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Current and Projected Liquid Low-Level Waste Generation at ORNL

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Chemical Technology Division

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ACRONYMS

BSR	Bulk Shielding Reactor
CY	calendar year
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
ERP	Environmental Restoration Program
FFA	Federal Facilities Agreement
HFIR	High Flux Isotope Reactor
HOG	hot off-gas
IFDP	Isotopes Facilities Deactivation Project
ITE	in-tank evaporation
LITR	Low-Intensity Test Reactor
LLLW	liquid low-level waste
LLLWC	liquid low-level waste concentrate
LLW	low-level waste
MVST	Melton Valley Storage Tank
NTF	North Tank Farm
OGR	Old Graphite Reactor
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Research Reactor
OSR	Operational Safety Report
OTE	out-of-tank evaporation
PWTP	Process Waste Treatment Plant
R&D	research and development
RA	remedial actions
REDC	Radiochemical Engineering Development Center
SC	solidification campaign
STF	South Tank Farm
TRU	transuranic
VOG	vessel off-gas
VRF	volume reduction factor
WAG	Waste Area Grouping

EXECUTIVE SUMMARY

Liquid low-level waste (LLLW) is generated by various programs and projects throughout Oak Ridge National Laboratory (ORNL). This waste is collected in bottles, by trucks, or in underground collection tanks; it is then neutralized with sodium hydroxide and reduced in volume at the ORNL LLLW evaporator. This report presents historical and projected data concerning the volume and the characterization of LLLW, both prior to and after evaporation. Storage space for projected waste generation is also discussed.

1. INTRODUCTION

The Waste Management Operations group within the Waste Management and Remedial Actions Division operates the Oak Ridge National Laboratory (ORNL) liquid low-level waste (LLLW) system, which collects radioactive wastewaters produced by reactor operations, research and development (R&D) projects, Environmental Restoration Program (ERP) activities, and waste operations. An ongoing effort to develop and implement improved liquid processing systems has been under way with 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 volume of secondary waste generated. Efforts began in the mid–1980s to develop a consistent, logical approach for upgrading the low-level waste system to meet these objectives. A strategy was developed for upgrading the LLLW system; R&D programs and technical assessments were initiated to support these plans; and capital projects were implemented to perform the planned upgrades. This report was prepared to support the LLLW management strategy by reflecting evaluations of current and future waste characterization/generation data, changes in interagency agreements and regulations, and advances in the R&D program to treat LLLW.

2. BACKGROUND

LLLW has been generated at ORNL since the inception of laboratory operations in the 1940s. This type of waste is usually collected in underground storage tanks (or, more recently, collected in bottles and trucked), neutralized with sodium hydroxide, and transferred to the central LLLW system where it is concentrated via evaporation. The liquid LLW concentrate (LLLWC) that is removed as bottoms from the evaporators is transferred to the evaporator service tanks (ESTs) and the Melton Valley Storage Tanks (MVSTs), where it separates into sludge and supernate phases. This waste is stored in the MVSTs until further processing steps render it suitable for disposal.

From 1964 to 1984 the LLLWC was stirred into a homogeneous mixture, mixed with grout, and disposed via underground hydrofracturing. Following the discontinuation of hydrofracture disposal in 1984, LLLWC has been allowed to accumulate in the ESTs and the MVSTs. The maximum storage capacity of these tanks will be attained within 3 to 5 years if further waste processing and removal are not undertaken.

In 1987, a planning team was established to develop a strategy for the disposal of the LLLWC stored since the shutdown of the hydrofracture disposal facility. The recommended strategy contained near-, intermediate-, and long-term treatment plans.[1]

The near-term management plan for treatment of LLLWC consisted of three phases: (1) reduction of generated wastes by identifying and evaluating LLLW sources and treatment systems, (2) removal of excess water from the stored waste by in-tank evaporation (ITE) in the MVSTs, and (3) solidification of MVST supernate in a concrete matrix to free storage space in the tanks and provide operational flexibility of the current LLLW system. The intermediate-term management plan for LLLWC was to process existing MVST transuranic waste sludge and the associated supernate for disposal at the Waste Isolation Pilot Plant (WIPP), which is the deep geologic repository that the U.S. Department of Energy (DOE) is establishing as the disposal site for all DOE-generated TRU waste. 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 and would minimize the production of TRU waste and other solid waste requiring off-site disposal.

Significant accomplishments and changes have occurred since this strategy was developed. The near-term plans are progressing very effectively; however, delays in capital and line-item projects and some increases in waste generation have warranted an increase in storage space in the near term. The sources of LLLWC have been identified, and source treatment options are being developed for the largest generators of LLLWC. The ITE method was used successfully for almost 3 years, during which time a total of approximately 45,000 gal of water was evaporated from the MVSTs. Four solidification campaigns, in which a total of approximately 193,000 gal of supernate was solidified and stored, have been successfully completed as of October 31, 1995. At present generation rates and with no other treatment of MVST waste, capacity for only about 5 years of LLLWC storage is available. Waste generation from remedial activities, mainly the emptying of inactive LLLW tanks, is expected to require additional space in the MVSTs, thus lowering the figure to 3 years of available storage. Even though much of this waste will be evaporated at the MVSTs using out-of tank evaporation (OTE), additional tank storage space will eventually be needed. A long-term treatment facility for this waste will not be available within less than 8 to 10 years. In the meantime, a line-item project termed the Melton Valley Storage Tank Capacity Increase Project (MVSTCIP) will install six new 100,000-gal tanks at the Melton Valley site by the year 2000.

With regard to intermediate and long-term plans for the treatment of LLLWC, programs are in place to perform R&D work to define flowsheets for processing this waste. Implementation of land disposal restrictions for Resource Conservation and Recovery Act (RCRA) waste has required that the research concerning long-term treatment options for newly generated waste be accelerated. This research is being performed in conjunction with the development of the Transuranic Waste Processing Facility, which will treat the waste in the tanks and render it suitable for disposal.

Two previous reports have summarized LLLW generation through 1993.[2,3] This report will summarize generation of LLLW since 1993 and will discuss projected generation rates over the next 10 years. Operations to reduce LLLWC over the last few years will be discussed, as will the plans currently being developed to reduce LLLW generation and activity in the near future.

3. GENERATION OF LIQUID LOW-LEVEL WASTE

This document summarizes the status of LLLW generators, along with their waste volumes and characteristics, and analyzes the operation of the current LLLW system. Many changes have taken place in the use and operation of the LLLW system over the past several years. Significant changes in the generators of LLLW include the (1) shutdown of the isotope production programs, (2) shutdown of the Oak Ridge Research Reactor (ORR) and Bulk Shielding Reactor (BSR), and (3) restart of the High Flux Isotope Reactor (HFIR). The Federal Facilities Agreement (FFA) took effect in January 1992, which led to the shutdown of several active LLLW tanks. The generators that had previously used those tanks began bottling or trucking LLLW. Those tanks are now collecting only nonprogrammatic waste (filter-pit inleakage, sumps, etc.). Over the next several years, many operational modifications are expected to reduce the generation of LLLW. The Process Waste Treatment Plant (PWTP) upgrade, source treatment at HFIR, source treatment at the Radiochemical Engineering Development Center (REDC), and rerouting of some nonprogrammatic waste streams will all have a significant impact on operations of the LLLW system. Conversely, the shutdown of many facilities is predicted to temporarily generate large volumes of LLLW in the future.

Data to support the analysis of LLLW (dilute and concentrate) generation have been obtained over the past 7 years through generator surveys. These surveys have provided information on (1) the programs and activities that generate LLLW, (2) estimates of the volume of dilute LLLW, (3) radioactivity of the waste, and (4) solids contents of the waste (caustic, cleaners, etc.). This information has been used to predict dilute and concentrated waste generation rates for each generator, their needs with regard to concentrate storage volume, and future waste profiles. The following sections summarize the information received during this calendar year, as well as the forecasted changes as currently envisioned.

3.1 GENERATION OF DILUTE LLLW

3.1.1 Current Generation of Dilute LLLW

Table 1 presents the historical generation of dilute LLLW from 1992 through 1994, as well as the expected generation for 1995 (based on collection rates through May 1995 and the 1995 generator surveys). Generator LLLW (as opposed to nonspecific source generation, i.e., inleakage and sump accumulation) volumes have not changed significantly during the past 4 years; however, nonspecific source generation increased in 1994 due to heavy rainfall. During 1995, the latter accumulation is expected to decrease again, but this volume does not significantly add to the LLLW concentrate volume; thus it is not a concern. A

Table 1. Generation of dilute liquid low-level waste for the period 1992-1995

Tank	Generator/facility [a]	Dilute LLLW (gal/year) 1992	1993	1994	1995
		Generators			
WC-10	Bldgs. 3028, 3029, 3030-32, 3038, 3039, 3047, 3093	3,000	4,000	26,000	1,800
WC-19	Bldgs. 3001 (OGR), 3042 (ORR), 3119 (BSR)	4,000	1,200	2,400	2,400 [b]
2026	Bldg. 2026	2,700	2,300	580	2,300
WC-20	Bldg. 7920, 7930 (REDC)	13,000	17,500	13,200	15,000
HFIR	Bldg. 7900 (HFIR)	121,400	110,000	100,000	100,000
WC-7	Bldg. 3504	120	120	50	0
W-16	Bldg. 3026D	550	500	500	0
WC-3	Bldg. 3025	270	380	1,200	750
W-22	PWTP feed	10,800	10,800	9,500	10,800
	3039 stack	38,900	41,400	44,300	44,000
N-71	Bldg. 3019	360	150	430	420
S-324, -223, -523	Bldg. 3517	400	0	400	0
Trucked	Bldg. 3074	1,900	1,700	800	1,500
	Bldg. 3525	1,300	1,700	300	15,000 [c]
Bottled	Bldg. 3026C		12	1	0
	Bldg. 3047		12	3	1
	Bldg. 3592	50	96	1	1
	Bldg. 4500N	6	12	15	3
	Bldg. 4500S		12	60	163
	Bldg. 4501		12	25	25
	Bldg. 4508		12	3	3
	Bldg. 5505			6	6
SUBTOTAL		198,756	191,918	199,774	194,172
	Sumps, filter pits, other nonprogrammatic waste, and inleakage				
WC-10	HOG pots in Isotope Area	9,200	15,400	17,600	36,000
WC-19	Bldg. 3042 HOG pot	7,000	2,000	25,800	1,000
W-1A	Inleakage	21,000	22,200	42,400	35,000
WC-11	Bldg. 4556 (filter pit) and 4500N west-wing sump	5,600	5,100	6,000	7,000
WC-12	Tank T-30 sump	700	400	400	600
WC-13	Inleakage	840	200	100	100
WC-14	Bldg. 4501 sumps	160	400	400	0
WC-8	Pump prime water	1,400	2,400	1,400	1,100
WC-9	HOG pot	7,760	14,000	14,300	14,000
WC-5, -6	Inleakage	2,650	2,200	3,400	3,300
W-12	Inleakage	4,300	4,000	7,700	7,500
HFIR	Bldgs. 7911, 7913, 7922 (stack, filter pit, etc.)	26,000	16,000	16,000	13,000
WC-2	Isotope HOG pot, 3039 HOG pot	300	300	500	100
WC-7	Inleakage	410	400	370	300
W-17, -18	Inleakage	9,700	14,900	26,000	0 [d]
S-324, -223, -523	Bldg. 3517 filter pit, HOG pot	9,300	33,000	32,000	8,500
WC-3	Bldg. 3098 (filter pit)	100	100	100	100
W-16	Seal traps for W-16, -17, -18, Bldg. 3515	200	100	100	300
SUBTOTAL		106,620	133,100	194,570	127,900
	Other (sumps, etc.)	90,000	89,500	147,000	100,000
	Inactive tanks	2,100	5,500	16,000	167,000
TOTAL		397,476	420,018	557,344	589,072

[a] OGR = Old Graphite Reactor; ORR = Oak Ridge Research Reactor; BSR = Bulk Shielding Reactor; REDC = Radiochemical Engineering Development Center; HFIR = High Flux Isotope Reactor; PWTP = Process Waste Treatment Plant; HOG = hot off-gas.

[b] Within this group of reactors, only the OGR currently generates LLLW.

[c] Tank W-12 will be used by Bldg. 3525 for the disposal of LLLW during 1995.

[d] The waste collected in tank W-18 has been routed to the PWTP.

discussion of LLLW collection tanks and associated generators with their expected generation for the current year is provided below.

WC-10 — (Building 3047) An estimated 150 gal/month (1800 gal/year) of dilute LLLW will be generated in the ongoing surveillance and maintenance of Building 3047. Other isotope facilities are still actively connected to tank WC-10, but they are not expected to undergo significant amounts of cleanup or decontamination during 1995. Heavy decontamination of these facilities is dependent on funding availability, which will probably not occur until 1997 or later.

WC-19 — (Old Graphite Reactor/ORR/BSR) The ORR and BSR have stopped generating LLLW. Each of these facilities is regenerating its reactor pool water by taking a bleed stream from the pool to the PW system while feeding in a deionized-water stream for replacement water, rather than the customary regeneration by demineralizer columns, which produces LLLW. A 1992 General Plant Project was implemented to make this a permanent arrangement. A reduction of about 1000 gal of dilute LLLW annually was accomplished through these upgrades (6000 to 7000 gal/year if the reactors were operating). Regeneration of the demineralizer columns in Building 3001, the Old Graphite Reactor (OGR), is ongoing. This operation results in approximately 2400 gal of dilute LLLW per year.

S-324, -223, -523 — (Building 3517) Currently, this facility is doing minimal cell washings to contain radioactivity. Most of the volume collected in tanks S-324, -223, and -523 is due to rainfall inleakage. Extremely heavy rainfall in early 1995 caused the filter pits to be jetted several times during this period.

WC-20 — (REDC) No change from the previous year is expected. The volume generated was somewhat lower than expected during 1994, and is predicted to increase slightly during 1995, based on collection volumes to date. REDC personnel are working on waste minimization projects, which primarily involve a reduction of transuranic activity.

HFIR — HFIR generation has remained approximately the same for the last four years (all operating years). The current estimate is about 100,000 gal of dilute LLLW generation for CY 1995.

W-12 — (Building 3525) Building 3525 has been allowed to use tank W-12 temporarily, although it was removed from service several years ago by the FFA. Major decontamination work is being performed in the facility this year; therefore, generation is much higher (15,000 gal for 1995 compared with a much lower volume of 300 gal for 1994). Generation is expected to decrease in the following years since the facility will again be trucking waste to the LLLW evaporators.

WC-3 — (Building 3025) The 1995 generator estimate for Building 3025 is 750 gal/year. This estimate is very conservative and, to date (based on the actual generation), is better estimated to be about 150 gal for the year. Building 3098, the filter facility for the BSR and the Low-Intensity Test Reactor, also discharges an estimated 100 gal to this tank annually.

Bottled waste — (Chemistry Division, Chemical Technology Division, Health and Safety Research Division, Environmental Sciences Division, Metals and Ceramics Division) A total of 202 gal of dilute LLLW per year is estimated to be bottled by these divisions for CY 1995.

Inactive tanks — (TH-4, W-3, W-6, W-8) Several inactive tanks will possibly be pumped to the LLLW system in 1995. As of June 1995, 37,000 gal has already been transferred — 12,000 gal from TH-4 and 25,000 gal from W-3. An additional 130,000 gal is to be transferred from tanks W-6 and W-8 to the LLLW system.

Trucked waste — (Buildings 3074 and 7830) The Manipulator Repair Facility (Building 3074) is estimating a generation rate of 1500 gal for 1995, somewhat higher than the actual generation during 1994. Waste is also trucked from the inactive facility, Building 7830, as necessary.

The major *dilute* LLLW generators for 1995 are as follows: nonprogrammatic/inleakage (39%), inactive tanks (28%), HFIR (17%), the 3039 stack (8%), REDC (3%), and the PWTP (2%); all others account for the remaining 3% of the dilute LLLW generation predicted for 1995.

3.1.2 Projected Future Generation of Dilute LLLW

Several changes are expected in the generation of dilute LLLW over the next 15 years. Predicted generation rates are listed in Table 2. Included are generation

Table 2. Predicted generation of dilute liquid low-level waste for the period 1996 - 2010

Tank (facility)[a]	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Dilute LLLW (gal/year)														
							Generators								
WC-2, -10 (Isotope Area)	2,000	68,000	68,000	68,000	68,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
WC-19 (Reactors)	2,400	2,400	0	0	0	0	0	0	0	0	0	0	0	0	0
2026 (Bldg. 2026)	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
WC-20 (REDC)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
HFIR	100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W-16 (Bldg. 3026D)	0	37,000	37,000	37,000	0	0	0	0	0	0	0	0	0	0	0
WC-3 (Bldg. 3025)	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
W-22 (PWTP Feed)	10,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(3039 Stack)	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000
N-71 (Bldg. 3019)	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
S-523 (Bldg. 3517)	400	93,500	93,500	93,500	93,500	400	400	400	400	400	400	400	400	400	400
Trucked (Bldg. 3074)	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
(Bldg. 3525)	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Bottled (various bldgs.)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
SUBTOTAL	181,050	265,350	262,950	262,950	225,950	66,850	66,850	66,850	66,850	66,850	66,850	66,850	66,850	66,850	66,850
							Others								
Nonprogrammatic waste[b]	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000
Inactive-tanks supernate	0	0	36,700	0	95,500	114,500	65,700	0	0	0	0	0	0	0	0
Inactive-tanks sludge	0	0	5,840	0	17,400	8,300	21,400	0	0	0	0	0	0	0	0
D&D activities	11,244	41,584	56,326	81,457	62,278	127,204	72,432	72,638	64,925	140,456	140,456	140,456	75,531	75,531	77,158
RA activities	131,260	169,510	105,585	108,817	110,592	110,594	41,606	46,992	59,877	47,186	34,243	34,243	33,918	33,573	23,664
SUBTOTAL	357,504	426,094	419,451	405,274	500,770	575,598	416,138	334,630	339,802	402,642	389,699	389,699	324,449	324,104	315,822
TOTAL	537,554	691,444	682,401	668,224	726,720	642,448	482,988	401,480	406,652	469,492	456,549	456,549	391,299	390,954	382,672

[a] REDC = Radiochemical Engineering Development Center; HFIR = High Flux Isotope Reactor; PWTP = Process Waste Treatment Plant; D&D = decontamination and decommissioning; RA = remedial actions.

[b] Nonprogrammatic waste refers to inleakage, collection in hot off-gas pots, stacks, etc., throughout the active LLLW system.

rates of LLLW for decontamination and decommissioning (D&D) activities by the Surplus Facilities Program, as well as remedial actions (RA) that primarily consider the cleanup and remediation of waste area grouping sites by ERP. In each case, the LLLW to be generated is the result of decontamination activities. The transfer of inactive tank supernates will be a major source of dilute LLLW during the next decade, as will decontamination of the isotope facilities. The following paragraphs summarize changes in LLLW generation expected by the current generators.

Tank WC-10 is serving only to maintain and, eventually, to decontaminate the isotope facilities. The shutdown of these facilities is dependent on budgeting available to the Isotopes Facilities Deactivation Project (IFDP).[4] Currently, the funding for shutdown is not expected to become available until 1997; thereafter, shutdown is expected to require approximately 4 years to complete for all facilities. The availability of WC-2 and WC-10 during this period is uncertain; however, for the purposes of projection, it is assumed that these tanks will be available. Volumes to be expected were taken from the *Work Plan for the Isotopes Facilities Deactivation Project at Oak Ridge National Laboratory* and are given in Table 2.[4]

Tank WC-19 is currently receiving waste only from the regeneration of ion-exchange columns at the OGR. This is expected to occur for several more years, until the required decontamination work in that facility is completed. This work is dependent on budget concerns and will change with funding availability.

The PWTP dilute "feed" stream should be eliminated. Currently, a portion of the ion-exchange regeneration solution at the PWTP is sent to the LLLW system for evaporation (i.e., the PWTP "feed" stream) because of the limited capacity of the PWTP evaporator. An upgrade at the PWTP has been completed and should enable the entire stream to be evaporated on-site, thereby eliminating this LLLW stream. The PWTP "concentrate" stream, which is sent directly to storage in tank W-21, will increase somewhat, but an overall waste reduction from the PWTP will be realized (see Sect. 3.3.2).

LLLW from HFIR will possibly be eliminated by 1997. Resins in the ion-exchange columns (used to demineralize and reduce the radioactivity in the pool waters) are presently regenerated, resulting in a large volume of LLLW. In the near future, these resins will be replaced with a resin that will be disposed of as a solid waste.

Building 3026D, which is a part of the IFDP, is scheduled to be decontaminated/decommissioned in the same time frame as the other isotope facilities.[4] Liquid waste generated during the past few years at this building has been the result of cleanup and decontamination activities. The final cleanup and decontamination of the facility are dependent on budget concerns and availability and are, therefore, subject to change, depending on the procurement of these funds. The availability of tank W-16 during this period is unknown; however, for projection purposes, it is assumed that the tank will be available.

REDC is researching various techniques for the removal of TRU elements from its waste stream, although the volume is not expected to decrease much in the next several years. Significant strides in volume reduction have occurred in the previous few years at REDC from conversion to a sodium hydroxide solution for the off-gas scrubber. (Previously, a more concentrated solution of potassium hydroxide was used.)

Forecasts for LLLW generation by the D&D projects and RA activities at ORNL have been incorporated in the projections in this report for planning purposes. The majority of this waste will not be generated until after 2000. In addition, the LLLW generated through these programs will be decontamination liquids. A large volume reduction factor (VRF) has been applied to these dilute volumes when predicting concentrate volumes, since the estimates appear to be extremely conservative.

Generation rates for the remainder of the facilities have been assumed to remain constant for the 1996–2010 time frame for projection purposes. However, these estimates are certain to change as time progresses.

3.2 CHARACTERISTICS OF LLLW

3.2.1 Characteristics of Current LLLW

Generators are also asked to report on the radioactive contents of the liquid waste in the LLLW surveys. Table 3 summarizes the current findings on radioactive species being disposed of through the LLLW system, as reported in the surveys. The curie quantities given there are estimates; actual sample analyses have not been made. REDC is the source of the majority of the radioactivity in the currently generated LLLW, and this area will continue to contribute significantly to the total activity of the waste. In addition, Building 3525 is predicted to make a large contribution to the activity of the LLLW stream due to cleanup activities during 1995. The estimated volume to be sent to the LLLW system by the inactive tanks will also contribute to the activity of the waste, as seen in Table 3.

Other contaminants (such as cleansers, acids, caustics, and salts used and disposed of by the facility) determine the volume of LLLWC generated. In addition, caustic is added to many of the tanks when they are jetted or pumped to the central LLLW system for evaporation. This addition also increases the volume of concentrate produced. Most facilities use nitric acid, sodium hydroxide, and commercial cleansers such as Ajax and Mr. Clean when decontaminating and washing hot cells. The amounts of these products used by the facility determine the VRF that will be achieved when the waste is processed through the LLLW evaporator. This VRF is used in calculating the volume of LLLWC generated by the facility. Table 4 lists the major contaminants in the LLLW generated during CY 1995, as estimated in the LLLW surveys.

3.2.2 Characteristics of Future LLLW

Changes in the radioactivity levels and compositions of LLLW streams during the next 15 years cannot be estimated easily. The following occurrences

Table 3. Isotopes in liquid low-level waste reported by generators for CY 1995 [a]

Isotope	Facility	Quantity for each facility (Ci/year)	Total quantity of isotope (Ci/year)
H-3 [b]	HFIR	4	4
	Others	<1	
Na-24	HFIR	396	396
Mg-27	HFIR	22	22
Fe-59	Bldg. 3525	20	20
Cr-51	Bldg. 3525	1,300	1,384
	HFIR	84	
	Others	<1	
Co-60	HFIR	8	15
	Bldg. 3525	4	
	Inactive tanks	3	
	Others	<1	
Sr-90 [b]	Inactive tanks	22	22
	Others	<1	
Nb-95	Bldg. 3525	1	1
Zr-95	Bldg. 3525	2	2
Cs-134 [b]	Bldg. 3525	20	20
	Bldg. 4500N	<1	
Cs-137 [b]	Bldg. 3525	900	1,430
	Inactive tanks	530	
	Others	<1	
Ce-144	Bldg. 3525	9	9
Eu-152, 154, 155 [b]	Bldg. 3525	31	33
	Inactive tanks	2	
	Others	<1	
W-181	HFIR	968	968
W-187	HFIR	4	4
Ir-192	Bldg. 3525	200	200
Pu-238 - 242	REDC	20	20
	Bldg. 3019	0.6	0.6
	Others	<1	
Am-241, 242, 243	REDC	1.2	1.2
Cm-244, 245, 246	REDC	81	81
Cf-250, 252	REDC	0.6	0.6
MFP	REDC	10,000	10,000
	Others	<1	
Total			**14,633**

[a] Other non-TRU isotopes reported in trace quantities (<1 Ci/year total) are not included.

[b] See MFP (mixed fission products), which also includes these isotopes.

Table 4. Contaminants disposed of via the liquid low-level waste system in 1995

Contaminant	Facility	Quantity (g/year)	Quantity (lb/year)	Contaminant	Facility	Quantity (g/year)	Quantity (lb/year)
Acetic acid	Bldg. 4508	1.1E+02	2.3E-01	Nitric acid	Bldg. 2026	9.1E+05	2.0E+03
Acetone	Bldg. 3025	7.9E+02	1.7E+00		Bldg. 3001	5.8E+03	1.3E+01
Adogen-364	Bldg. 7920	4.0E+04	8.8E+01		Bldg. 3019	2.8E+03	6.2E+00
Alpha-hydroxyisobutyric acid	Bldg. 7930	8.0E+02	1.8E+00		Bldg. 3525	2.5E+02	5.5E-01
Aluminum	Inactive tanks	1.6E+03	3.5E+00		Bldg. 3544	5.8E+06	1.3E+04
Ammonium hydroxide	Bldg. 7920	2.4E+03	5.2E+00		Bldg. 3592	2.4E+01	5.3E-02
AMSCO (petroleum naptha)	Bldg. 7920	4.0E+02	8.8E-01		Bldg. 4500N	1.4E+01	3.1E-02
Arsenic	Inactive tanks	6.2E+01	1.4E-01		Bldg. 4500S	7.0E+01	1.5E-01
Barium	Inactive tanks	1.4E+01	3.0E-02		Bldg. 4501	6.0E+02	1.3E+00
Bromide	Inactive tanks	2.8E+03	6.2E+00		Bldg. 5505	3.8E+03	8.3E+00
Butyl cellosolve	Bldg. 4508	2.0E+02	4.4E-01		Bldg. 7900	6.0E+05	1.3E+03
Calcium	Inactive tanks	2.9E+04	6.4E+01	Selenium	Inactive tanks	6.1E+01	1.3E-01
Cadmium	Inactive tanks	1.0E+01	2.3E-02	Silver	Inactive tanks	2.1E+01	4.6E-02
Chloride	Inactive tanks	7.7E+04	1.7E+02	Sodium	Inactive tanks	3.0E+06	6.7E+03
Chromium	Inactive tanks	2.7E+03	6.0E+00	Sodium aluminate	Bldg. 7920	3.3E+04	7.2E+01
Detergents (Mr. Clean, Ajax, etc.)	Bldg. 2026	2.0E+02	4.4E-01	Sodium chloride	Bldg. 4501	1.1E+01	2.4E-02
	Bldg. 3025	1.5E+04	3.3E+01	Sodium hydroxide	Bldg. 3001	6.0E+03	1.3E+01
	Bldg. 3047	7.1E+04	1.6E+02		Bldg. 3092/3039	4.0E+04	8.9E+01
	Bldg. 3074	2.4E+05	5.2E+02		Bldg. 3525	1.6E+04	3.4E+01
	Bldg. 3525	2.4E+05	5.2E+02		Bldg. 3544	4.0E+06	8.7E+03
Diethylbenzene	Bldg. 7920	1.7E+05	3.8E+02		Bldg. 4501	7.8E+02	1.7E+00
Ethanol	Bldg. 3025	1.2E+03	2.6E+00		Bldg. 7900	1.1E+06	2.4E+03
	Bldg. 4508	3.0E+03	6.5E+00		Bldg. 7930	2.8E+04	6.2E+01
Fluoride	Inactive tanks	1.7E+05	3.7E+02	Sodium sulfate	Bldg. 4500N	3.0E+02	6.6E-01
Freon 113	Bldg. 3025	1.0E+03	2.2E+00	Sodium chloride	Bldg. 4500N	5.0E+01	1.1E-01
HDEHP extractant	Bldg. 7920	4.1E+04	9.1E+01	Sodium hydrocholride	Bldg. 4500N	2.5E+02	5.5E-01
Hydrazine decomp. product	Bldg. 7930	trace		Sodium nitrate	Bldg. 4500N	5.0E+01	1.1E-01
Hydrochloric acid	Bldg. 3525	1.1E+02	2.4E-01		Bldg. 4501	4.3E+03	9.4E+00
	Bldg. 4500S	1.0E+01	2.2E-02		Bldg. 7920	3.4E+05	7.5E+02
	Bldg. 4501	4.7E+02	1.0E+00		Bldg. 7930	6.0E+05	1.3E+03
Iron	Inactive tanks	8.7E+01	1.9E-01	Sodium nitrite	Bldg. 4501	4.7E+03	1.0E+01
Lead	Inactive tanks	3.5E+02	7.7E-01	Sodium thiosulfate	Bldg. 7920	1.3E+03	2.9E+00
Lithium chloride	Bldg. 7920	4.2E+04	9.3E+01	Strontium	Inactive tanks	5.4E+01	1.2E-01
Mercury	Inactive tanks	4.4E+01	9.7E-02	Sulfuric acid	Bldg. 3025	8.8E+02	1.9E+00
Methanol	Bldg. 3025	4.0E+03	8.7E+00		Bldg. 3592	1.3E+03	2.9E+00
	Bldg. 3592	2.1E+03	4.6E+00		Bldg. 4500S	9.6E+00	2.1E-02
	Bldg. 4500N	1.5E+02	3.3E-01		Bldg. 4508	3.7E+01	8.1E-02
	Bldg. 4508	3.0E+03	6.6E+00	Sulfate	Inactive tanks	1.2E+06	2.7E+03
Nickel	Inactive tanks	1.1E+02	2.5E-01	Thallium	Inactive tanks	3.2E+02	7.0E-01
Nitrate	Inactive tanks	3.2E+06	7.1E+03	Thorium	Inactive tanks	1.1E+04	2.4E+01
Palladium tetramine dihydrate	Bldg. 7930	trace		Tributyl phosphate	Bldg. 7920	1.0E+04	2.2E+01
Perchloric acid	Bldg. 4508	2.9E+01	6.4E-02	Uranium	Inactive tanks	7.1E+05	1.6E+03
Phosphorus	Inactive tanks	3.5E+05	7.7E+02				
Potassium	Inactive tanks	1.3E+05	2.8E+02	TOTAL		2.3E+07	5.1E+04

are expected to have an impact on the radioactivity of the LLLW, the extent of which is given if known:

1. HFIR conversion of LLLW to solid LLW will remove the majority of ^{3}H, ^{24}Na, ^{54}Mn, ^{60}Co, and $^{181,187}W$ from the waste. Projections based on current planning scenarios indicate that this will begin in 1997.
2. The IFDP will generate a significant amount of radioactivity from a broad spectrum of isotopes, including most of those listed in Table 3 (especially ^{90}Sr and ^{137}Cs, which would figure prominently in the cleanup of Building 3517).
3. REDC source treatment, if implemented, would reduce the activity of its waste stream, especially the TRU content and possibly the ^{137}Cs.

Changes in the quantities of nonradioactive contaminants in the LLLW can be summarized as follows:

1. HFIR conversion of LLLW to solid LLW will result in a large decrease in NaOH and HNO_3 quantities.
2. PWTP conversion of LLLW to solid LLW would result in a large decrease in NaOH and HNO_3 quantities.
3. The IFDP, when implemented, will result in an increase of HNO_3, oxalic acid, and cleaning agents (Mr. Clean, Ajax, etc.) used in decontaminating hot cells and glove boxes.

3.3 GENERATION OF LLLW CONCENTRATE

3.3.1 Current Generation of LLLWC

The four largest dilute waste generators are the major sources of LLLWC: the PWTP, HFIR, inactive tanks, and REDC. Approximately half of the concentrate produced is attributed to operations at the PWTP. HFIR operations generate an estimated 20 to 26%, while REDC generates an estimated 8% of the LLLWC. These estimates were based on generator survey information. Table 5 summarizes the concentrate generated during 1992-94 and the expected generation during 1995.

LLLWC generation during 1995 is expected to be approximately 17% higher than in 1994 due to the addition of waste from the inactive tanks (grouped under "Others" in Table 5). The actual rate of concentrate generation for the first eight months of 1995 is in keeping with these estimates. Based on generator estimates, the PWTP is expected to account for 47% of LLLWC generated, HFIR for 20%, inactive tanks for 22%, REDC for 8%, and all others for ~4%.

3.3.2 Projected Future Generation of LLLWC

Table 6 lists the projected LLLWC generation rates for 1996–2010. These rates are calculated based on the increase or decrease in dilute LLLW generation rates expected and, if known, changes in the concentrations of other contaminants, acids, bases, salts, and cleaners in the LLLW stream. However, in most cases, the current VRFs (calculated based on current LLLW

Table 5. Generation of liquid low-level waste concentrate for the period 1992-1995

Generator/facility	1992 (gal/year)	1992 (%)	1993 (gal/year)	1993 (%)	1994 (gal/year)	1994 (%)	1995 (gal/year)	1995 (%)
Process Waste Treatment Plant	10,500	61	13,800	57	10,000	57	10,600	47
High Flux Isotope Reactor	4,500	26	7,900	32	4,500	26	4,500	20
Radiochemical Engineering Development Center	1,500	9	2,000	8	1,400	8	1,700	8
Bethel Valley Reactors [a]	200	1	0		0		0	
Bldg. 3517	<100	<1	0		<100	<1	<100	<1
Bldg. 3525	<100	<1	<100	<1	<100	<1	100	<1
Isotopes Area	<100	<1	<100	<1	1,000	6	<100	<1
Others (includes inactive tanks)	< 200	1	< 550	2	< 400	2	5,500	24
TOTAL	17,200		24,450		17,500		22,600	

[a] Bethel Valley Reactors include the Oak Ridge Research Reactor, Bulk Shielding Reactor, and Old Graphite Reactor.

Table 6. Projected generation of liquid low-level waste concentrate for the period 1996 - 2010

Generator/facility	LLLW concentrate generation (gal/year)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Process Waste Treatment Plant	10,600	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400
High Flux Isotope Reactor	4,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radiochemical Engineering Development Center	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
Bldg. 3517	<100	3,200	3,200	3,200	3,200	0	0	0	0	0	0	0	0	0	0
Bldg. 3525	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Isotopes Area	<100	3,500	3,500	3,500	2,300	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Others	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
SUBTOTAL, generators	**17,220**	**17,120**	**17,020**	**17,020**	**15,820**	**10,320**	**10,420**	**10,420**	**10,420**	**10,420**	**10,420**	**10,420**	**10,420**	**10,420**	**10,420**
Inactive tanks:															
Supernate + sluice water [a]	0	0	6,100	0	4,800	16,100	5,500	0	0	0	0	0	0	0	0
Sludge [b]	0	0	5,840	0	17,400	8,300	21,400	0	0	0	0		0	0	0
Surplus Facilities Programs	200	800	1,100	1,600	1,300	2,600	1,500	1,500	1,300	2,800	2,800	2,800	1,500	1,500	1,600
Remedial Actions Programs	2,600	3,400	2,100	2,200	2,200	2,200	900	900	1,200	1,000	700	700	700	700	500
TOTAL	**20,020**	**21,320**	**32,160**	**20,820**	**41,520**	**39,520**	**39,720**	**12,820**	**12,920**	**14,220**	**13,920**	**13,920**	**12,620**	**12,620**	**12,520**

[a] The volume of concentrate is supernate concentrate and sluice water concentrate (after settling and evaporation). This is one scenario; it is possible that the tank sludges will be solidified in place and no sludge or sluice water concentrate will be generated. In addition, the volumes shown here are for a single scenario; volumes and dates are subject to change.

[b] Active tank W-22 sludge is sluiced into the Melton Valley Storage Tanks in 2000.

characteristics) are used along with the estimated future dilute LLLW generations to give future LLLWC volumes. These LLLWC volumes are used to determine the storage space needed over the next 12 years. The following is a summary of changes that will affect the volume of LLLWC generated over the given time frame:

1. The PWTP upgrade has been completed and should result in an overall reduction of LLLWC for this facility of approximately 2700 gal/year. A holding tank has been installed to enable the treatment of the entire PWTP LLLW stream by the PWTP evaporator. Currently, a portion of the PWTP stream is evaporated at the LLLW evaporator facility, which is less efficient than the PWTP evaporator. Earlier plans for the PWTP included an upgrade such that no LLLW would be produced in the future; however, funding has been reduced and this upgrade has been canceled. The PWTP is expected to continue producing LLLWC at the rate shown in Table 6 in the near future.
2. HFIR will dispose of loaded ion-exchange resin as solid waste, eliminating LLLWC from this facility beginning in 1997. The annual rate of solid LLW generated is expected to be approximately 10 m^3 (35 ft^3).[5]
3. After the IFDP has been effectively carried out, Building 3517 will not generate LLLWC.

The remaining generators have been estimated to continue production of dilute and concentrated LLLW at the current rates.

LLLWC generation is expected to vary greatly during the next 15 years, depending on the timing and extent of the remediation of the inactive tanks (liquids and sludges), Surplus Facility Program D&D projects, and RA activities. Estimates for the volumes of LLLWC to be generated by these programs are given in Table 6.

Another activity that will generate significant amounts of LLLWC is sludge removal from the ESTs and inactive tanks. The current scenario includes the sluicing of sludges in the following ESTs: W-22 during 2000, and C-1, C-2, W-21, and W-23 during 2001 (removal by sluicing). The sluicing of tank W-22 is expected to generate approximately 14,500 gal of LLLWC (sludge and concentrated sluice water). Normally, sluicing a tank will increase the volume of LLLWC to be stored by the volume of sludge plus the volume of sluice water concentrate; however, the sluicing of C-1, C-2, W-21, and W-23 would increase the volume of stored LLLWC only by the volume of sluice water concentrate because the sludge volumes are already included as part of the total cumulative LLLWC volumes. The water needed for sluicing a given amount of sludge was estimated as that volume necessary to reduce the sludge to 10% solids–90% water. The sluice water can then be evaporated after the sludge has settled. The sludge and sluice water volumes of the inactive tanks are included in the forecasted dilute and concentrated LLLW volumes in Tables 2 and 6.

3.4 STORAGE OF LLLWC

Several options are being implemented to provide additional storage space in the MVSTs. A liquid waste solidification project (LWSP III) completed in 1995 has freed about 48,000 gal of space. OTE, which is in the process of being developed for use at the MVSTs to evaporate excess sluice water used to carry over sludges from the inactive tanks, will be tested on waste in the MVSTs in early 1996. The removal of cesium from supernates at the MVSTs is being studied; supernate would be run through an ion-exchange resin to reduce the amount of cesium in the waste. This process would indirectly free space in the tanks by enabling solidification of waste that otherwise is too high in cesium concentrations to be treated in the current solidification process.

Six new 100,000-gal storage tanks will be available in 2000 according to the current strategy plans, thus increasing the Operational Safety Report (OSR) limit to 900,000 gal. The OSR limit is calculated by (1) allowing tank W-21 to serve as an LLLW feed tank; (2) permitting tank W-23 to be used for segregation of waste only, not storage; and (3) decreasing the maximum tank capacity to 90% rather than the current 95%. The OSR also requires that the equivalent volume of one tank remain available for emergency use. Current plans are to continue to utilize tanks C-1 and C-2 for storage; however, in the past, the removal of these tanks from service has been discussed. In the event that these tanks should be removed from service, the OSR limit would be 810,000 gal.

4. SUMMARY AND CONCLUSIONS

Generation rates for dilute LLLW at ORNL are predicted to be higher for 1995, primarily because of the predicted transfer of 167,000 gal of supernate waste from inactive tanks W-3, W-6, W-8, and TH-4. To date, only the supernates from TH-4 and W-3 have been transferred to the LLLW evaporator. Most generators have not significantly changed their 1995 waste generation rates over the previous year's estimates. However, Building 3525, a metal polishing and isotope recovery facility, has increased its LLLW generation this year because of decontamination work being performed there. Isotope facilities that use tank WC-10 are predicting lower generation rates for 1995 as compared with 1994 because of reduced funding for decontamination work. Groundwater and rainwater continue to make up a large portion (approximately 50%) of the dilute LLLW generation. All other facilities have predicted generation rates comparable with those of the previous year.

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