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MARTIN MARIETTA

Update of the Management Strategy for Oak Ridge National Laboratory Liquid Low-Level Waste

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Chemical Technology Division

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ACRONYMS

ANS	Advanced Neutron Source
CAT	Collection and Transfer (System)
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration (Program)
ES&H	environmental, safety, and health
FFA	Federal Facilities Agreement
GPP	general plant project
HFIR	High Flux Isotope Reactor
HOG	hot off-gas
ITE	in-tank evaporation
LDR	land disposal restriction
LLLW	liquid low-level waste
LLLWC	liquid low-level waste concentrate
LLW	low-level waste
MVST	Melton Valley Storage Tank
NHF	New Hydrofracture Facility
OGR	Old Graphite Reactor
ORNL	Oak Ridge National Laboratory
ORR/BSR	Oak Ridge Research and Bulk Shielding reactors
OSR	operational safety requirement
PBR	permit-by-rule
PWTP	Process Waste Treatment Plant
R&D	research and development
RCRA	Resource Conservation and Recovery Act
REDC	Radiochemical Engineering Development Center
TCLP	Toxicity Characteristic Leaching Procedure
TDC	Tennessee Department of Conservation
TRU	transuranic
WAC	waste acceptance criteria
WBS	work breakdown structure
WHPP	Waste Handling and Packaging Plant
WIPP	Waste Isolation Pilot Plant

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ABSTRACT

The strategy for management of the Oak Ridge National Laboratory's (ORNL) radioactively contaminated liquid waste was reviewed in 1991. The latest information available through the end of 1990 on waste characterization, regulations, U.S. Department of Energy (DOE) budget guidance, and research and development programs was evaluated to determine how the strategy should be revised. Few changes are needed to update the strategy to reflect new waste characterization, research, and regulatory information. However, recent budget guidance from DOE indicates that minimum funding will not be sufficient to accomplish original objectives to upgrade the liquid low-level waste (LLLW) system to comply with the Federal Facilities Agreement, provide long-term LLLW treatment capability, and minimize environmental, safety, and health risks. Options are presented that might allow the ORNL LLLW system to continue operations temporarily, but they would significantly reduce its capabilities to handle emergency situations, provide treatment for new waste streams, and accommodate waste from the Environmental Restoration Program and from decontamination and decommissioning of surplus facilities. These options are also likely to increase worker radiation exposure, risk of environmental insult, and generation of solid waste for on-site and off-site disposal/storage beyond existing facility capacities. The strategy will be fully developed after receipt of additional guidance. The proposed budget limitations are too severe to allow ORNL to meet regulatory requirements or continue operations long term.

1. INTRODUCTION

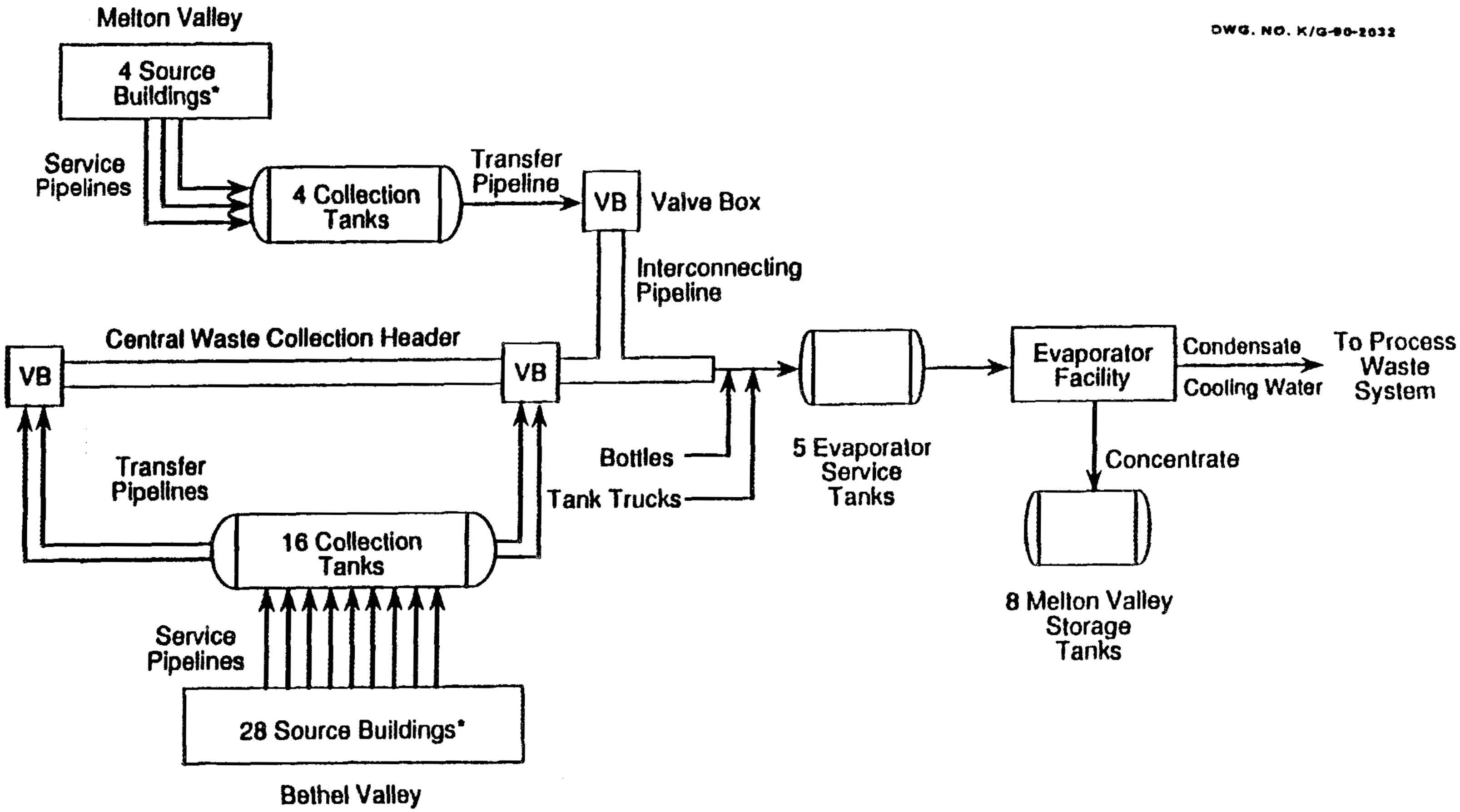
The Office of Waste Management and Remedial Actions operates the liquid low-level waste (LLLW) system that collects high concentrations of radioactive wastewaters produced by Oak Ridge National Laboratory (ORNL) reactor operations, research and development (R&D) operations, Environmental Restoration (ER) activities, and Waste Operations activities. The ongoing effort to develop and implement improved liquid-processing systems has the following objectives: (1) to provide facilities to treat all present and future wastewaters generated at ORNL, (2) to meet applicable regulatory requirements, and (3) to improve effluent quality while reducing the amount of secondary waste generated. All LLLW is presently being concentrated and stored, requiring the building of processing facilities to treat these wastes for disposal. In addition, the Federal Facilities Agreement (FFA) requires upgrading of the LLLW system to meet secondary containment and leak-detection standards for storage tanks. This report updates the strategy for implementing these activities at ORNL. The purpose of this report is to review the LLLW management strategy and update it to reflect evaluations of waste characterization/generation data; changes in regulations, including FFA requirements; advances in the R&D program to treat LLLW; and recent budget guidance from the Department of Energy (DOE). Information available in 1990 for each of these areas is discussed, and suggested changes in the strategy for management of LLLW are given.

2. BACKGROUND

Liquid radioactive waste has been generated at ORNL since the inception of Laboratory operations in the 1940s. This waste has been collected in tanks, neutralized with sodium hydroxide, concentrated by evaporation, and stored for future processing and disposal. Upon cooling, the liquid low-level waste concentrate (LLLWC) separates into sludge and supernatant phases. Until 1984, the LLLW was then stirred into a homogeneous mixture, mixed with grout, and disposed of underground at a hydrofracture facility. A diagram of the liquid waste system is shown in Fig. 1.

Since the discontinuation of hydrofracturing in 1984, LLLWC has been accumulated in the LLLW evaporator service tanks and in the Melton Valley Storage Tanks (MVSTs), which have a limited storage capacity. In 1987, a planning team was established to determine a strategy for the disposal of LLLWC that has been stored since the shutdown of the hydrofracture disposal facility. The recommended action plan[1] contained near-, intermediate-, and long-term treatment plans.

The near-term management plan for treatment of LLLWC consisted of three phases: (1) reduce waste generation by identifying and evaluating LLLW sources and treatment systems, (2) remove excess water from the stored waste by evaporation, and (3) solidify MVST supernatant in a concrete matrix to provide space in the MVST until LLLW treatment facilities can be built. Improvements in waste management operations and reductions at the source have reduced the LLLWC generation rate from about 34,000 gal/year to about 13,000 gal/year over the last 6 years. In-tank evaporation (ITE) has been initiated and is expected to initially reduce the MVST volume by 1400 gal/year per tank.[2] The efficiency will decrease as the supernatant becomes more concentrated. Improved evaporation methods (with heating inside or outside of the tanks) are also being considered to increase the rate at which the supernatant inventory can be reduced. A solidification campaign in 1988 removed and



*Generator tanks located at buildings.

Fig. 1. Existing LLLW collection, transfer, and treatment system.

solidified 48,000 gal of supernatant from the MVST,[3] and similar campaigns were planned for FY 1992 and 1993.

The intermediate-term management plan for LLLWC was the processing of transuranic (TRU) waste sludge and the associated supernatant for disposal at the Waste Isolation Pilot Plant (WIPP). The Waste Handling and Packaging Plant[4] (WHPP), proposed as an FY 1994 line item project for ORNL, will remotely process accumulated LLLWC to produce a homogenous salt cake for shipment to WIPP. The proposed WHPP process will mobilize supernatant and sludge from the MVST, evaporate the excess water from the resultant slurry using a thin-film evaporator, and melt the sodium nitrate salt using a microwave system. Upon cooling, the mixture will form a solid monolith that will meet the proposed WIPP waste acceptance criteria (WAC). The long-term management plan recommended the development of a treatment flowsheet that would produce a solid waste form for on-site disposal of newly generated LLLWC after the WIPP closes.

The LLLW strategy was reviewed, and changes were made in February 1990 based on new waste treatment information.[5,6] Development studies have been performed since 1987 to define flowsheets for treatment of LLLWC for disposal. Results from scoping studies indicated that hexacyanoferrate ion exchangers and sodium titanate could result in decontamination factors of 10^4 for cesium and 10^3 for strontium.[7,8] Studies showed that this could easily be accomplished in the WHPP facility with minimal changes to the existing flowsheet.

The recommended changes in 1990 were to incorporate additional treatment options in the WHPP facility to increase the flexibility of the plant and to extend the life of the facility to allow processing of waste for on-site disposal after WIPP closes. Supernatant treatment capabilities have been added to the conceptual design report for the WHPP. The capability to add a binder to the solidification system is also being included in the design to enable production of a nonsoluble (potentially leach-resistant) waste form should the WIPP WAC change and/or to produce waste forms acceptable for on-site disposal.

3. WASTE CHARACTERIZATION AND STORAGE CAPACITY

Waste characterization studies for management of LLLW have been focused on two areas: (1) characterization of the concentrated waste that has been stored since 1984 and (2) projections of the volume and composition of waste to be generated in the future at ORNL.

The waste in eight MVSTs and two LLLW evaporator service tanks located in Bethel Valley was sampled in early 1990. Typical compositions[9] of the supernatant and sludge phases are given in Tables 1 and 2. The supernatant is approximately 4–5 *M* sodium nitrate contaminated with soluble radionuclides, primarily ^{137}Cs and ^{90}Sr with trace quantities of ^{60}Co and ^{134}Cs. The supernatant contains essentially no TRU materials. Approximately two of four had pH >12.5 and were corrosive. A total of seven out of ten tanks contained supernatants that were mixed wastes under the Resource Conservation and Recovery Act (RCRA) definition of the Toxicity Characteristic Leaching Procedure (TCLP). Supernatants containing RCRA materials are considered mixed wastes. The sludges consist of precipitated carbonates and hydroxides, primarily calcium carbonate and magnesium hydroxide. Since radioactive actinides, such as TRU elements, and most metals are insoluble in alkaline solutions, these constituents are mostly found in the sludge phase. Analytical results show that the sludges contain between 3310 and 76,200 Bq/g of TRU material. RCRA materials have been detected in all the sludges; however, TCLP tests have not been performed to determine if the leachates exceed the RCRA limits and are thus mixed wastes. Waste classification is important because

Table 1. Typical composition of LLLWC supernatant

Chemical	Concentration (mg/L)	Radionuclide	Concentration (Bq/L)
Na	92,300	Gross beta	6.5×10^8
K	19,000	^{137}Cs	5.3×10^8
Ca	1,800	^{90}Sr	5.4×10^7
Mg	300	^{134}Cs	5.5×10^6
Sr	20	^{60}Co	3.6×10^6
Al	15	Gross alpha	1.4×10^5
Ba	3		
Cr	3		
Pb	3		
NO_3	280,000		
CO_3	3,600		
Cl	3,100		

Source: M. B. Sears et al., *Sampling and Analysis of Radioactive Liquid Wastes and Sludges in the Melton Valley and Evaporator Facility Storage Tanks at ORNL*, ORNL/TM-11652, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1990.

Table 2. Typical composition of LLLWC sludge

Chemical	Concentration (mg/L)	Radionuclide	Concentration (Bq/L)
Na	66,000	Gross beta	4.0×10^6
Ca	38,000	^{90}Sr	2.0×10^6
K	9,000	^{137}Cr	2.0×10^5
Mg	6,000	^{152}Eu	8.0×10^4
U	5,000	Gross alpha	5.0×10^4
Th	4,000	^{154}Eu	5.0×10^4
Al	3,000	^{60}Co	4.0×10^4
Fe	1,000	^{155}Eu	1.0×10^4
Sr	150	^{134}Cs	7.0×10^2
Ba	60	^{14}C	2.0×10^2
Cd	10		
Cr	60		
Hg	40		
Ni	30		
Pb	220		

Source: M. B. Sears et al., *Sampling and Analysis of Radioactive Liquid Wastes and Sludges in the Melton Valley and Evaporator Facility Storage Tanks at ORNL*, ORNL/TM-11652, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1990.

it determines the type of facility in which the waste can be processed and ultimately how and where the waste can be disposed of.

An extensive review of the ORNL liquid waste system has been performed to determine the impact that newly generated waste streams have on the volume and composition of LLLWC. The study evaluated 1986–90 data on the LLLW collection tanks, LLLW evaporator, LLLW concentrate tanks, and rainfall. In addition, LLLW generator information for 1989 and 1990 was considered. The results of these studies have been reported in ORNL/TM-11227[10] and ORNL/TM-11250,[11] are summarized in Tables 3 through 6, and are discussed below.

The systems analysis data indicate that the major generators of LLLWC (in descending order based on volume) were the Radiochemical Engineering Development Center (REDC), the Process Waste Treatment Plant (PWTP), the High Flux Isotope Reactor (HFIR), Building 3525, and the Oak Ridge Research and Bulk Shielding reactors (ORR/BSR). Over 99% of the

Table 3. Generation rates of dilute LLLW for 1989 and 1990

Tank or source building	1989 average generation rate (gal/month)	1990 average generation rate (gal/month)	Estimated percentage of waste collected from nongenerator sources[a]
W-1A	4,067	3,884	100[b]
3039 stack	3,698	3,818	0
High Flux Isotope Reactor	3,086	6,169	0
3026	3,142	2,663	95[b]
Oak Ridge Research and Bulk Shielding reactors	2,390	2,433	55[b]
3525	1,899	1,725	0
WC-8	1,366	1,189	100[b]
3517	1,324	979	40[b]
Isotopes Circle	1,104	610	40
Radiochemical Engineering Development Center	992	1,066	0
4500 area	1,278	756	90[b]
3544 feed	521	311	0
Hot Off-Gas Pot	382	881	100[b]
WC-5 & WC-6	283	344	100[b]
3504	117	38	0
2026	81	113	0
3019	76	95	0
3025	26	1	0
Other	292	109	0
Total	26,124	26,888	720

[a]Values based on differences between generator estimates and tank measurements.
[b]Tank systems collect waste from vault sumps, filter pit sumps, building floor drains, and other sources.

Table 4. Calculated generation rates of LLLWC

Tank or source building	1989 LLLWC generation rate (gal/year)	1990 LLLWC generation rate (gal/year)	1989 percent contribution	1990 percent contribution
Radiochemical Engineering Development Center	4,700	4,700	30	38
Process Waste Treatment Plant (PWTP) feed	2,250	900		
PWTP concentrate	3,700	3,800	46	38
3517	850[a]	100[b]	6	<1
3525	650	750	5	6
Oak Ridge Research and Bulk Shielding reactors	550	500	4	4
High Flux Isotope Reactor	250[b]	1,200[a]	2	10
Isotopes Circle WC-10	150	50	1	<1
Other	700	500	6	4
Total	13,800[c]	12,500[d]		

[a]Estimate based on information obtained during operation.

[b]Estimate based on information obtained during shutdown.

[c]Actual concentrate generation during 1989 was 13,400 gal (including some concentrate generated early in 1990).

[d]Actual concentrate generation through October 1990 is 12,600 gal.

radionuclides entering the LLLW system were generated at Building 3517 (the Fission Product Development Laboratory, which ceased operations in 1989) and at the REDC. The only other generators to produce more than 5 Ci/year were the Isotopes Area facilities (most operations ceased in early 1990), Building 3525, and the HFIR. The majority of the TRU isotopes were generated at the REDC. The majority of the ^{90}Sr and ^{137}Cs was generated at Building 3517, and the HFIR generated most of the ^{60}Co. The primary contributors of dissolved solids to the LLLW were REDC, PWTP, and Building 3517. These results are particularly important because the dissolved solids content and amount of dilute LLLW fed to the evaporator during a given run are the primary factors that determine the efficiency of the LLLW evaporator.

In the future, the REDC production rate will increase significantly when Mark-42 targets from Savannah River are being processed and will continue to be high when the Advanced Neutron Source (ANS) comes on-line. The REDC will continue to be a primary source of newly generated radionuclides, TRU isotopes, and dissolved solids through the end of the century. Waste generation rates from other presently operating facilities are expected to remain fairly constant, except for the isotopes facilities. Most of the Isotopes Area facilities and Building 3517 have been shut down, so they will not produce significant amounts of waste in the future except from decontamination activities. Except for REDC wastes, essentially all newly generated waste will be non-TRU.

Remediation of inactive tanks and decontamination of surplus facilities will generate large volumes of LLLW in the future. Although the schedules and treatment methods for these programs have not been finalized, waste generation estimates for the next 10 years are summarized below. The ER Program will remediate the inactive LLLW tanks, containing >200,000 gal of supernatant and <50,000 gal of sludge, before 2003. The supernatants in these

Table 5. Radionuclide contributors to the LLLW system[a]

Radionuclide	Generation rate (Ci/year)	Building	Percent contribution
^{60}Co	<10	High Flux Isotope Reactor	99
		3001	1
		4501	<0.1
		Other	Trace
^{90}Sr	20,000	3517	99
		3030	<0.1
		Other	Trace
^{137}Cs	15,060	3517	99
		3525	<1
		4501	<0.1
		3001	<0.1
		2026	<0.1
		Other	Trace
Mixed U	2	3019	99
		Other	<1
^{252}Cf	2	Radiochemical Engineering Development Center	100
Mixed fission products[b]	42,000	Radiochemical Engineering Development Center	99
		3525	<0.1
		Other	Trace

Other radioisotopes reported to be disposed of via the LLLW system (in trace quantities)

^{3}H	^{64}Cu, ^{67}Cu
^{99}Tc	^{106}Ru
^{110m}Ag	^{123}I, ^{125}I, ^{131}I
^{134}Cs	^{152}Eu, ^{154}Eu, ^{155}Eu
^{188}W	^{195}Pt
^{198}Au, ^{199}Au	^{232}Th
^{244}Cm, ^{246}Cm	Mixed Pu

[a]Estimated from 1989 data.
[b]Predicted to be disposed of by REDC during future Mark-42 processing.

tanks are LLW, while the sludges in one-third of the inactive tanks are TRU wastes. The amount of this waste that will be processed in the active LLLW system has yet to be determined. However, facilities should be designed with the flexibility to treat these wastes. Major decontamination efforts for the decommissioning of surplus facilities are expected to begin after the year 2000 and will produce mostly non-TRU wastes. Presently, 480,000 gal of concentrate[12] is stored in the MVSTs and LLLW evaporator service tanks. The maximum allowable inventory based on the operational safety requirement (OSR) for these tanks is 520,000 gal, while the operational flexibility range needed for efficient plant operations is

Table 6. Major contributions of solids to the LLLW system[a]

Generator	Generation rate (kg/year)	Percent contribution
Radiochemical Engineering Development Center	13,000	52
Process Waste Treatment Plant	6,200	25
3517	2,500	6
High Flux Isotope Reactor	1,500	2
3525	600	2
Isotopes Circle	500	2
2531	300	1
Bulk Shielding Reactor and Oak Ridge Research reactors	200	1
3026C	200	1

[a]Based on 1989 data.

420,000 to 470,000 gal. The projected inventory of waste requiring storage is shown in Figs. 2 through 4.

Note that all projections are based on the assumption that all existing storage tanks (C-1, C-2, W-21, W-23, and the MVSTs) will be available for long-term storage of LLLWC. However, the tanks, particularly C-1 and C-2, are vulnerable to shutdown as a result of the FFA. Loss of any storage tank would automatically shut the LLLW system down; therefore, any upgrades required by the regulators to keep the tanks operational must be implemented.

Figure 2 shows the inventory in the tanks based on the future generation estimates described above (assuming all the waste from the inactive LLLW tanks is transferred to the active LLLW system). It also shows the effect of the presently funded supernatant treatment projects, which will increase the storage space in the tanks: (1) two 50,000-gal supernatant solidification projects and (2) ITE of six tanks (without heating). Results from the ITE project indicate that the compressor will need to be replaced for long-term operation. Even with this treatment, the data in Fig. 2 indicate that the inventory level will be above the OSR level by 1997. Additional supernatant treatment or source treatment/waste minimization projects will be needed to prevent overfilling the tanks or program shutdown.

The major generators of LLLW are being considered for waste minimization projects or treatment at the source to reduce LLLWC production. Generators producing wastes high in dissolved solids in proportion to their relatively small amounts of radioactivity (PWTP, HFIR, and ORR/BSR) are being considered for source treatment (i.e., conversion to solid waste). Waste streams with components that are difficult to treat in the centralized facilities (potassium, cobalt, and TRU waste) are also being considered for treatment at the source (HFIR and REDC).

Upgrades are planned for the PWTP to drastically decrease its LLLW contribution in 1992 and eliminate completely its contributions after 1997. The ORR/BSR is eliminating LLLW production by converting from regeneration of ion-exchange columns to disposal of loaded ion-exchange resins as a solid waste in 1994. HFIR is proposing to do the same with ion-exchange columns; however, the solid waste disposal facilities cannot presently accommodate the resulting waste. Research is being performed at REDC to eliminate potassium, to significantly reduce the total dissolved solids, and to remove TRU materials at

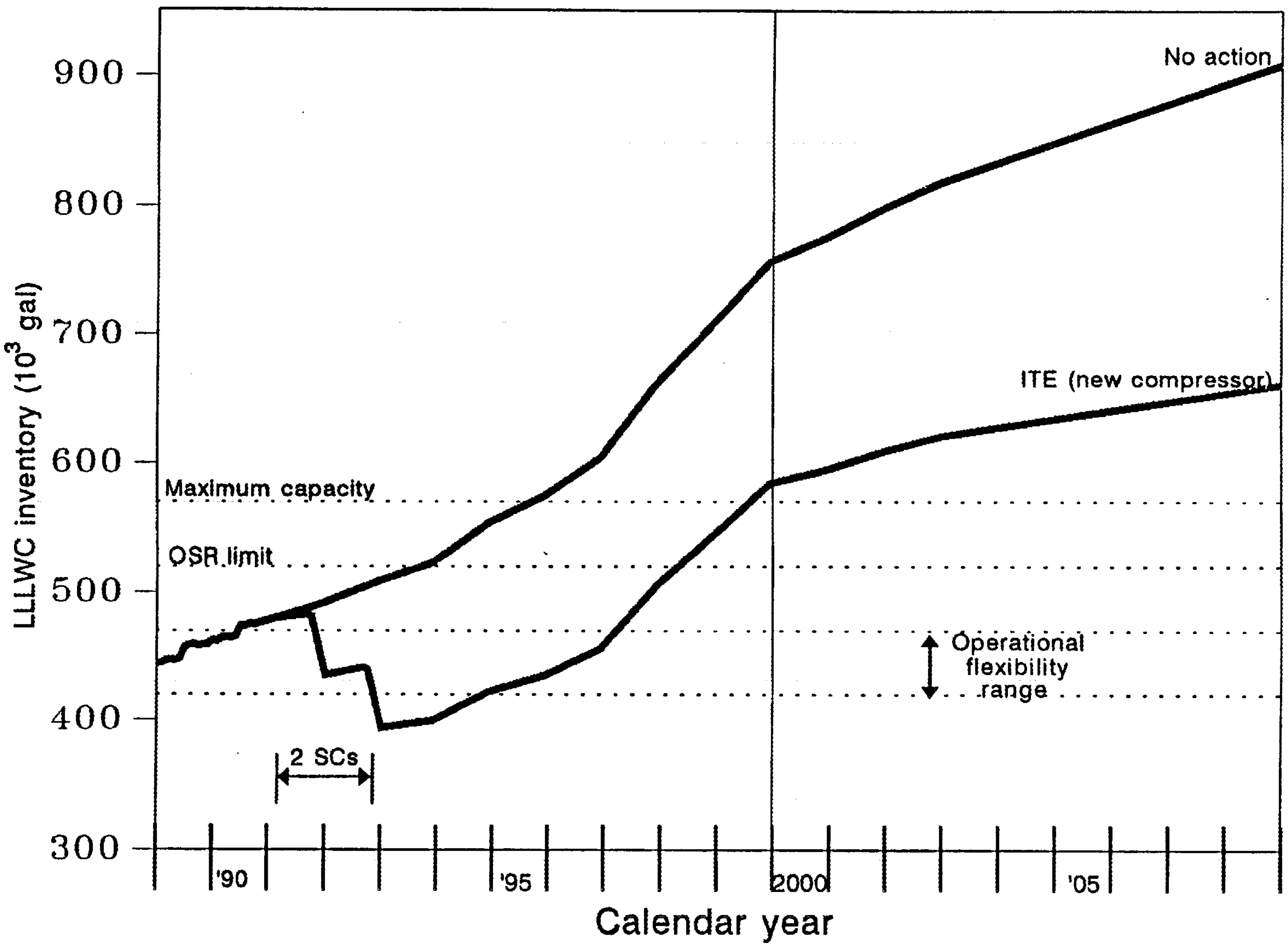


Fig. 2. LLLWC profile assuming no source treatment.

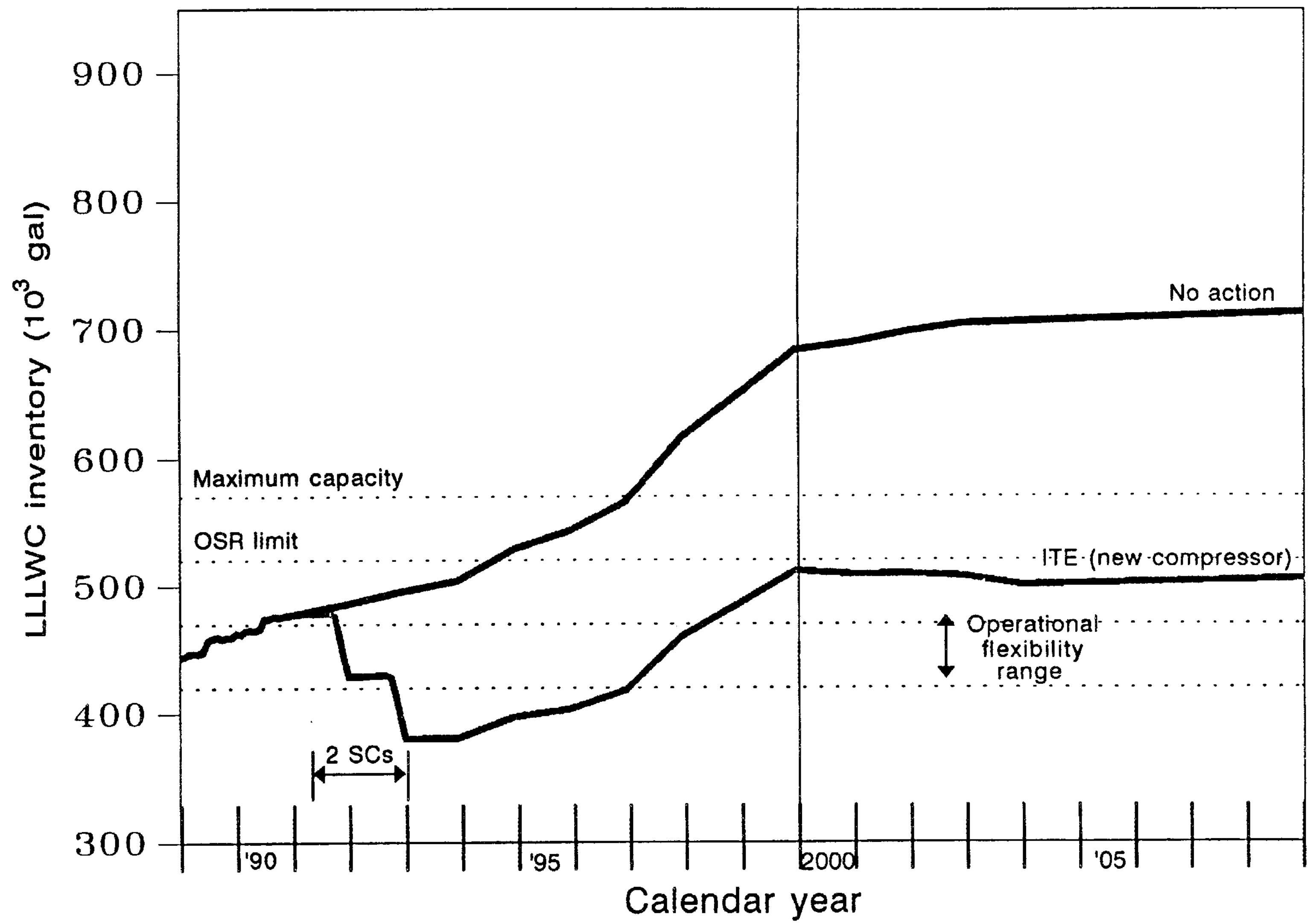


Fig. 3. LLLWC profile assuming source treatment for REDC, HFIR, PWTP, and ORR/BSR wastes.

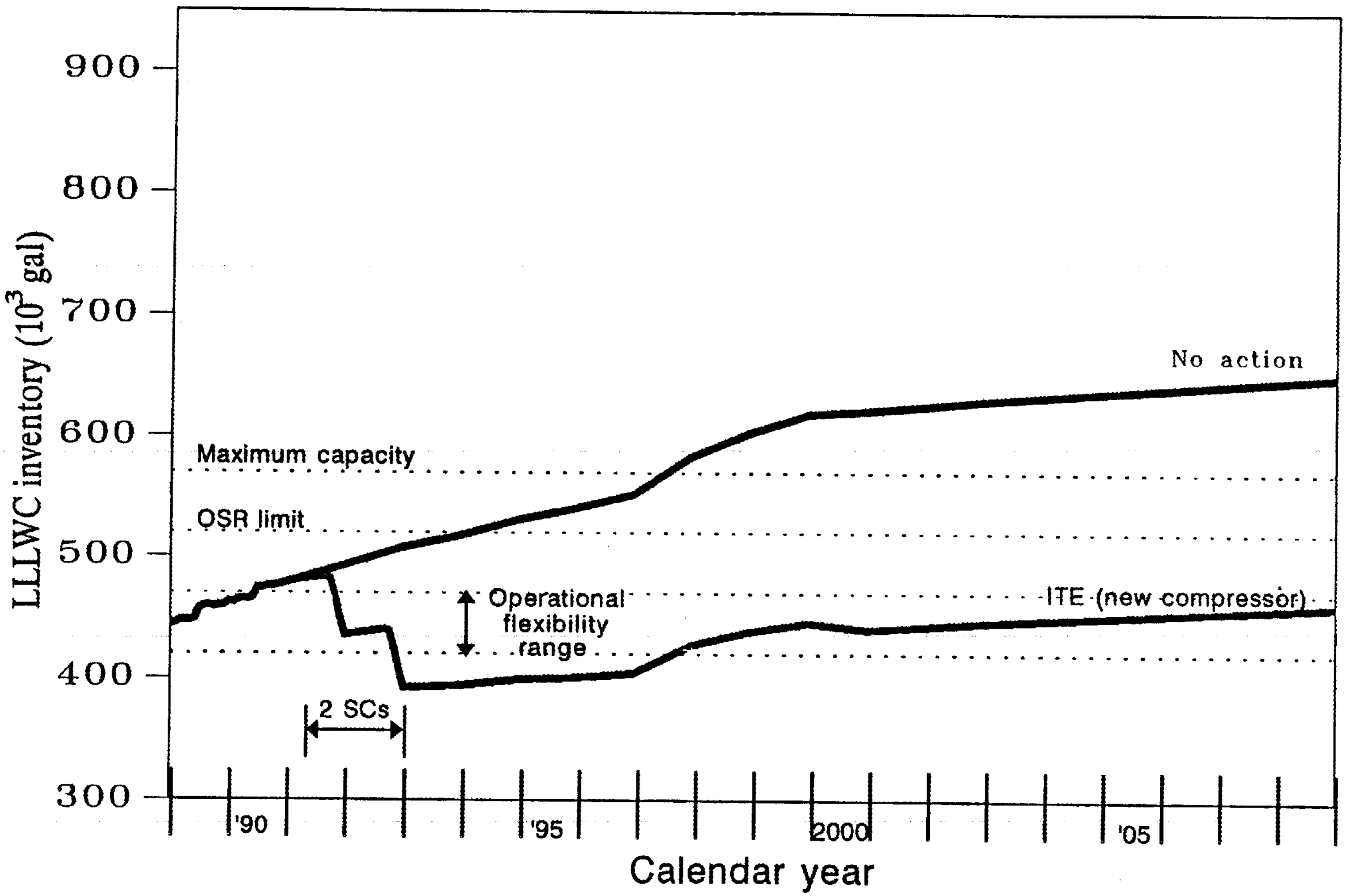


Fig. 4. LLLWC profile assuming source treatment for PWTP, ORR/BSR, and inactive tank wastes.

the source. An optimistic assumption is that HFIR can totally eliminate its LLLW production and REDC can reduce its LLLWC generation by 65% by 1995, assuming that solid waste disposal facilities will be available to accept the solid waste generated from these activities.

The projects that have been proposed for implementing these upgrades are consistent with the upgrades planned for the LLLW system to meet the FFA and are addressed in more detail in Sect. 7 of this report. Removal of these waste streams from the LLLW system will eliminate TRU materials, most of the nonradioactive dissolved solids, and much of the high-activity radionuclides. The remaining waste will be much easier to process in a centralized system for on-site disposal. A best-case scenario of the effects of these projects on LLLWC inventory is shown in Fig. 3. Even though the projects will significantly reduce long-term generation rates, the operational flexibility range will still be exceeded by 1998. The LLLW system will be shut down at that time unless additional supernatant treatment processes are implemented or large-volume generators are not allowed to use the LLLW system.

Figure 4 shows LLLWC inventory levels if the wastes from the inactive LLLW tanks are not transferred to the active LLLW system. Figure 4 indicates that ITE and two solidification campaigns will be enough to keep the inventory within the operational flexibility range through 2007 as long as no inactive tank wastes are introduced into the system and source treatment at the PWTP and ORR/BSR (presently approved projects) is implemented. This scenario should be considered only as a last resort because it would impose potentially unacceptable problems for the ER Program.

4. REGULATORY AND OPERATIONAL CONCERNS

Several regulatory and operational concerns must be considered in the development of the LLLW management strategy. The most significant of these are the FFA, RCRA regulations, and WAC for solid waste disposal facilities.

The FFA for the Oak Ridge Reservation establishes new requirements for tank systems at ORNL. It will require major upgrades to the active LLLW system and will drive the closure schedules for many active and inactive LLLW tanks. This agreement states that all LLLW tanks and associated piping must be doubly contained and must meet leak-detection requirements or be scheduled for upgrade/replacement with components that meet these requirements. Singly contained systems must also pass leak tests and integrity assessments in order to remain in operation temporarily until replaced. Doubly contained systems that do not meet all of the new requirements must be upgraded to meet these requirements. All singly contained systems that are known to leak (either inleakage or outleakage) must be either repaired or permanently removed from service immediately.

The status of the ORNL LLLW tanks with respect to the FFA is shown in Table 7. Thirty-nine LLLW tanks are inactive and are "owned" by the ER Program. The remaining 59 tanks are "owned" by Waste Management Operations or by the LLLW-generating research divisions at ORNL. Eighteen of these tanks (W-1I, 4501-C, 4501-D, 3002A, T-14, S-424, WC-4, 4501-P, W-12, W-17, W-18, WC-5, WC-6, WC-8, WC-11, WC-12, WC-13, and WC-14) will be removed from service prior to the FFA signing because they are no longer being used or they are known or are suspected to leak. Tanks W-16 and WC-2 will be used for near-term decontamination activities (1991–94) and will then be removed from service. Tanks W-21 through W-31 and T-13 are expected to meet secondary containment standards without upgrades. The remaining 27 tank systems (C-1, C-2, N-71, P-3, P-4, S-223, S-324, S-523, L-11, B-2-T, B-3-T, C-6-T, F-111, F-126, WC-20, 2026A, WC-3, LA-104, WC-9,

Table 7. FFA requirements for ORNL's LLLW tank systems

Existing tank systems with secondary containment				Existing tank systems without secondary containment requiring replacements		Existing tank systems without secondary containment that are removed from service		
Not requiring upgrades or replacements		Requiring upgrades or replacements				Waste Management inactive tanks		Environmental Restoration inactive tanks
Tank ID	Facility served	Tank ID	Facility served	Tank ID	Facility served	Tank ID	Facility served	Tank ID
W-21	LLLW evap.	C-1	LLLW evap.	2026A	2026	3002A	3002	3001-B
W-22	LLLW evap.	C-2	LLLW evap.	WC-3	3025	WC-4	3026D	3001-S
W-23	LLLW evap.	N-71[b]	3019	LA-104[b]	3047	W-11	3028	3003-A
W-24	LLLW evap.	P-3[b]	3019	WC-9	HOG Pot	WC-5	3508	3004-B
W-25	LLLW evap.	P-4[b]	3019	WC-7	2533, 3504	WC-6	3508	3013
W-26	LLLW evap.	S-223[b]	3517	F-201[b]	3525	WC-8	—	WC-1
W-27	LLLW evap.	S-324[b]	3517	F-501[b]	3525	S-424[b]	3517	TH-4
W-28	LLLW evap.	S-523[b]	3517	HFIR	HFIR	WC-11[a]	4500	TH-1
W-29	LLLW evap.	L-11	PWTP	T-1[c]	HFIR	WC-12[a]	4500	TH-2
W-30	LLLW evap.	B-2-T[b]	REDC	T-2[c]	HFIR	WC-13[a]	4500	TH-3
W-31	LLLW evap.	B-3-T[b]	REDC	WC-10[c,d]	Isotopes Circle	WC-14[a]	4500	H-209
T-13	NHF	C-6-T[b]	REDC	WC-2[d]	Isotopes Circle	4501-C[b]	4501	W-19
		F-111[b]	REDC	WC-19[c]	ORR, BSR	4501-D[b]	4501	W-20
		F-126[b]	REDC	W-16[d]	3026D, OGR	4501-P[b]	4501	WC-15
		WC-20	REDC			T-14	—	WC-17
								T-30
								7560
								7562
								7503-A
								W-1
								W-13
								W-15
								W-1A
								W-2
								W-3
								W-4
								T1
								T2
								T3
								T4
								T9
								W-10
								W-11
								W-5
								W-6
								W-7
								W-8
								W-9
Total no. tanks								
12		15		14		18		39

LLLW = liquid low-level waste; NHF = New Hydrofracture Facility; PWTP = Process Waste Treatment Plant; REDC = Radiochemical Engineering Development Center; HFIR = High Flux Isotope Reactor; HOG = hot off-gas; ORR = Oak Ridge Research Reactor; BSR = Bulk Shielding Reactor; OGR = Old Graphite Reactor.

[a]Tanks will be used until the FFA becomes effective.

[b]Generator-owned tanks.

[c]Tank systems to be used for collection of wastes for environmental, safety, and health reasons only.

[d]Tank systems will be used for decontamination activities in 1991–94 and removed from service.

WC-7, F-201, F-501, HFIR, T-1, T-2, WC-10, WC-19) must be upgraded or replaced to remain in service. Note that C-1 and C-2 may meet the requirements for double containment, depending upon the interpretation of the FFA language. This is presently being evaluated.

The upgrade/replacement plans for the active LLLW system include (1) local collection and transport of waste to the central LLLW system, (2) upgrade or replacement of systems (partial upgrades are also required in some cases to keep the systems in interim service), (3) source treatment, (4) waste reduction at the source, and (5) process relocation. The methods proposed to implement these plans are listed in Tables 8 through 10. Areas selected for source treatment were determined based on the waste characterization/generation analyses discussed in the previous section. Bottling and process relocation will be implemented where feasible. All other facilities (most of which have hot cell activities) are being considered for upgrade or replacement of the Collection and Transfer (CAT) System to avoid program shutdown.

Section 3004(j) of 40 CFR Part 268 prohibits storage of land disposal restriction (LDR) hazardous RCRA waste except "solely for the purpose of accumulation of such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal." DOE is developing documentation to support a request for the U.S. Environmental Protection Agency (EPA) to grant a variance from this prohibition for wastes such as those in the MVSTs through 1994. A treatment system for newly generated waste and any waste transferred from inactive tanks containing RCRA-regulated materials must be operational in 1994 to gain

Table 8. Expense-funded projects identified for FFA implementation[a]

Funding year	Title	Current scope	Building/facilities affected
1990–91	Temporary Bottling Stations	Installs bottling stations for tanks removed from service in 1991. 1992 GPPs will upgrade stations as necessary for permanent use	4500 area
1990–91	3525 Trucking Station	Installs a temporary trucking station for Tank F-501 to allow removal of tank W-12 from service in 1991. Station will be removed from service by 1992 GPP #3.28	3525
1991	3047 Trucking Station	Installs a temporary trucking station for Building 3047. Station will be upgraded as necessary for long-term use by 1992 GPP #3.03	Isotopes Circle
1991–92	Relocation Activities	Relocates activities in buildings utilizing tanks W-17 and W-18, which are removed from service in 1991	Isotopes Circle
1990–92	HFIR Source Treatment	Installs source treatment to reduce volume and radioactivity of LLLW	HFIR
1990–94	REDC Source Treatment	Installs source treatment to reduce volume and radioactivity of LLLW	REDC
1990	4501 Source Treatment	Installs source treatment to reduce radioactivity of LLLW	

HFIR = High Flux Isotope Reactor; REDC = Radiochemical Engineering Development Center; GPP = general plant project; LLLW = liquid low-level waste.

[a]Based on requirements-level funding.

Table 9. GPPs identified for FFA implementation[a]

Funding year	ID (WBS)	Title	Current scope	Building/facilities affected
1992	3.79	ORR/BSR LLW Upgrade	Provides source treatment to convert LLLW to solid and process waste	ORR/BSR
1992	3.78	3544 Column Room Upgrade	Upgrades secondary containment for Tank L-11	3544
1992	3.01	HFIR LLW System Upgrade	Provides source treatment to convert LLLW from laboratory facilities to solid and process waste	HFIR
1992	3.02	3000 Area LLW Upgrade	Provides bottling stations for low-volume generators	3504
1992	3.96	4500 Area LLW Upgrade	Provides bottling stations for low-volume generators	4500 complex
1992	3.03	Building 3047 Trucking Station	Provides trucking station for 3047 generators	Isotopes Circle
1992	3.28	FFA Compliance Work I	Doubly contains noninspectable piping for 3019. Installs doubly contained piping to bypass leaking LLLW tank at 3525	3525 3019
1993	3.85	FFA Compliance Work II	Provides bottling/trucking stations for 3025	3025
1993	3.35	LLLW Treatment Alternative	Provides source treatment to convert LLLW from HFIR reactor to solid and process waste	HFIR
1993	3.16	Piping Additions for FFA	Pipes 4500 area floor sumps to process waste system	4500 complex
1993	2.29	Filter Pit Upgrade	Encloses filter pit at REDC	REDC
1993	2.30	3108 Filter Pit Enclosure	Encloses filter pit 3108, which services Building 3019	3019
1994	—	3 GPPs to be defined	Eliminate nonprogrammatic waste generation or upgrade appropriate collection/transport system for secondary containment	—
1995	—	3 GPPs to be defined	Eliminate nonprogrammatic waste generation or upgrade appropriate collection/transport system for secondary containment	—
1996	—	3 GPPs to be defined	Eliminate nonprogrammatic waste generation or upgrade appropriate collection/transport system for secondary containment	—

WBS = work breakdown structure; ORR/BSR = Oak Ridge Research/Bulk Shielding reactors; LLLW = liquid low-level waste; HFIR = High Flux Isotope Reactor; REDC = Radiochemical Engineering Development Center.

[a]Based on requirements-level funding.

Table 10. Line item projects identified for FFA implementation[a]

Funding year	ID (WBS)	Title	Current scope	Building/facilities affected
1988	3.37	Bethel Valley CAT System Upgrade	Replaces Bldg. 2026 tank system and hot off-gas scrubber LLLW piping. Provides upgraded tanker truck and bottle unloading stations	2026 Hot Off-Gas Scrubber
1992	3.45	Melton Valley CAT System Upgrade	Replaces or upgrades tank systems for REDC and HFIR	REDC HFIR
1992	1.1.4.1	Landfill Leachate Waste Decontamination Facility	Provides source treatment to convert LLLW generated at Bldg. 3544 to solid waste. Increases feed capacity of Bldg. 3544 to accommodate new waste streams from LLLW system	3544
1994	3.31	Bethel Valley FFA Upgrades	Replaces WC-9 tank system and tank systems for Bldgs. 3517, 3025, and 3525. Doubly contains LLLW piping for 2533	3025 3517 3525 Hot Off-Gas Scrubber 2533 Transfer Lines
1994	4.13	Waste Handling and Packaging Plant	Provides treatment capabilities for concentrated LLLW wastes. Tanks C-1 and C-2 will be emptied and removed from service when treatment system becomes operational	C-1 and C-2 of Evaporator Complex
1995	3.04	FFA LLW System Upgrade	Replaces tank system WC-10 of the Isotopes Circle and tank system WC-14 for Bldg. 4501	Isotopes Circle 4501

WBS = work breakdown structure; CAT = Collection and Transfer; LLLW = liquid low-level waste; REDC = Radiochemical Engineering Development Center; HFIR = High Flux Isotope Reactor; FFA = Federal Facilities Agreement.

[a]Based on requirements-level funding.

compliance. A RCRA permit-by-rule (PBR) exempts the LLLW system (including the supernatant solidification campaigns) from other RCRA requirements. However, the PBR could be eliminated in the future. The present waste management strategy does not include contingency measures for this possibility.

Another major area of uncertainty involves the storage and disposal of solid radioactive waste. Much work has been done to define the disposal requirements for wastes containing different levels of radioactivity, but meaningful estimates of radionuclide concentration limits cannot be made for disposal sites on the Oak Ridge Reservation until performance assessments required by DOE Order 5820.2A are completed for each individual disposal site. Similar situations exist for off-site disposal facilities such as WIPP. In addition to ongoing uncertainty with respect to the applicability of RCRA requirements to waste disposal at WIPP, the state of New Mexico is developing additional requirements that will be imposed.

There will be radioactive waste storage facilities on the Oak Ridge Reservation that have the capability to handle solid waste produced by treatment of ORNL LLLW. Since these facilities will have a limited amount of storage capacity, further work needs to be done to ensure that any solid waste produced for on-site storage/disposal as a result of new LLLW treatment schemes can be accommodated.

Note that the upgrade of the PWTP could also be affected by these performance assessments. The line item to build centralized solid waste disposal facilities for the Oak Ridge Reservation will replace the PWTP with increased treatment operations and feed capacity. This treatment facility will also allow treatment of some LLLW streams and the decontaminated LLLWC supernatant as well as eliminate production of LLLW at the PWTP. However, if the performance assessment required by DOE Order 5820.2A yields extremely low concentration limits, the proposed landfill will not likely be constructed, and the PWTP upgrade will not be funded.

5. DEVELOPMENTS IN WASTE TREATMENT PROCESSES

Studies have been performed since 1987 to define flowsheets for the liquid waste treatment portion of WHPP and for long-term treatment of wastes for on-site disposal. The sludge handling and treatment processes for the WHPP have been demonstrated at the bench scale using simulated waste. A pilot-scale facility has been built but has not been operated because of a lack of funding. Ion-exchange processes to remove cesium and strontium from LLLW supernatant (presently stored and newly generated) have been demonstrated at the laboratory scale.[7,8] The results indicated that hexacyanoferrate ion exchangers and sodium titanate could be used to treat existing waste, while several options are available to process the easier-to-treat newly generated waste.[8,13] More bench-scale and pilot-scale tests are needed to determine the effects of waste stream composition, ion-exchange material production variables (if hexacyanoferrate is used), and processing parameters before treatment options can be implemented for either newly generated or stored waste.

6. BUDGET LIMITATIONS

Previous LLLW strategies assumed receipt of minimum funding needed to (1) achieve responsive and reasonable compliance with FFA requirements; (2) optimize long-range treatment capability (including facility consolidation, assurance of needed processes/capacity, and minimization of secondary waste generation); and (3) minimize environmental, safety, and health (ES&H) risks associated with management of LLLW.

Initial DOE budget guidance for the period FY 1993 through 1997 prohibits the ability to accomplish any of these objectives. Initial guidance has been that funding to provide compliance with FFA requirements (including system upgrade and replacement, contingency implementation, and system assessment) will be approximately one-third of identified minimum requirements. Tables 8 through 10 outline the requirements-level activities needed for compliance with the FFA. Under the initial funding guidance, major new line item projects cannot be supported. The Bethel Valley FFA Upgrade and FFA LLW System Upgrade line items proposed to replace existing LLLW collection tank systems for the majority of the liquid waste generators in Bethel Valley cannot be funded before FY 1998. Funding for the WHPP line item is not available in this scenario until after 1998. The line item to replace the ORNL PWTP may also be delayed 2 to 3 years because of budget constraints. Reduced expense and general plant project funding will reduce efforts for source treatment, waste minimization process, relocation, and treatment of MVST supernatant to provide storage capacity until the delayed capital projects can be implemented and the strategy can be updated to reflect changes in budget guidance. These projects provide compliance with FFA requirements and optimize long-range treatment capability, as well as minimize ES&H risks.

ORNL has two line item projects approved: the Bethel Valley CAT System Upgrade (FY 1988 with a budget of $35M) and the Melton Valley CAT System Upgrade (FY 1992 with a budget of $41M). These two projects will replace the LLLW CAT systems for REDC, HFIR, and Buildings 3092 and 2026 and will build a tanker truck/bottle unloading station at the LLLW evaporator facility.

7. STRATEGY DEVELOPMENT

The WHPP has been the cornerstone of the LLLW waste management strategy. It is required to meet regulatory requirements to avoid shutdown of the LLLW system because of a lack of storage space. Recent budget guidance from DOE indicates that the WHPP line item may be delayed at least until the WIPP WAC have been finalized. Studies indicate that existing sludges in the MVSTs cannot be treated without a facility comparable to the WHPP and that a facility such as the WHPP is necessary to complete the long-term LLLW treatment strategy. The WHPP is also needed to treat TRU-waste sludges from inactive LLLW storage tanks and possibly to treat some wastes generated by decontamination and decommissioning (D&D) of surplus facilities. However, in the near term, most newly generated D&D wastes can be treated with less complex processes if they are properly segregated or pretreated. Therefore, it appears that ORNL has three options for dealing with LLLW long-term: (1) proceed with WHPP as an FY 1994 line item designed with the flexibility to produce any waste form required to meet WAC for the WIPP and on-site disposal facilities, (2) build a treatment facility as soon as possible to treat newly generated waste and construct the WHPP to treat legacy waste in the MVSTs after the WIPP WAC are finalized, and (3) build the portion of the WHPP that could be used to treat newly generated waste for on-site disposal as soon as possible and complete construction of WHPP after the WIPP performance assessment is complete. Facilities to treat LLLWC need to be operational by 1995 to meet the LDR treatment requirements for newly generated wastes (highly improbable), or a Federal Facilities Compliance Agreement needs to be negotiated to allow storage of LLLW until the treatment systems are in place.

Although additional work needs to be done to determine the costs for each of these options, it is likely that the first option would be the most economical. It is also likely that any of the three options will require more line item funding than is projected to be available through FY 1997. The priorities for development and engineering efforts will be different for each case, and expense funding is not available to pursue all options in parallel. Given the present budget limitations, near-term development efforts for option one would focus on design of the WHPP facility to treat the existing MVST waste for disposal as TRU waste at WIPP. Long-term development efforts would focus on source pretreatment/treatment and modifications to WHPP for on-site disposal of non-TRU waste. If option two were to be implemented, near-term development efforts would focus on source treatment and centralized treatment of remaining newly generated waste, and studies for treatment of waste to be processed for WIPP would be deferred. If option three were to be implemented, near-term development efforts would focus on centralized treatment of both the waste stored in the MVSTs and newly generated waste. If ORNL pursues one option and future funding dictates that another be implemented, the LLLW system would likely be shut down for a number of years until the development engineering work could be performed. Therefore, additional guidance or funding from DOE is required before these efforts can effectively proceed.

Regardless of the option used to install treatment facilities for LLLWC, source treatment/pretreatment should be considered for some newly generated waste streams: (1) source treatment should be implemented for streams with low concentrations of radioactivity and (2) pretreatment systems should be developed for streams containing components that cause problems with centralized treatment (see Sect. 3 for details). The remaining waste streams should be processed in the centralized treatment system through a facility designed to produce the optimum waste forms for WIPP or on-site disposal/storage. Supernatants in the MVSTs must be treated to provide storage space for the LLLWC generated until new treatment facilities can be installed. Supernatant is presently being treated by solidification in concrete (two additional 50,000-gal campaigns are planned) and by ITE at ambient temperature. Both will be required to avoid shutdown of the LLLW system (see Figs. 2–4). The air compressor at the MVSTs will need to be replaced for ITE to be continued long term.

Evaluations of future waste generation indicate that ITE, two solidification campaigns (or enhanced evaporation), and no acceptance of inactive tank waste for treatment in the LLLW system should be adequate to provide the storage capacity needed if new systems/facilities are operational in the early 2000s. However, note that this will severely limit the capabilities of the LLLW system to handle emergency situations. New programs will be limited as to the type and amount of wastes they can generate. In addition, limitations and potential regulatory problems will be imposed on the ER Program. Therefore, it is recommended that the economics of enhanced evaporation be investigated for supernatants in both the active and inactive LLLW tanks as an alternative to additional solidification campaigns.

Supernatant pretreatment prior to solidification is being considered to reduce the activity in the waste to produce a waste form acceptable for on-site disposal. Studies have been performed to determine if decontamination could be performed in situ (inside the MVSTs) or if treatment would have to be performed in a processing facility under more controlled conditions. These studies indicate that in situ pretreatment is not feasible.[13] Pretreatment in a processing facility appears possible, but significant development work will be required. Recent activities in the solid waste program indicate that the preliminary WAC may change significantly before these are finalized. Since the WAC for disposal facilities will not be finalized for some time, and in view of the constrained near-term budget, it is recommended that these pretreatment efforts be temporarily discontinued.

Recent budget guidance from DOE indicates that line item funding may not be available to upgrade the LLLW system to meet FFA requirements as described in Tables 8 through 10 until after FY 1998. This delay will probably not be acceptable to the regulatory authorities in the EPA and Tennessee Department of Conservation (TDC). If these funds cannot be obtained, all capital projects presently designated to upgrade/replace tank systems should be reevaluated to determine the potential for implementing less costly alternative waste treatment/transport mechanisms to avoid shutdown by the EPA and TDC.

Source reduction and treatment systems should be developed for HFIR, PWTP, and ORR/BSR to eliminate LLLW waste generation. Pretreatment should be installed at REDC to eliminate cobalt, TRU, and potassium from the central treatment system per the discussion in Sect. 3. The pretreated waste from REDC and waste from all remaining facilities with LLLW tank systems that are being upgraded or replaced by capital projects (Buildings 3525, 3517, 3047, 3025, 2026, 3092, and 3019) should be reevaluated to determine if the waste should be trucked or treated at the source or if new LLLW collection systems must be installed. Dilute "nongenerator" waste sources (i.e., groundwater inleakage and waste collected from filter pits, sumps, floor drains, and condensate from the hot off-gas system) should be evaluated to determine if they can be eliminated, trucked, or diverted to the process waste system or if new LLLW collection systems must be installed. The criteria that should be used to select the upgrade/replacement methods include economics, the type and amount of solid and process waste potentially generated during both construction and operation, and ES&H concerns. Although source treatment or trucking may be less costly than installation of new LLLW tank systems, such alternatives will likely increase worker radiation exposure significantly, as well as the potential for environmental insult from accidental spills occurring during waste transportation/transfers. An evaluation of this risk is currently being conducted.

8. SUMMARY

Until now, plans for LLLW management have been to either upgrade or replace the LLLW CAT System (for the most part by replacement of underground tanks/lines) to meet new FFA standards and to build the WHPP to treat existing LLLWC for disposal at WIPP and future LLLWC for on-site disposal/storage. This approach is considered to be the safest and most flexible way of handling LLLW. It also efficiently utilizes funding by increasing the treatment capabilities and life expectancy of the WHPP (which must be built to treat legacy TRU waste) for a small incremental cost. These LLLW management strategies have assumed that the minimum funding needed to implement these activities would be received from DOE. However, initial DOE budget guidance for the period from FY 1993 through FY 1997 indicates insufficient funds to accomplish these objectives.

The discrepancies between requirements-level funding and DOE's initial budget guidance break the LLLW strategy to the point that it no longer holds together. Forecasted expense and general plant project funds are insufficient to develop the contingencies necessary to keep the LLLW system operational. If ORNL continues assuming that requirements-level funding will be obtained, and instead the DOE-proposed level of funding is received in FY 1993–97, major ORNL facilities will be shut down for 3 to 10 years. This scenario would also stretch the replacement timing for the LLLW system to 2006 or later.

Because of the budget uncertainties, less costly alternatives for upgrading the LLLW system to avoid shutdown of programs under compliance with the FFA are being considered. These alternatives are likely to significantly increase worker radiation exposure and the potential for accidental spills from increased waste-handling activities.

New centralized treatment facilities must be built to treat existing and newly generated LLLW for WIPP and on-site disposal/storage. However, the number and type of facilities to be built depend on approval of line item projects by DOE. ORNL recommends that the WHPP facility be built as an FY 1994 line item to process LLLWC stored in the MVSTs for disposal at WIPP and for on-site disposal of waste generated in the future. However, if the WHPP (as proposed) is not funded until after the WIPP WAC are developed, other, more costly alternatives must be implemented. The expense funding is not available to develop all these alternatives, and it is likely that none of these can be implemented with the level of line item funding that DOE has proposed for FY 1993–97. Immediate guidance is needed from DOE on the WHPP schedule, and the remaining alternatives need to be evaluated in detail as soon as possible.

Treatment facilities should also be developed for the PWTP, the REDC, the HFIR, and the ORR/BSR to eliminate nonradioactive dissolved solids, cobalt, and TRU waste from the centralized LLLW system. The solid waste generation rates for ORNL will increase significantly above previous estimates when these projects are implemented. It is likely that presently operational and proposed solid waste storage/disposal facilities will have trouble accommodating these waste streams. The impacts of increasing solid waste generation will need to be examined and incorporated into the solid waste management strategy. Additional funding for solids disposal facilities may be required before these projects can be implemented.

Because of the uncertainty associated with the LLLW upgrade projects, new waste streams that significantly increase the LLLWC inventory may not be accepted until the new treatment facilities are operational. Also, sludges from the inactive LLLW tanks cannot be accepted into the active LLLW system until WHPP becomes available. The feasibility of acceptance of the supernatants from the inactive LLLW tanks for treatment in the centralized facilities in the near term needs to be determined. If these supernatants are not accepted for treatment, the ER Program could face potential regulatory problems.

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