCRA Subsection 261.7(b)(1), and must be considered best management practices.

2. Low-level radioactive waste. Treatment of used drums may be limited to volume reduction and packing contaminated scrap in B-25 strong-tight containers for storage at the Oak Ridge K-25 Site as "contaminated scrap metal."

3. Clean scrap metal. Methods may be employed to clean used drums to meet the plant standard for clean scrap metal.[2] This standard defines clean equipment or material as follows: "Equipment or material which has a surface contamination level of less than 5,000 d/min/100 cm^2 surface alpha; 1,000 d/min/100 cm^2 transferable alpha and a beta-gamma surface reading less than 0.1 mr/hr."

4. Department of Transportation. Used drums may be shipped off-site for treatment. Appropriate DOT shipping requirements, including the use of strong-tight containers for shipment, will be met if this option is chosen.

PROCUREMENT OF SERVICES

The services of an industrial firm will be procured to remediate untreated waste. Waste remediation will be conducted in three phases, as follows: Phase 1, Process Qualification; Phase 2, Full-Scale Demonstration of Waste Treatment; and Phase 3, Waste Treatment.

Phase 1 of the waste remediation procurement will demonstrate that the proposed technology will provide a final product that meets performance criteria as outlined above. Performance qualification testing will be conducted during Phase 1 to ensure that the proposed process will treat the waste to the specified performance criteria, using the most economical process conditions. Pilot-scale testing may be conducted off-site. A statistically valid experimental design will be used to identify optimum process parameters. All tests will be conducted at selected industrial firms and confirmed by conducting independent tests.

In addition to standard procurement requirements, criteria were selected to qualify industrial firms for this task. Qualified firms will participate in Phase 1 at their expense and furnish all information so that the results of tests can be independently verified. Vendors must provide documentation that EPA-approved analytical methods are used in a laboratory managed under the EPA Contractor Laboratory Program and demonstrate the capability to perform the required process qualification tests. Qualified vendors will provide evidence they have the appropriate EPA and state licenses and/or permits to store and perform studies on the mixed waste at their facilities. To supplement the information supplied, an evaluation team may be sent to the vendor's facility for further evaluation purposes.

Phase 2 of the waste remediation procurement consists of full-scale demonstration of a limited number of proposed waste treatment processes. Firms will be selected for participation in Phase 2, based on the performance of the proposed process in Phase 1, their willingness to share the expense of Phase 2, and the technical specifications of the proposed full-scale treatment unit. The selected company will be required to prepare a RCRA Part B permit application for the proposed process. A full-scale treatment unit will be mobilized by the selected firms to demonstrate the maintainability, operability and controllability of the process, and the performance of the waste form under full-scale process operations. Independent verification of process and waste form performance will be required.

Phase 3 of the waste remediation procurement consists of construction, erection, installation and operation of facilities that will treat the waste in accordance with the qualified process and the specified performance criteria. All of the overpacked, raw-waste drums will be returned from storage; then the fraction of "solidified" material in each that was not properly stabilized will be removed from the pad and treated. Used drums will be cleaned, volume-reduced, and packaged according to waste acceptance criteria. Specifications have been developed for technical requirements, quality assurance, system inspection and testing, documentation, and on-site work requirements.

Phase 3 qualification criteria includes a liability clause; each firm will warrant that the treated waste will meet performance criteria after treatment and will remain in its treated state in accordance with the requirements of 10 CFR 61. Evidence of participation with similar projects with similar materials and complexity within the last 3 years will be provided. Health, Safety and Environmental (HSE) capabilities must be demonstrated.

EVALUATION OF REGULATIONS

LOGIC FOR EVALUATING REGULATIONS

Regulations for mixed waste can be grouped into requirements for hazardous waste (as governed by RCRA) and radioactive waste (as governed by DOE and NRC). Each set of requirements is evaluated prior to selection of treatment options. A logic diagram for evaluating mixed-waste regulatory requirements is shown in Fig. 1. The LDR and radioactive waste requirements are discussed in the section entitled "Technical Approach." A detailed evaluation of deadlines that may be applied to the storage of untreated waste follows in the section entitled Land Disposal Restrictions."

Untreated K-25 pond waste must be treated, of course, to meet both RCRA and radioactive waste requirements prior to long-term storage or disposal. However, several options for storage and disposal are being considered. These options are discussed in the paragraphs that follow.

No disposal site has been identified for mixed waste generated on the Oak Ridge Reservation. Potential off-site mixed-waste disposal sites are: (1) Envirocare of Utah — a commercial mixed-waste disposal facility; and (2) Nevada Test Site — a DOE-operated disposal facility for defense waste. However, a change in DOE policy would be required before either of these facilities could be used for K-25 mixed waste. On-site disposal of mixed waste is not being considered in the long term for the waste management strategy for Oak Ridge.

If no disposal options are available for mixed waste, an incentive to separate untreated waste into hazardous and radioactive fractions exists. An evaluation of the technical feasibility of waste segregation through treatment will be made by industrial firms interested in

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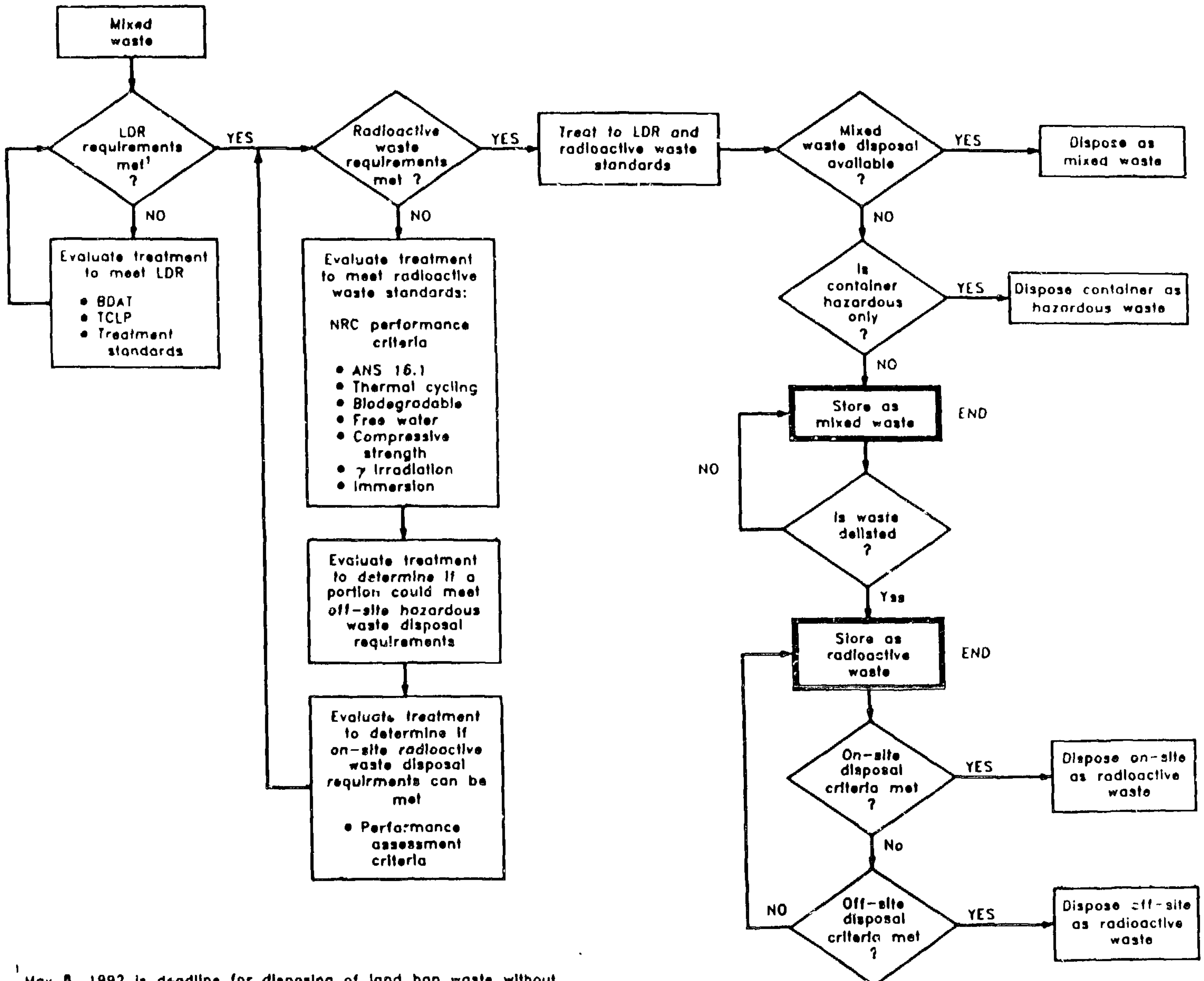

[1] May 8, 1992 is deadline for disposing of land ban waste without treatment to Land Disposal Restrictions (LDR) standards.

Fig. 1. Logic for Evaluating Mixed Waste Regulatory Requirements.

providing a treatment service contract. The feasibility of any proposed waste segregation process will be evaluated and confirmed independently. If this type of waste treatment scheme is implemented, a fraction of the waste could be disposed of off-site as hazardous waste. The remainer would be stored as mixed waste until a delisting petition is approved.

Perpetual, compliant storage of the treated material as "mixed waste" is a likely conclusion of the current project. However, in an effort to avoid perpetual mixed-waste storage, characterization data will be collected to support a delisting petition. Such a petition will be submitted; however, approval of the petition to remove the waste stream from regulation as a hazardous waste is uncertain. If the delisting petition is approved, the product will be stored as low-level radioactive waste and radioactive waste disposal options will be pursued. Perpetual storage as radioactive waste is another likely end point for this project because there are currently no approved disposal sites. Disposal of radioactive waste off-site at a commercial site (e.g., the Barnwell Disposal Site operated by Chem Nuclear Systems, Inc. located in Barnwell, South Carolina) would require a change in DOE policy. Fortunately, plans for on-site radioactive waste disposal are progressing (see the Appendix).

Concentration limits have been established for on-site low-level radioactive waste disposal. In order to determine whether treatment could separate the radionuclides so that a fraction of the waste would be suitable for on-site disposal, qualified industrial firms are being asked to propose treatment schemes. Qualified processes will be evaluated independently for technical feasibility. In addition to technical viability, an economic evaluation will be used to justify or eliminate proposed processes.

LAND DISPOSAL RESTRICTIONS

Summary of LDR. LDR governs the disposal of hazardous waste on land. Treatment standards and limitations on the length of storage of untreated waste are established. An action plan for bringing the ~78,000 drums into compliance with RCRA regulations, which requires remediation of untreated waste by September 1995, has been approved by the state of Tennessee and EPA Region IV.[3]. In addition to this plan, a Federal Facilities Compliance Agreement (FFCA) for noncompliant LDR radioactive mixed waste is being negotiated. A deadline for treatment has not been negotiated under this agreement. It is hoped that this deadline, when established, will be supported by FFCA negotiations; however, if a certain regulatory category is found to be applicable (i.e., California list), a more stringent deadline for storage of untreated waste may be applied.

Regulatory Background. A brief history and pending legislation of applicable regulations can be summarized as follows:

1. In 1984, Congress required EPA to address the land management of waste. Disposal of hazardous waste on the land without treatment could no longer be permitted (1984 HSWA Amendments to RCRA).

2. On July 8, 1987, EPA promulgated regulations for certain California list wastes. Radioactive waste mixed with California list waste is prohibited from land disposal pursuant to the land disposal prohibitions. EPA subsequently decided that radioactive mixed waste in the first-third and second-third would be addressed in the third-third rule.

3. On August 11, 1987, the state of Tennessee received authorization from EPA to regulate radioactive mixed waste.

4. On May 8, 1990, EPA promulgated regulations for third-third waste, including radioactive mixed waste. However, waste subject to the third-third rule was granted a 2-year

capacity extension. Therefore, effective May 8, 1992, hazardous wastes that are radioactive mixed wastes will be prohibited from land disposal.

5. EPA and TDHE (now known as Tennessee Department of Conservation, TDOC) have determined that the storage of prohibited wastes restricted from land disposal constitutes a violation of applicable hazardous waste laws and regulations, including RCRA regulations found in 40 CFR Section 268.50 and Tennessee Rule 1200-1-11-.10(4). The Oak Ridge Reservation is currently storing prohibited waste, and such storage could be construed to be for purposes other than accumulating quantities necessary to facilitate proper recovery, treatment, or disposal of such wastes. *On August 9, 1989, DOE-HQ proposed instituting* compliance agreements with EPA to address the mixed LDR waste issue.

6. RCRA closure of the Oak Ridge K-25 Site's K-1407-B and -C settling ponds resulted in the generation of sludges that meet the LDR definition of an F006 listed waste and potentially meet the LDR definition of a California List waste due to contamination with nickel. F006 listed waste is covered under the third-third rule while California List waste is covered under the FFCA.

7. RCRA is scheduled to be overhauled during 1992. DOE is providing comments on the proposed rulemaking and is suggesting new rules for mixed waste.

8. EPA has been awaiting the new rulemaking to propose establishment of a de minimus quantity for mixed waste.

Evaluation of LDR Deadline for Storage of Untreated Waste. The effective date for regulations governing certain California listed waste was July 8, 1987. Since the K-25 pond waste was stored after this time, it is governed by the regulation 52 FR 25760. Also, once the waste is "actively handled" (i.e., overpacked and moved to storage) it is subject to LDR and a 1-year limit for storage prior to treatment is imposed. Variances to this 1-year limit can be negotiated under the proposed FFCA, if the waste is California listed, or under the National Capacity Variance, if the waste is F006 nonwastewater. A diagram for evaluating the applicable deadline for storage of untreated waste is shown in Fig. 2 and is described as follows:

1. If the raw waste solids pass the TCLP, the waste meets LDR treatability standards. LDR requirements would be met and the logic of Fig. 1 could be pursued without further consideration of LDR requirements.

2. If the raw waste solids fail the TCLP, they must be treated to meet LDR standards. TCLP would then be conducted on the treated waste, and the product would be stored as mixed waste, pending action on the delisting petition; however, the deadline for storage of untreated waste would be dependent on the waste classification. Current plans are based on the assumption that the project action plan establishes the treatment deadline.

3. K-25 pond waste is included in the FFCA because of the potential for free liquid to contain nickel at concentrations in excess of 134 mg/L.

4. If sampling indicates that free liquid contains >134 mg/L, the waste would be classified as a California listed mixed waste. Management of such waste would then be negotiated under the FFCA.

5. If sampling indicates that the free liquid contains nickel at a concentration <134 mg/L, data would be provided to the state and EPA to indicate that pond waste can be withdrawn from the FFCA.

6. If free liquid contains nicket at <134 mg/L, the waste would be classified as F006 nonwastewater, listed waste. The deadline for storage of raw waste would then be negotiated under the National Capacity Variance.

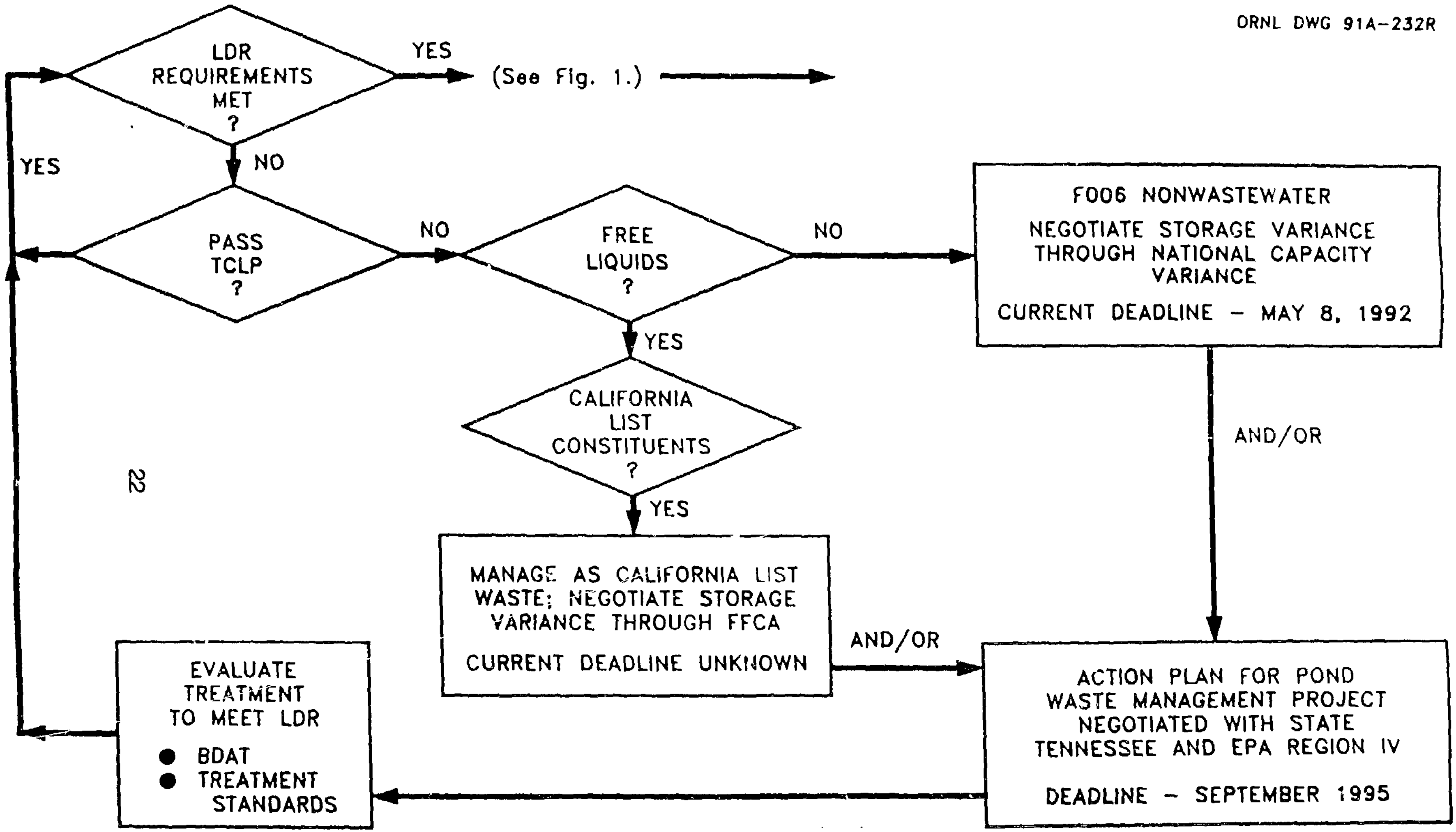

Fig. 2. Logic for evaluating deadline for storage of untreated waste.

7. A deadline for the completion of waste treatment (i.e., ending the storage of prohibited waste) has been negotiated with the state of Tennessee and EPA Region IV and documented in the project action plan. Current plans assume that the deadline under this plan supersedes deadlines that may be imposed by the FFCA or the National Capacity Variance.

RADIOACTIVE WASTE REQUIREMENTS

Regulatory aspects of radioactive waste management are governed by DOE orders. Guidance on waste form performance and methods for process control is provided by NRC, as discussed in the section entitled "Technical Approach." No deadlines for the storage of untreated waste are imposed by radioactive waste requirements.

Pathways analyses are used to establish concentration limits for radionuclides in various disposal scenarios. These analyses have not been completed for Oak Ridge Reservation wastes. Preliminary limits for on-site disposal of radioactive materials are described in the Appendix. Concentration limits for radionuclides are also being established for hazardous waste disposal. A pathways analysis is currently being conducted so that guidelines can be established for off-site disposal of hazardous waste.

SUMMARY

Mixed waste, generated from an environmental restoration project, is currently being stored at the Oak Ridge K-25 Site and is not in compliance with RCRA requirements. Industrial firms have been contracted to demonstrate technology and treat ~78,000 drums of low-level radioactive mixed waste. Waste remediation will be conducted in three phases as follows: Phase 1, Process Qualification; Phase 2, Full-Scale Waste Treatment Demonstration;

and Phase 3, Waste Treatment. Because a disposal site for treated waste has not been identified, an assessment of applicable regulations has been used to determine the criteria that the treated waste must meet. An action plan has been negotiated with the state of Tennessee and EPA Region IV to establish project milestones and the deadline for storage of untreated waste. This paper describes: (1) the background of the situation; (2) an action plan for remediating untreated waste; and (3) an evaluation of regulations.

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APPENDIX

OAK RIDGE RESERVATION

MANAGEMENT OF LOW-LEVEL WASTE

1. BACKGROUND

Martin Marietta Energy Systems, Inc., manages a low-level waste (LLW) program. The purpose of this program is to develop a comprehensive strategy for managing LLW on the Oak Ridge Reservation (ORR), based on the current status of state and federal regulations and DOE orders. The strategy relies on the concept of waste segregation to provide needed control of the concentration and isotopic composition of LLW before final disposition. The approach to managing the segregated wastes depends on the level of contamination present. This approach is based on the performance assessment of the disposal site and the technology used for disposal of the waste. The LLW program has proposed five classes of LLW to be managed on the ORR. These are described below. The K-25 pond waste can only potentially qualify for Class I.

1. BRC Waste - LLW that is suitable for disposal in a sanitary/industrial landfill facility and will not expose any member of the public to an effective dose equivalent to more than 4 mrem/year at the time of disposal.
2. Class I Waste - LLW that is suitable for disposal using sanitary/industrial landfill technology and will not expose any member of the public to an effective dose equivalent to more than 10 mrem/year at the time of disposal.
3. Class II Waste - LLW primarily containing fission product radionuclides with half-lives of 30 years or less that is suitable for disposal in engineered facilities designed to isolate the waste from the environment and public for a period of

time sufficient to allow for the decay of radionuclides to such a level that any member of the public will not be exposed to an effective dose equivalent to more than 10 mrem/year.

4. Class III Waste - LLW consisting of radionuclides that have long half-lives and will be disposed of in facilities having intruder protection.

5. Class IV Waste - LLW that is not suitable for disposal on the ORR and would require either treatment to reduce the level of contamination to a level consistent with any of the other four waste classifications or shipment to an off-site LLW disposal facility.

2. ALTERNATIVE METHODS FOR CALCULATING RADIONUCLIDE CONCENTRATION

2.1 If more than one isotope is present in the waste package, the total activity concentration must follow the "sum of fractions" rule. That is, the sum of the ratios of each isotope's concentration in the waste package to that isotope's limiting concentration must be less than or equal to 1, expressed mathematically as:

$$\sum_{i=1}^{n}\left(\frac{C}{C_L}\right)_i \leq 1.0, \qquad (1)$$

where

C = the measured or calculated concentration of a given radionuclide in the waste package plus the associated uncertainty,

C_L = the concentration limit for that radionuclide shown in Table A-1, and

n = the total number of principal radionuclides in the waste package.

2.2 For the purposes of waste acceptance, a radionuclide listed in Table A-1 may be considered not to be present in the waste if the following conditions apply:

1. The ratio of the concentration of the radionuclide in the waste to the concentration limit for that radionuclide does not exceed 0.1, and

$$\frac{C}{C_L} \le 0.1. \qquad (2)$$

2. The sum of such ratios for all radionuclides considered not to be present does not exceed 0.25,

$$\sum_{k=1}^{n} \left(\frac{C}{C_L} \right)_k \le \frac{1}{4} \qquad (3)$$

3. Radionuclides that are not specifically listed in Table A-1, including beta-gamma-emitting radionuclides with half-lives less than 5 years, may be considered not to be present if the activity of the particular radionuclide does not exceed 5% of the total activity of the waste package.

Table A-1. Site-specific, dose-based concentration* limits

Nuclide	Class L-I (11-16-90)	Class L-II (10-01-90)
H-3	1.39E+10	1.16E+12
Be-10	4.30E+04	1.96E+06
C-14	5.93E+05	2.01E+02
Na-22	1.37E+05	>1.00E+12
Co-60	1.14E+07	>1.00E+12
Ni-63	8.82E+04	2.83E+04
Sr-90	1.40E+-3	8.88E+05
Zr-93	2.55E+02	2.55E+02
Tc-99	1.07E+01	5.53E+02
Cd-113m	6.61E+04	9.76E+09
Sn-121m	1.35E+03	5.74E+04
Cs-137	6.98E+02	2.53E+05
Sm-151	1.56E+06	2.57E+07
Eu-152	1.03E+04	1.35E+09
Eu-154	1.81E+05	5.13E+12
Eu-155	4.61E+07	>1.00E+12
Th-232	1.27E+00	4.48E-01
U-233	1.22E+03	2.36E+01
U-235	9.97E+00	2.53E+01
U-238	2.09E+01	2.75E+01
Np-237	8.08E-03	1.05E-02
Pu-238	5.46E+02	1.49E+01
Pu-239	2.17E-01	2.95E-01
Pu-241	5.35E+02	9.39E+03
Pu-242	9.19E-00	4.99E+02
Am-241	9.92E+00	1.34E+02
Am-243	4.61E-01	1.81E+01
Cm-243	1.71E+03	1.03E+06
Cm-244	1.42E+02	2.14E+02
Cf-252	2.56E+04	>1.00E+12

*$\mu Ci/m^3$.

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3. *Action Plan for the Management of K-1407-B and -C Ponds Waste at the Oak Ridge K-25 Site, Pond Waste Management Project*, K/PW-3, Martin Marietta Energy Systems, Inc., Oak Ridge Gaseous Diffusion Plant, January 31, 1991.