ORNL/TM-11227

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Contingency Plan for the Oak Ridge National Laboratory Liquid Low-Level Waste System

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

ORNL/TM-11227

Chemical Technology Division

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Date Published - December 1989

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for the
U.S. DEPARTMENT OF ENERGY
under
Contract DE-AC05-840R21400

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EXECUTIVE SUMMARY

BACKGROUND

The primary sources of liquid low-level waste (LLLW) at Oak Ridge National Laboratory (ORNL) include a number of facilities that perform research and development (R&D) activities involving use and/or production of radioisotopes and certain systems that support these R&D facilities (Fig. ES.1). The LLLW is collected in underground tanks (see Dilute LLLW Collection, Fig. ES.1) and, in turn, is transported to the evaporator system where it is concentrated and then transferred to storage tanks [four evaporator service tanks and eight Melton Valley Storage Tanks (MVSTs)], which have a total capacity of 570,000 gal. The evaporator condensate containing trace radioactivities is transported to the Process Waste Treatment Plant (PWTP) for decontamination.

In the past, the LLLW concentrate was converted to a grout and then disposed of by means of injection into shale formations approximately 1100 ft underground. Primarily because of the very low costs, this "hydrofracture" technique was in use for management of LLLW until 1984, when it was terminated upon discovery of radionuclide migration in the vicinity of monitoring wells adjacent to the hydrofracture site. Changes in environmental regulatory standards also contributed to termination of the hydrofracture method.

CURRENT STATUS OF LLLW MANAGEMENT

No permanent alternative method for LLLW disposal has been identified since the use of hydrofracture was discontinued; thus, the LLLW concentrate has been accumulating in 12 underground storage tanks. The volume of stored LLLW concentrate as of March 1989 totaled ~442,800 gal, which left about 127,200 gal of free space. However, the Operational Safety Requirements (OSRs) require that a minimum of 50,000 gal of storage space must remain unused, leaving only about 77,200 gal of space available for storage. Further, an additional restriction in the available storage space is imposed by the Operational Flexibility Range (50,000 to 100,000 gal of unused storage space) to be used as the "trigger" point at which some means for reducing the volume or disposing of the LLLW concentrate must be implemented.

Although the available storage space could accommodate the volume of LLLW concentrate to be generated in the next 3 years under present conditions, the rate of concentrate generation in the immediate future is expected to increase above the current rate

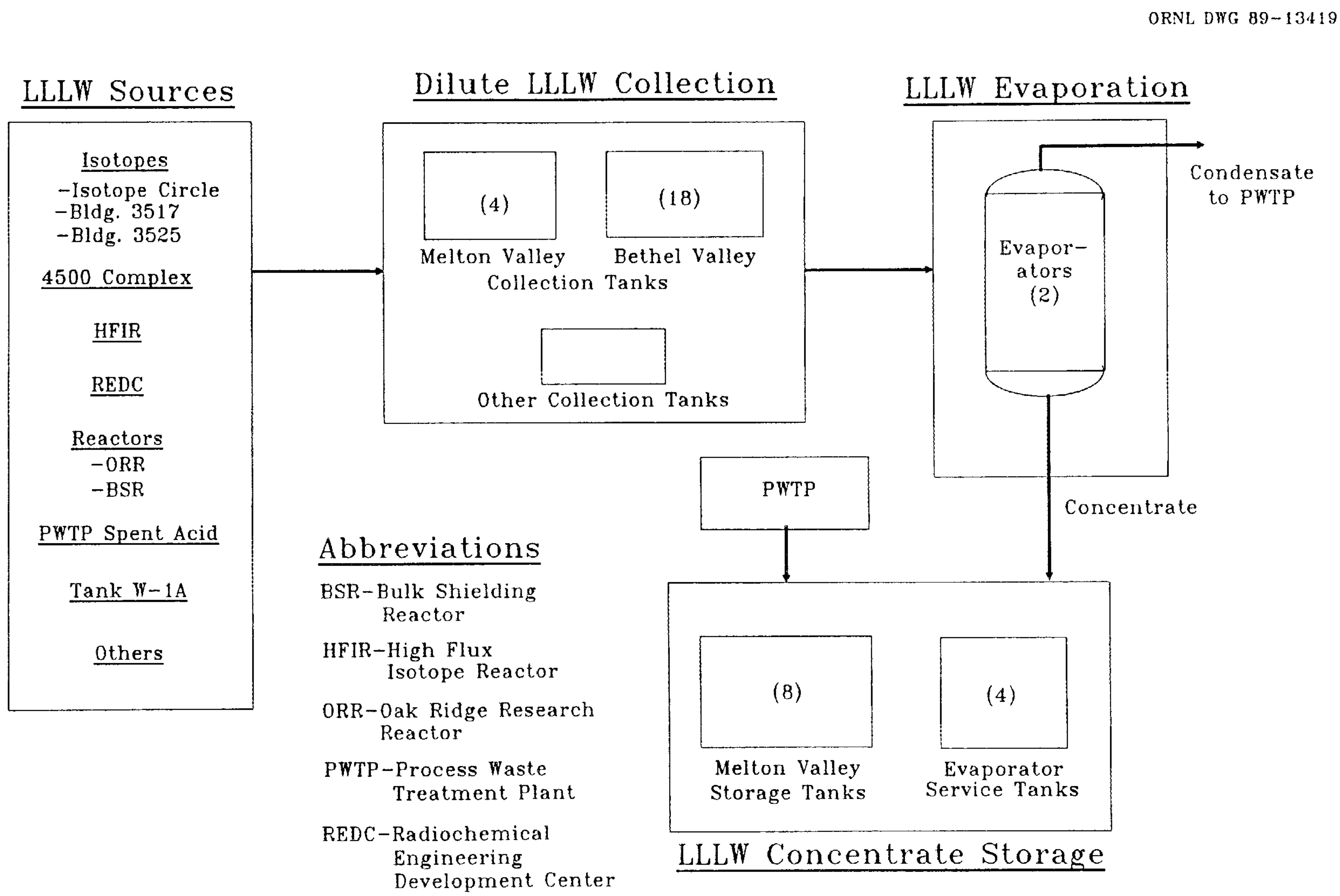

Fig. ES.1. Schematic flow diagram of ORNL low-level liquid waste system.

primarily because of activities related to remedial action programs [i.e., decontamination and decommissioning (D&D) of inactive tanks]. Likewise, unexpected operational incidents (e.g., spills) could result in the generation of additional volumes of LLLW, which would further deplete the available storage space.

In addition to situations affecting the storage of LLLW concentrate, several scenarios involving the storage of dilute LLLW prior to evaporation are examined in this report.

SCOPE AND OBJECTIVE

In view of the possible development of the above situations before the Waste Handling and Packaging Plant (WHPP) becomes operational in approximately 10 years, two methods (solidification and in-tank evaporation) are scheduled for implementation as interim solutions to the storage space problems. Despite such efforts, however, there is still a possibility that the storage space may be depleted much sooner than expected because of factors that are beyond our control. Thus, the primary objective of this task is to develop specific plans of action to be implemented, in the event that the storage space for the LLLW concentrate should approach the minimum value in the operational flexibility range or a problem should develop concerning storage space available for dilute LLLW.

This report considers contingency plans/options in the light of six different scenarios, including "normal operation" and five others. Evaluation and prioritization of the options were carried out separately for each case. Brief discussions of these scenarios and contingency plans/options are presented below.

CONSIDERATION OF CREDIBLE SCENARIOS

A number of possible conditions that could deplete the available storage space have been considered. Of these, the following six scenarios are considered to be credible:

1. normal operation;
2. excessive, unexpected generation of LLLW concentrate;
3. loss of one LLLW concentrate storage tank;
4. excessive, unexpected generation of dilute LLLW;
5. evaporator failure (affecting the storage of dilute LLLW); and
6. heavy rainfall (affecting the storage of dilute LLLW).

CONTINGENCY PLANS/OPTIONS

Six options were selected for consideration under each of the six scenarios mentioned above. These can be summarized as follows:

1. Use of inactive gunite tanks for storage of dilute LLLW - Six gunite tanks, each having a 170,000-gal capacity, may be considered for temporary storage under an emergency condition. These tanks, however, require changes in piping configurations and other upgrading before they can accept the LLLW.

2. Use of tank vaults in MVST area for storage of LLLW concentrate - There are two vaults, each serving as the secondary containment for four storage tanks that could provide up to 200,000 gal of storage space. They are constructed of reinforced concrete and lined with 304L stainless steel.

3. Installation of new storage tanks for storage of dilute LLLW or LLLW concentrate - Up to four new tanks providing 200,000 gal of storage space are envisioned. This option could enable more efficient operation of the evaporator system. High costs and the time required to implement this plan are distinct disadvantages.

4. Shutdown or curtailing of operation of selected LLLW generators - Most of the major LLLW generators cannot be shut down, either because their operations are critical to maintaining a safe environment or because of the unique nature of the project work at the facilities. Shutdown of the remaining generators could reduce the LLLW generation rate by approximately 20% for 4 months or less. Curtailment of decontamination activities concerning the inactive tanks would significantly reduce the dilute LLLW rate by approximately 90,000 gal per year. Long-term (4 to 6 years) shutdown of a few generators (corresponds to nearly 12% of dilute LLLW) is possible.

5. Additional solidification campaign - The LLLW concentrate solidification process is based on established technology, and a campaign utilizing this technology was completed in CY 1988. Approximately 50,000 gal of storage space was freed. The time required from initiation of the plan to implementation of the solidification campaign could be as long as 2 years; consequently, early decision and planning for this would be important.

6. Use of mobile ion-exchange unit to remove radionuclides from LLLW - Lease arrangements with a vendor to make use of one or more ion-exchange units from the vendor to decontaminate LLLW with respect to dissolved ionic radionuclides is a possible contingency option. Several different types of ion-exchange resins may be required to process a wide variety of dissolved radionuclides.

EVALUATION OF CONTINGENCY PLANS/OPTIONS

The contingency plans/options described above have been evaluated for each of the six different scenarios to select and prioritize practicable options for each. Among the major factors considered in the evaluation were the time and the costs required for implementation. The "normal operation" scenario represents not only the normally scheduled operations (including the restart of HFIR), but also nonroutine D&D activities (e.g., for inactive tanks), and includes implementation of the in-tank evaporation technology and one solidification campaign.

The option to utilize a mobile ion-exchange unit has been excluded from further consideration primarily because of the perceived long lead time and high costs required for development, implementation, safety, and regulatory documentation.

CONCLUSIONS/RECOMMENDATIONS

The scenarios affecting the dilute LLLW system, namely a sudden generation of dilute LLLW and an excessive rainfall, have been determined to have no adverse effect on the LLLW system storage capacity. The amount of dilute liquid waste generated can be readily processed by the existing collection, transfer, and evaporation systems. Loss of evaporation capability, however, might require use of dilute LLLW storage in excess of the current collection and transfer system capacity. The inactive gunite tanks will need to be used if this situation occurs. Although the occurrence of this contingency is quite unlikely, a strategy for the use of the gunite tanks should be developed in the near future. As part of this strategy, some expenditures will need to be made to upgrade the transfer system associated with these tanks.

Those scenarios which affect the LLLW concentrate system include the loss of 50,000 gal of storage capacity (one tank) and an unforeseen LLLW concentrate generation of 30,000 gal. These scenarios are more serious than those affecting the dilute side of the LLLW system. Realistically, if either of these scenarios were to occur, one or more additional solidification campaigns will be required. In the case of a tank failure, the tank vaults themselves will need to be used to temporarily contain the LLLW concentrate, in accordance with the tank vault design. Use of the tank vault for storage in the event of an unexpected, large generation of concentrate is unlikely to occur. However, since this is a possibility, it is recommended that a study be performed to determine the steps necessary to prepare the MVST vaults for such a use.

Recommended, prioritized contingency actions for each accident scenario are summarized in Fig. ES.2, where the numbers correspond to the preferred actions for each contingency (e.g., 1 corresponds to the most favorable option). In conclusion, the projected normal operation of the LLLW system must be modified to include a solidification campaign in addition to the campaign planned for FY 1991. This is needed in order to provide the storage space necessary to continue operation of the system for the next 10 years when WHPP is expected to begin operations. It is recommended that the second solidification campaign be implemented following the FY 1991 campaign. In order to do this, the contract between ORNL and the solidification vendor should be written such that additional solidification campaigns, if necessary, can be performed with minimal effort in the event that the applicable contingencies should occur.

This report was based on the assumption that the WHPP will start up in FY 2000. At present, the WHPP schedule is contingent on several issues that will not be discussed here. However, it is recommended that the contingency planning be reviewed in several years when the WHPP program and schedules are further clarified.

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Scenario / Options	Normal Operation	Evaporator Failure	Loss of Concentrate Storage	Generation of LLLW Concentrate
Solidification Campaign	1		1	1
Use of Old Tanks		2		
Construct New Tanks			3	3
Use Tank Vaults			2	2
Shutdown/Curtail Generators		1		

Fig. ES.2. Summary of ranked contingency options for the various scenarios.

1. INTRODUCTION

Oak Ridge National Laboratory (ORNL) is one of the major Department of Energy (DOE) facilities that performs various research and development (R&D) activities. The use and production of radioisotopes, in and by these activities, represent significant contributions that ORNL makes to the progress of science and technology. Liquid low-level waste (LLLW) is generated in the course of this work. Drains (known as "hot" drains) in sinks, hot cells, and hoods that provide for the collection of LLLW are connected via piping to underground tanks. The LLLW collected in these tanks is transferred to an evaporator facility where the "dilute" liquid is evaporated to reduce the volume of waste, and the concentrated LLLW is stored in underground storage tanks. This concentrated LLLW has been gradually accumulating in the storage tanks since 1984.

Currently, there is no routine, permanent disposal option for this waste, although a few disposal techniques have been used in the past, namely hydrofracture and solidification. Hydrofracture is presently not considered an acceptable disposal option, and solidification is used for disposal only if the stored volume reaches a critical level. This concentrated waste is expected to be processed in the Waste Handling and Packaging Plant (WHPP) and shipped for disposal to the Waste Isolation Pilot Plant (WIPP). These operations are scheduled to begin in the year 2000. In the interim, the LLLW is being stored in the Melton Valley Storage Tanks (MVSTs) and evaporator service tanks and is accumulating at the rate of approximately 26,000 gal/year. At the current rate, the storage space will become exhausted well before the WHPP is expected to become operational. The objective of this report is to describe a contingency plan for handling the LLLW in case the storage space in the MVSTs should decrease so as to affect routine operation of the LLLW system. Also considered is the situation in which an excess of dilute LLLW is generated, thereby depleting the available storage space on the collection side of the system. Several scenarios and various contingency options for individual scenarios are analyzed.

2. DESCRIPTION OF THE LIQUID LOW-LEVEL WASTE SYSTEM

Radioactively contaminated liquid wastes at ORNL are generated by various activities, including research activities performed within many divisions, hot-cell decontamination activities in the isotope development areas of the Chemical Technology Division, and reactor operations within the Research Reactors Division. Other significant sources of LLLW include ORNL's waste treatment facilities, such as the Process Waste Treatment Plant (PWTP - Building 3544) and the Central Off-gas System (Building 3039). Another major LLLW generation source is expected to be the remedial actions cleanup of inactive tanks and facilities during the next 10 years. Further discussion of the LLLW and the generators follows in Sect. 3.

Figure 1 shows a schematic of the LLLW system. The LLLW generated by various activities at the Laboratory is either discharged via "hot" drains located in laboratory sinks, hoods, floors, and hot cells, or the liquid is collected and trucked. Waste that is collected in "hot" drains flows by gravity through singly or doubly contained pipes to underground, stainless steel collection tanks where the waste is neutralized, if necessary. The piping and tanks are known as the Collection and Transfer System (CAT). The waste accumulated in the collection tanks is transferred via underground piping to the LLLW Evaporator Facility (Building 2531), where it is concentrated in one of the two evaporator units that reduce the volume of LLLW by a factor of about 20. From there the concentrated waste is placed in one of several storage tanks, and the condensate collected from the evaporator operation is transferred to the PWTP for further treatment.

2.1 LLLW COLLECTION SYSTEM

ORNL's LLLW collection and transfer system is divided into two branches, the Melton Valley Branch and the Bethel Valley Branch. Currently, there are 22 active, underground collection tanks, 4 of which serve the Melton Valley area and 18 that serve the Bethel Valley area. There are 33 underground, inactive collection and storage tanks. Their locations are shown in Fig. 2. Also shown in the figure is the inactive tank W-1A, which is periodically pumped to the evaporator system because of rainwater inleakage. The collection tanks and their capacities are listed in Table 1. The CAT system was designed and constructed in the 1950s. Most of the floor drains, collection tanks, and transfer lines in the system are singly contained. The system was designed to work approximately 20 years; however, most of it is older than this. Current regulations and

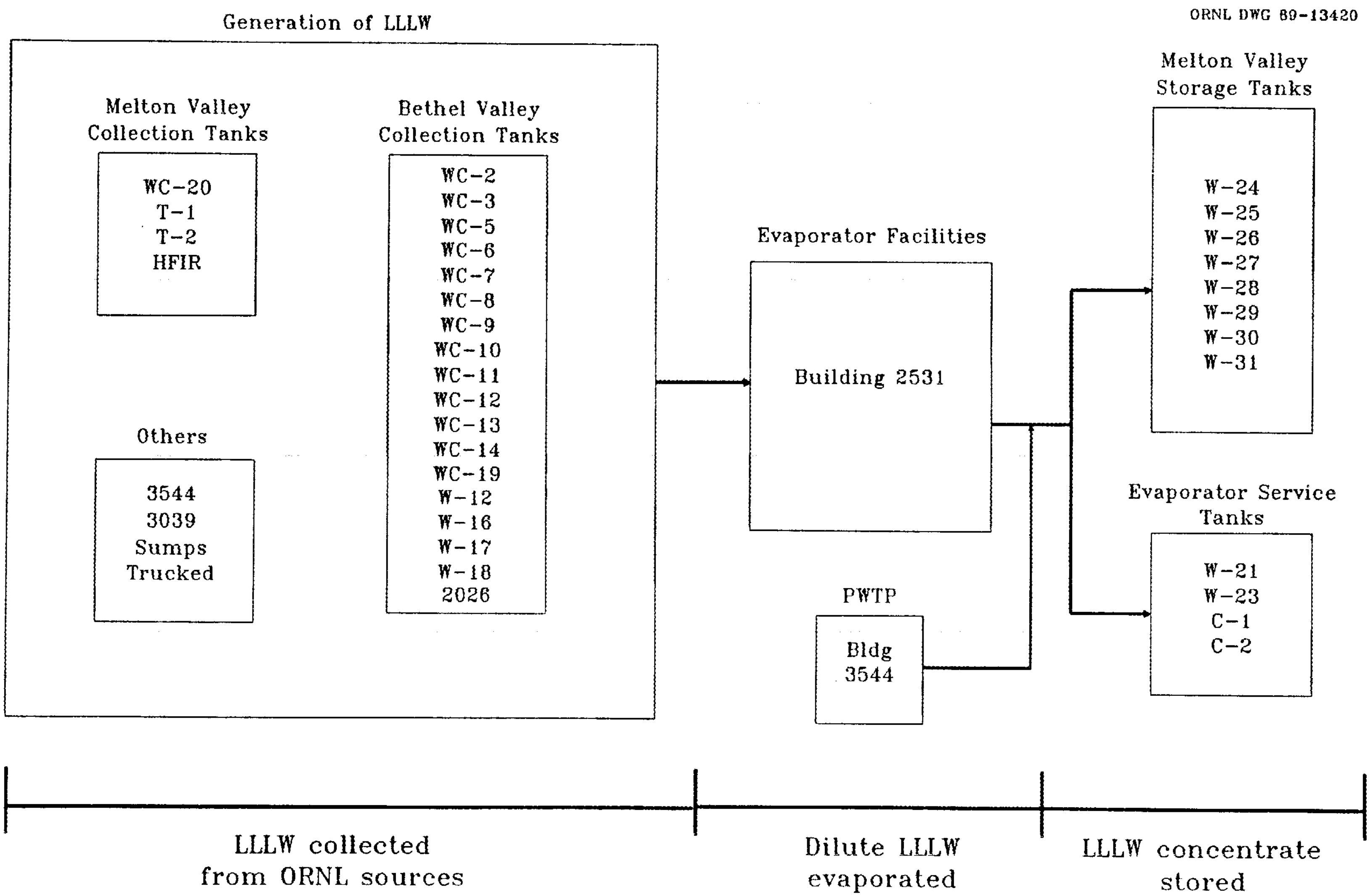

Fig. 1. Description of the LLLW system.

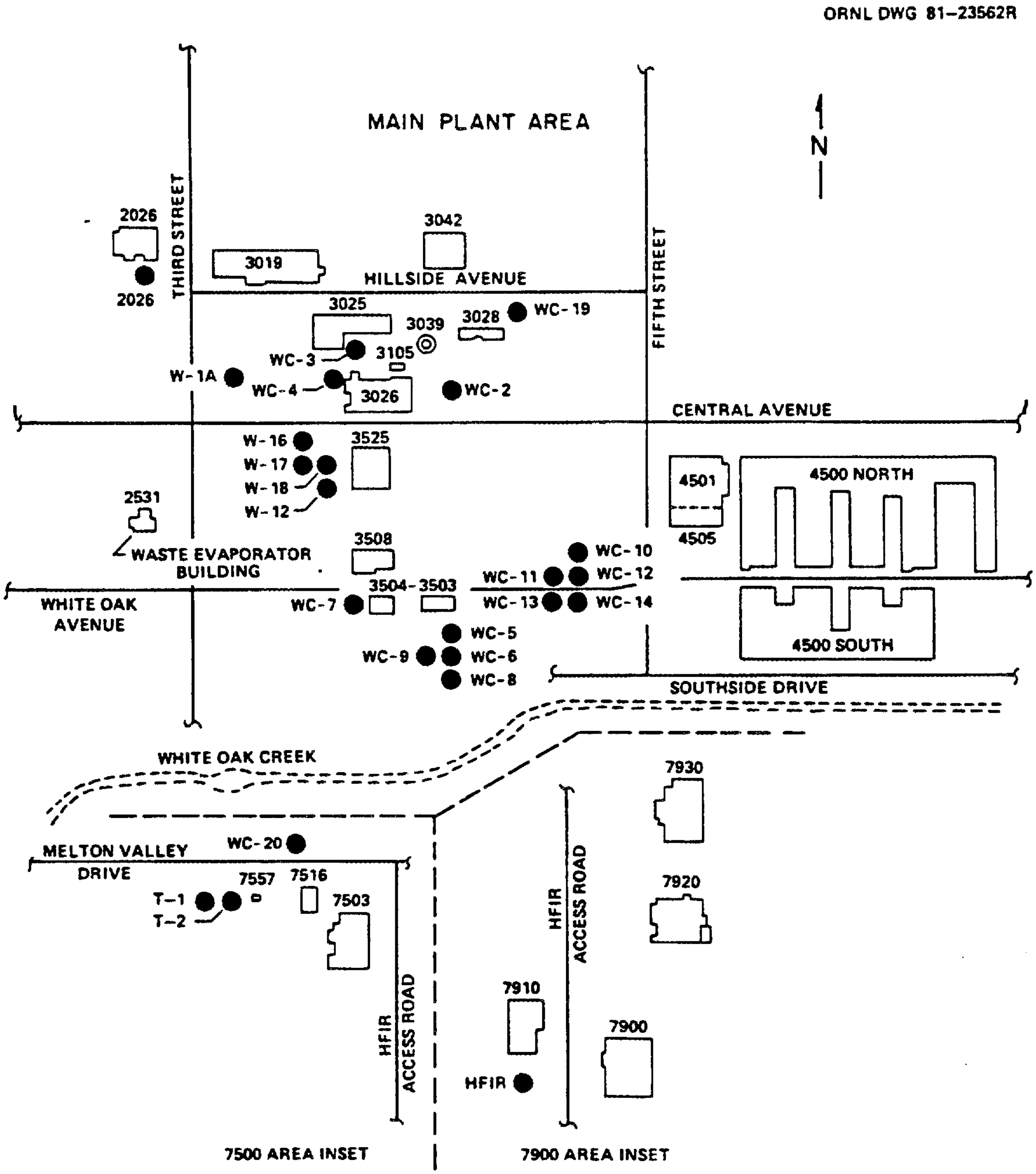

Fig. 2. Locations of active collection tanks.

Table 1. Collection tank capacities and source buildings[a]

Tank	Tank capacity (gal)	Operating capacity (gal)	Source building(s)
	Bethel Valley Collection Tanks		
2026[b]	500	350	2026
W-1A[c,d]	4,000 (Abandoned)	3,000	
WC-2[b]	1,000	700	3028 3038
WC-3[b]	1,000	700	3025E 3025M 3098
WC-4[b,d]	1,700 (Abandoned)	1,200	
WC-5[b]	1,000	750	3508
WC-6[b]	500	350	3508
WC-7[b]	1,100	750	3504
WC-8[b]	1,000	750	Pump pit
WC-9[b]	2,140	1,550	3503 Off-gas
WC-10[c]	2,300	1,650	3028 3029 3030 3031 3032 3033A 3047 3092 3093 3110

Table 1 (continued)[a]

Tank	Tank capacity (gal)	Operating capacity (gal)	Source building(s)
WC-11[c]	4,600	2,900	4500N 4505 4507 4507
WC-12[b]	1,000	700	4505
WC-13[b]	1,000	700	4500N 4500S 4501 4508
WC-14[b]	1,000	700	4501
WC-19[c]	2,100	1,500	3001 3002 3003 3004 3005 3008 3042 3109 3119
W-12[b]	700	400	3525E
W-16[b]	1,000	700	3026D
W-17[b]	1,000	700	3026C
W-18[b]	1,000	700	3026C

Table 1 (continued)[a]

Tank	Tank capacity (gal)	Operating capacity (gal)	Source building(s)
	Melton Valley Collection Tanks		
WC-20	10,000	7,000	7920 7930
T-1	15,000	10,500	7500 7503 7900 7911 7913 7920 7930
T-2	15,000	10,500	7500 7503 7900 7911 7913 7920 7930
HFIR	13,000	9,100	7900 7911 7913

[a]Data taken from ref. 2.
[b]Vertical tank.
[c]Horizontal tank.
[d]Inactive tank.

orders pertaining to this system require doubly contained piping and tanks, leak detection, and extensive documentation of waste generation. In order to comply with the regulations, the system is being upgraded and/or replaced. This work,which is under way, is expected to take approximately 6 years to complete.

Each collection tank is equipped with a sampling device, liquid-level instrumentation, and a filtered vent to the atmosphere or to the off-gas system of the facility that it serves. Underground collection tanks in the Bethel Valley area have "dry wells," which are concrete pads with sumps located at the low point and wells extending to the surface of the ground where groundwater is sampled to identify tank leakage. A typical tank design is shown in Fig. 3. A network of 0.05- and 0.08-m (2- and 3-in.) stainless steel underground pipelines connects the collection tanks to one of two 0.15-m (6-in.) doubly contained, stainless steel collection headers that direct the flow through doubly contained piping to the evaporator feed tank, W-22. Several source buildings feed waste directly to the collection header at valve box 2 and then directly to tank W-22. Waste is transferred by centrifugal pumps or steam jets.[1,2]

2.2 LLLW EVAPORATOR FACILITY

Liquid low-level waste solutions that accumulate in the collection tanks are periodically transferred to the evaporator service tank W-22 and then fed to evaporators A-2 and/or 2A-2 in which the processing of the radioactive waste solution is accomplished. The two evaporators are operated in a semicontinuous manner. Dilute LLLW is transferred by steam jet from feed tank W-22, as necessary, to maintain an operating level in the evaporator, where the waste is concentrated to a target specific gravity of approximately 1.25. The evaporator condensate, which may contain traces of radionuclides, is directed to the PWTP for further treatment.

When the evaporator bottoms or concentrated waste reaches a specific gravity between 1.25 and 1.5, or when there is no feed left to process, the evaporator is shut down, the contents cooled, and the "concentrate" jetted to one of the 12 storage tanks, which are discussed in more detail in Sect. 2.4.

The transfer of the concentrate from the evaporator facility to the storage tanks is done through a doubly contained stainless steel line that is cathodically protected and buried in a bed of specially prepared clay. The transfer route to the Melton Valley area (where eight of the storage tanks are located) is shown in Fig. 4.

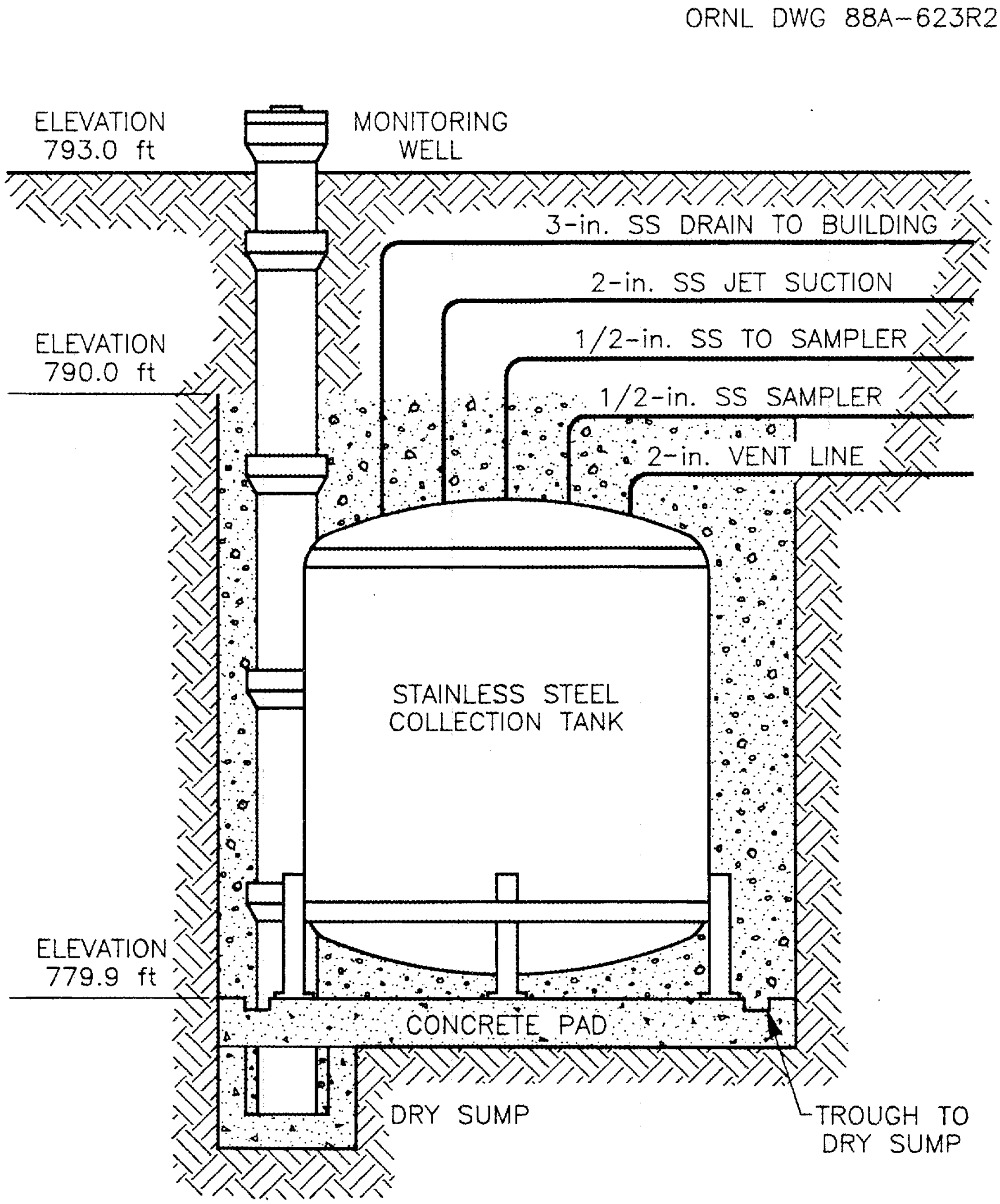

Fig. 3. Typical vertical collection tank.

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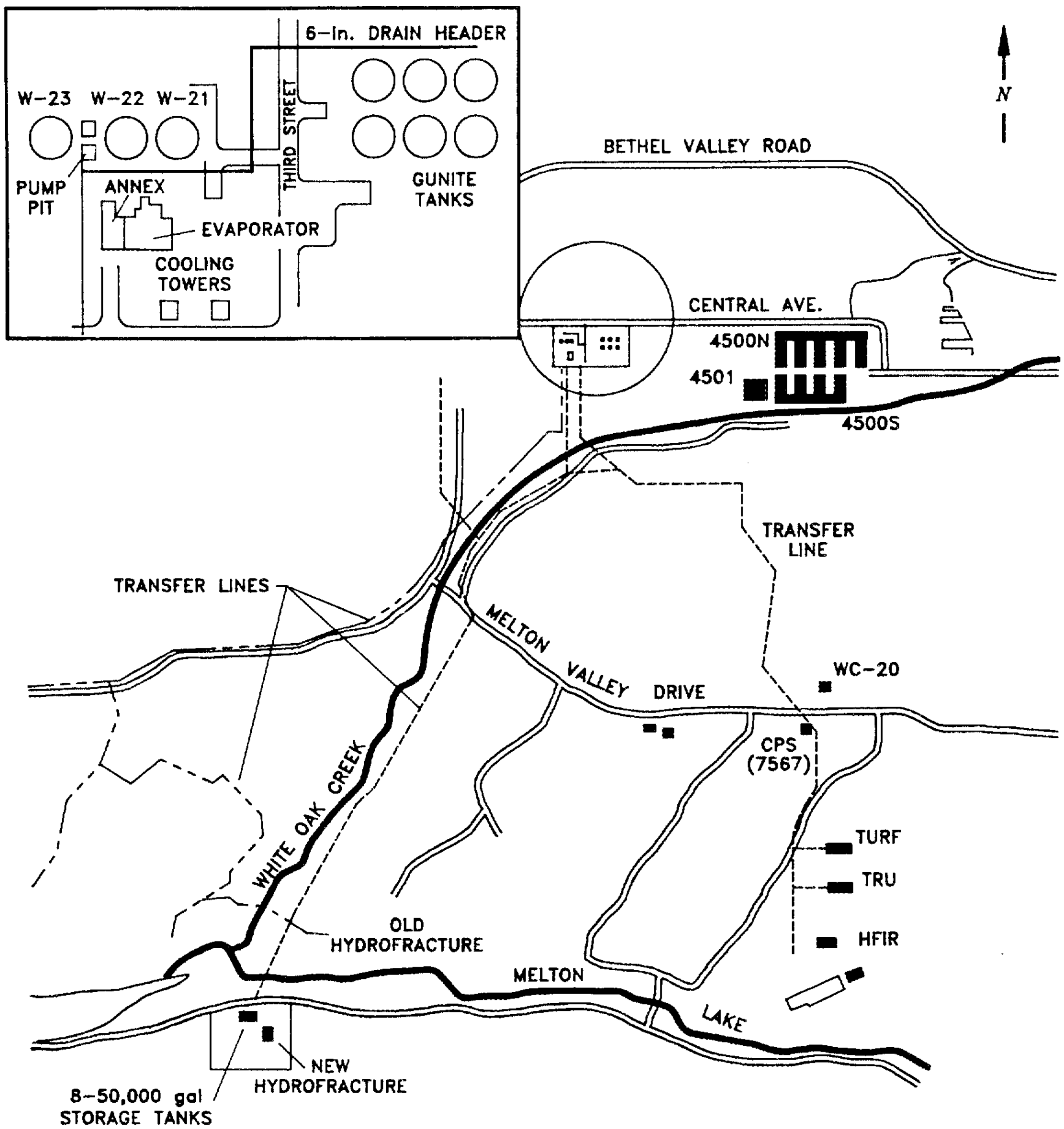

Fig. 4. Transfer line to the Melton Valley hydrofracture site.

2.3 LLLW EVAPORATOR FACILITY COMPLEX

The Radioactive Waste Evaporator Facility (Bldg. 2531), shown in the plan view of Fig. 5, includes the following major areas:

1. Evaporator service tank vault containing the evaporator feed tank W-22, the converted evaporator feed tank W-21 (now a storage tank for concentrated liquid waste generated by the PWTP), the concentrate storage tank W-23, and associated pumps, pipes, and controls. The evaporator service tanks W-21 and W-22 are enclosed in underground stainless-steel-lined concrete vaults.[1,2]
2. Underground pipe trench, for the transfer of liquid waste from the feed tank to the evaporator.
3. The HLW tank vault containing tanks C-1 and C-2, which are now storage tanks for concentrated waste from the evaporator.
4. Cells 1 through 4 in Building 2531, which contain the evaporators and associated equipment. Cell 1 contains evaporator A-2 and its feed tank, A-1. Cell 2 contains the auxiliary process equipment associated with evaporator A-2, which includes the condenser, vapor filter, condensate catch tank, off-gas scrubber, emergency condenser, and scrub liquor tank. Cell 4 holds evaporator 2A-2, and Cell 3 contains the condensate filter, evaporator condenser, condensate surge tank, off-gas scrubber, and the scrub liquor tank for evaporator 2A-2. Also in the building are the control room and service tunnel.

2.4 LLLW CONCENTRATE STORAGE TANKS

ORNL has twelve 50,000-gal capacity tanks for the storage of LLLW concentrate. Eight of these tanks, known as the MVSTs, are located on the new hydrofracture site in an underground concrete, stainless-steel-lined vault. The other four storage tanks, C-1, C-2, W-21, and W-23, are situated near the evaporator facility. Both C-1 and C-2 were originally built to contain high-level waste, but since high-level waste is not currently generated at ORNL, they were repiped to receive LLLW concentrate. W-21, originally a feed tank for the LLLW evaporator, was converted to a storage tank for LLLW concentrate produced by the PWTP in an effort to decouple the PWTP and LLLW operations. Currently, tank W-22 serves as the sole evaporator feed tank. Tank W-23, which receives concentrate directly from the evaporator, is normally used as a collection point for LLLW concentrate before it is transferred to the MVSTs or tanks C-1 and C-2 for storage.[1,2]

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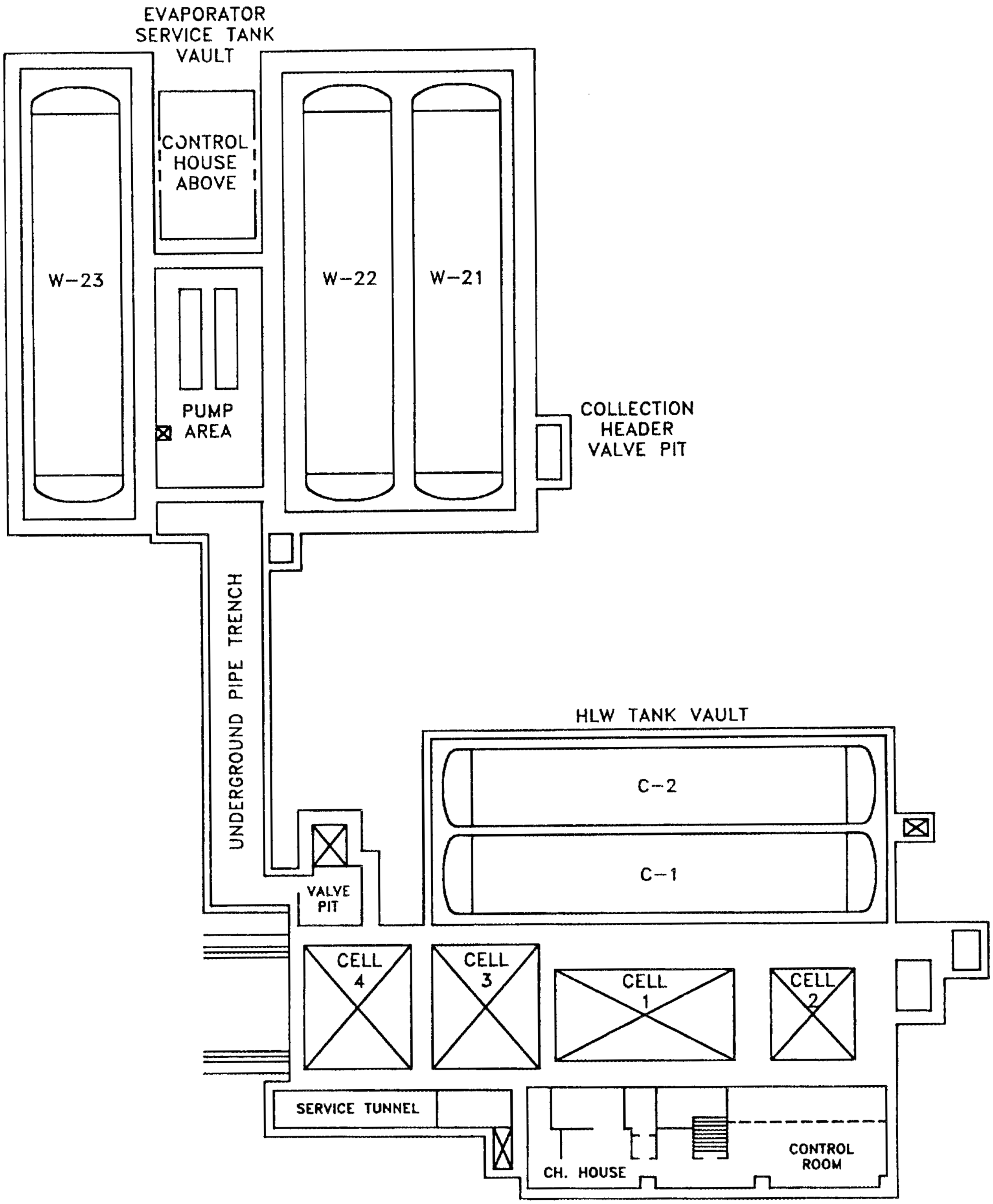

Fig. 5. Plan view of the Evaporator Facility Complex, Bldg. 2531.

3. SOURCES AND CHARACTERISTICS OF LIQUID LOW-LEVEL WASTE

Several facilities, as mentioned briefly in Sect. 2, contribute to the production of LLLW. The types of radioactive liquid wastes generated at ORNL arise from several different sources: (1) air and water treatment facility operations, (2) the decontamination of hot cells and various areas, and (3) R&D processes. Of these types, wastes from air and water treatment have accounted for approximately 34% of the dilute LLLW generated since 1986. Decontamination activities have produced about 45% of the waste; and other activities, including R&D activities and rainwater infiltration, account for the remaining 21% of the dilute LLLW generated during the past 3 years. The majority of this waste is rainwater inleakage. Contributions of rainfall to the LLLW system are discussed further in Sect. 3.2.

3.1 LLLW GENERATORS

Detailed information about LLLW generation rates and the activities of specific generators will be reviewed in this section. Section 3.2 will summarize attempts to determine the effects of rainfall in the LLLW collection and transfer system.

Table 2 summarizes the total dilute LLLW collections from all generators for the period 1986 through the first quarter of 1989. From 1986 to 1988, the dilute LLLW collections declined by approximately 44%, indicating that most generators have substantially decreased their LLLW production rates.

As mentioned in Sect. 2, the ORNL LLLW System is used to collect, neutralize, concentrate, and store radioactive waste solutions. Annual summaries of the LLLW collected from specific generators are contained in Tables 2-5. Tables 3, 4, and 5 summarize yearly LLLW generation rates for 1986, 1987, and 1988, respectively. As the data in these tables demonstrate, relatively few generators are responsible for the majority of the LLLW collected at ORNL since 1986. The primary generators and their contributions to the monthly collection of dilute LLLW are the Isotopes Area (16%), the 3039 Stack Area (11%), the High Flux Isotopes Reactor (HFIR) (11%), the Oak Ridge Research Reactor (ORR) and the Bulk Shielding Reactor (BSR) (11%), the Fission Products Development Laboratory (FPDL) (10%), the High-Radiation-Level Experimentation Laboratory (Bldg. 3525) (9%), the 4500 Complex (8%), the Radiochemical Engineering Development Laboratory (REDC) (4%), Building 3019 (3%), and the PWTP spent acid stream (3%). General descriptions of the activities of major

Table 2. Average monthly dilute LLLW generation (1986-4/9/89)

Generator	Monthly generation (gal)	Percent of total
Isotopes Area[a]	5189	16
3039 Stack Area	3629	11
HFIR	3571	11
Reactors[b]	3433	11
FPDL	3204	10
Bldg. 3525	2809	9
4500 Complex	2604	8
Tank W1-A[c]	2547	8
REDC	1391	4
Bldg. 3019	1065	3
PWTP spent acid	1011	3
Tank WC-8 pump pit	598	2
All others	1031	4
Total	32,082	

[a]Includes all collections from Isotopes Area collection tank, Bldg. 3026C collection tank, and Bldg. 3026D collection tank.

[b]Includes the ORR and the BSR.

[c]Tank W1-A has been abandoned, and the collections are considered to be primarily rainwater.

Table 3. Average monthly dilute LLLW generation for 1986

Generator	Monthly generation (gal)	Percent of total
Isotopes Area[a]	7466	17
Reactors[b]	5455	13
HFIR	5370	12
4500 Complex	5110	12
FPDL	4629	11
Bldg. 3525	3770	9
3039 Stack Area	3480	8
PWTP spent acid	2130	5
Tank W1-A[c]	1720	4
REDC	1608	4
Bldg. 3019	1151	3
Tank WC-8 pump pit	534	1
All others	703	2
Total	43,126	

[a]Includes all collections from Isotopes Area collection tank, Bldg. 3026C collection tank, and Bldg. 3026D collection tank.

[b]Includes the ORR and the BSR.

[c]Tank W1-A has been abandoned, and the collections are considered to be primarily rainwater.

Table 4. Average monthly dilute LLLW generation for 1987

Generator	Monthly generation (gal)	Percent of total
Isotopes Area[a]	3779	14
Reactors[b]	3601	13
3039 Stack Area	3539	13
FPDL	3362	12
HFIR	2620	10
4500 Complex	2419	9
Bldg. 3019	2172	8
Bldg. 3525	1830	7
REDC	1188	4
Tank W1-A[c]	1004	4
PWTP spent acid	592	2
3503 and off-gas drain	457	2
Tank WC-8 pump pit	293	1
All others	532	1
Total	25,216	

[a]Includes all collections from Isotopes Area collection tank, Bldg. 3026C collection tank, and Bldg. 3026D collection tank.

[b]Includes the ORR and the BSR.

[c]Tank W1-A has been abandoned, and the collections are considered to be primarily rainwater.

Table 5. Average monthly dilute LLLW generation for 1988

Generator	Monthly generation (gal)	Percent of total
Isotopes Area[a]	3766	16
3039 Stack Area	3275	14
FPDL	3150	13
HFIR	2996	12
Bldg. 3525	1857	8
REDC	1742	7
4500 Complex	1605	7
Reactors[b]	1378	6
Tank W1-A[c]	1161	5
Bldg. 3019	899	4
PWTP spent acid	652	3
Tank WC-8 pump pit	537	2
All others	1064	3
Total	24,082	

[a]Includes all collections from Isotopes Area collection tank, Bldg. 3026C collection tank, and Bldg. 3026D collection tank.

[b]Includes the ORR and the BSR.

[c]Tank W1-A has been abandoned, and the collections are considered to be primarily rainwater.

LLLW generators are presented in the succeeding sections. Building 3019 is expected to be only a minor LLLW generator in the future, and tank W1-A is an inactive tank; therefore, they are not discussed further.

3.1.1 Isotopes Area

The Isotopes facilities at ORNL are used primarily for producing and distributing various radionuclides. A wide range of radioisotopes are handled, and major activities include tritium processing, ^{85}Kr enrichment, short-lived fission product processing, ^{137}Cs and ^{90}Sr source fabrication, ^{60}Co storage and irradiation, ^{99}Tc processing, and some transuranic isotope processing.

While the Isotopes Area is primarily involved in development, very little LLLW is generated as a direct result of processing activities; most of it is the result of routine and nonroutine hot-cell decontamination. The primary nuclides expected to be in the waste streams generated from these facilities are ^{137}Cs, ^{90}Sr, and ^{131}I.

As summarized in Table 2, LLLW collections from the Isotopes Area have accounted for 16% of the total LLLW collections since 1986. The level of LLLW generation from the Isotopes Area decreased about 40% from 1986 to 1987. Since 1987, it has remained at approximately 3800 gal/month.

3.1.2 3039 Stack Area

Off-gas streams generated by processes or various R&D activities are vented to the Central Off-gas Collection System (Bldg. 3039). The primary purpose of this system is the removal of radioactive iodine; however, the off-gases potentially contain other radioactive species, flammable vapors, and toxic vapors. After collection, the gases are scrubbed with a 0.5 % caustic (NaOH) solution, passed through a HEPA filter, and then discharged. The scrubbing operation produces a spent caustic solution that is slightly radioactively contaminated. The 3039 Stack Area produces approximately 3700 gal of dilute LLLW per month and accounts for approximately 11% of the total LLLW collected since 1986.

3.1.3 High Flux Isotopes Reactor

LLLW collected from the HFIR is generated primarily from the following sources: (1) regeneration and backwashing of primary and pool demineralization systems, (2) waste from sampling, (3) head tank overflow, (4) gaseous waste filter pit, (5) 7911 stack drainage, and (6) the off-gas condensate collection pit.[3] An analysis of the primary demineralizer LLLW stream has been summarized by Pretez et al.[4] The LLLW generation rate in 1986 was approximately 5370 gal/month; however, since the HFIR shutdown, it has fallen to approximately 2700 gal/month. When the HFIR restarts in 1989, this reactor will probably become the largest LLLW generator.

The most significant LLLW generation sources in the HFIR facility are the solutions produced by the regeneration and backwashing of the primary and pool demineralization systems. These solutions account for approximately 17,250 gal of LLLW annually and also represent the primary source of ^{60}Co in the LLLW system at ORNL.[3]

3.1.4 Oak Ridge Research Reactor/Bulk Shielding Reactor

The ORR was shut down permanently in 1987 and will not be restarted. Current and future wastes generated by this reactor are the result of decontamination and decommissioning activities and consist primarily of ion-exchange column regenerant solutions.

The BSR is expected to continue operation. Sources of LLLW from the BSR are cooling water and ion-exchange column spent regeneration solutions. The monthly LLLW generation from these facilities has averaged approximately 3400 gal/month since 1986, falling from a level of 5500 gal/month in 1986 to approximately 1400 gal/month in 1988. Much of the decrease is due to the shutdown of the ORR and relatively light rainfall in 1987 and 1988.

3.1.5 Fission Product Development Laboratory (FPDL, Bldg. 3517)

Large quantities of ^{137}Cs (approximately 350,000 Ci/year) and ^{90}Sr (approximately 500,000 Ci/year) are processed at the FPDL. Other materials that might be processed at the FPDL are ^{60}Co and ^{192}Ir. Materials that have been handled in the past include ^{144}Ce and ^{147}Pm.

Building 3517 is the primary source of both cesium and strontium in the LLLW system. Estimated losses of each material to the LLLW system are on the order of 5,000 to 15,000 Ci per year. The activities that generate LLLW are not directly related to isotope processing. LLLW is primarily generated by routine decontamination of the hot cells that are used in cesium and strontium purification.

The facility's LLLW production since 1986 has averaged approximately 3200 gal/month, but the level decreased substantially during the period from 1986 to 1989.

In fact, the LLLW production rate in 1986 was approximately 4600 gal/month, and by 1988 that rate had fallen to 3150 gal/month. Recently, improvements have been made to the building's tank vault that have reduced groundwater inleakage; consequently, the LLLW generation rates are expected to decrease even further.

3.1.6 High-Level Radiation Examination Laboratory (HRLEL, Bldg. 3525)

The HRLEL primarily serves as an area where irradiated metallurgical specimens can be examined. Currently, the facility is expected to handle a variety of radionuclides, including ^{137}Cs and uranium, plutonium, and thorium isotopes. The area possesses both hot cells and storage wells for containment of radioactive materials.

The average monthly LLLW generation rate since 1986 has been approximately 2800 gal. The LLLW generation rate decreased from 3770 gal/month in 1986 to 1857 gal/month in 1988. In 1989, the LLLW generation rate is expected to increase to approximately 2500 gal/month because of hot-cell decontamination activities.

3.1.7 4500 Complex

The 4500 Complex (Bldgs. 4500N, 4500S, 4501, and 4508) serves as a multipurpose research facility. There is a large variation in the radioactive materials that are handled in the complex, and trace quantities of any radionuclide used at ORNL could originate at one of many active hot drains (approximately 89) in the facility.[5]

The 4500 complex has historically accounted for between 7 and 8% of all LLLW collected at ORNL. Since 1986, the average LLLW generation rate has been approximately 2600 gal/month. The monthly generation rate decreased from approximately 5110 gal in 1986 to only 1605 gal in 1988.

3.1.8 Radiochemical Engineering Development Center (REDC)

The REDC recovers a variety of radiochemicals produced by irradiation of selected isotopes.[6] The REDC has consistently generated approximately 1500 gal of LLLW per month. The LLLW is primarily generated from disposal of spent off-gas scrubber solutions, which typically have low radioactivity levels. Small volumes of waste are generated as a direct result of isotope processing from operations conducted at the REDC. These wastes, which are sent to the LLLW system, are major contributors to the transuranic isotope concentration in the system.

3.2 RAINFALL INLEAKAGE INTO THE LLLW SYSTEM

Inleakage of rainfall into the LLLW collection and transfer system has been qualitatively recognized for some time; however, a quantitative estimate of the effects of rainfall on the volume of LLLW collected at ORNL has not been previously made. Therefore, a quantitative relationship between rainfall levels and LLLW collections was developed to determine which of the tanks in the LLLW system were affected by rainfall.[7]

A time series analysis identified LLLW collections in the following tanks to be significantly influenced by rainfall: WC-19, W-1A, WC-11, WC-12, Bldg. 3517 tanks, WC-8, WC-5, W-17, and W-18. It was estimated that approximately 1500 gal of LLLW is collected from the above tanks for each inch of rainfall.[7] In addition, several filter pits and sumps throughout ORNL collect rainfall, which is sent to the LLLW system. Considering these other sources, it is estimated that a total of approximately 2000 gal of dilute LLLW is collected in the CAT system from each inch of rainfall.

3.3 CONCENTRATE GENERATION AND AVAILABILITY OF STORAGE SPACE

Hydrofracture was used as a means of disposing of LLLW concentrate until 1984 but was discontinued because of permitting issues and the need for extensive facility modifications. Currently, LLLW concentrate is being accumulated and is stored in the MVSTs and the Bethel Valley tanks. The capacities and waste volumes of the storage tanks are shown in Table 6.[8]

Figure 6 shows the decrease of available storage space for LLLW concentrate since 1986. As seen in the figure, the 1988 Emergency Avoidance Solidification Campaign (EASC) released about 47,000 gal of tank space. In the EASC, this LLLW concentrate was immobilized in a concrete-based mixture, and the solid waste forms that were produced are now in interim storage.

The monthly rate of concentrate generation since 1986 is shown in Table 7. This generation rate is expected to increase during the next several years for the following reasons: (1) nonroutine decontamination of facilities and hot cells, (2) D&D of inactive tanks by the Remedial Action Programs (RAP), and (3) the HFIR restart.

A procedure known as in-tank evaporation will be utilized in order to reduce the amount of liquid waste stored in the MVSTs. Each of the eight storage tanks has a ventilation system for purging gases from its contents, as well as submerged air sparges used to mix the contents. In the in-tank evaporation scheme, dry air will be introduced into each tank and will ideally leave the contents saturated. Several studies have been

Table 6. Capacities and waste volumes of LLLW concentrate storage tanks

Tank	Capacity (gal)	Volume stored (gal)[a]
	Melton Valley Storage Tanks	
W-24	50,000	45,700
W-25	50,000	45,700
W-26	50,000	45,780
W-27	50,000	46,190
W-28	50,000	44,630
W-29	50,000	22,750
W-30	50,000	21,890
W-31	50,000	45,420
	Bethel Valley Evaporator Service Storage Tanks	
W-21[b]	50,000	29,920
W-23	50,000	42,670
C-1	50,000	6,939
C-2	50,000	45,220
Total:	600,000[c]	442,809

[a]Volumes of waste stored as of April 1, 1989.
[b]Tank W-21 is currently receiving concentrated waste from the PWTP.
[c]This is the total capacity of the tanks. The operating capacity is 570,000 gal.

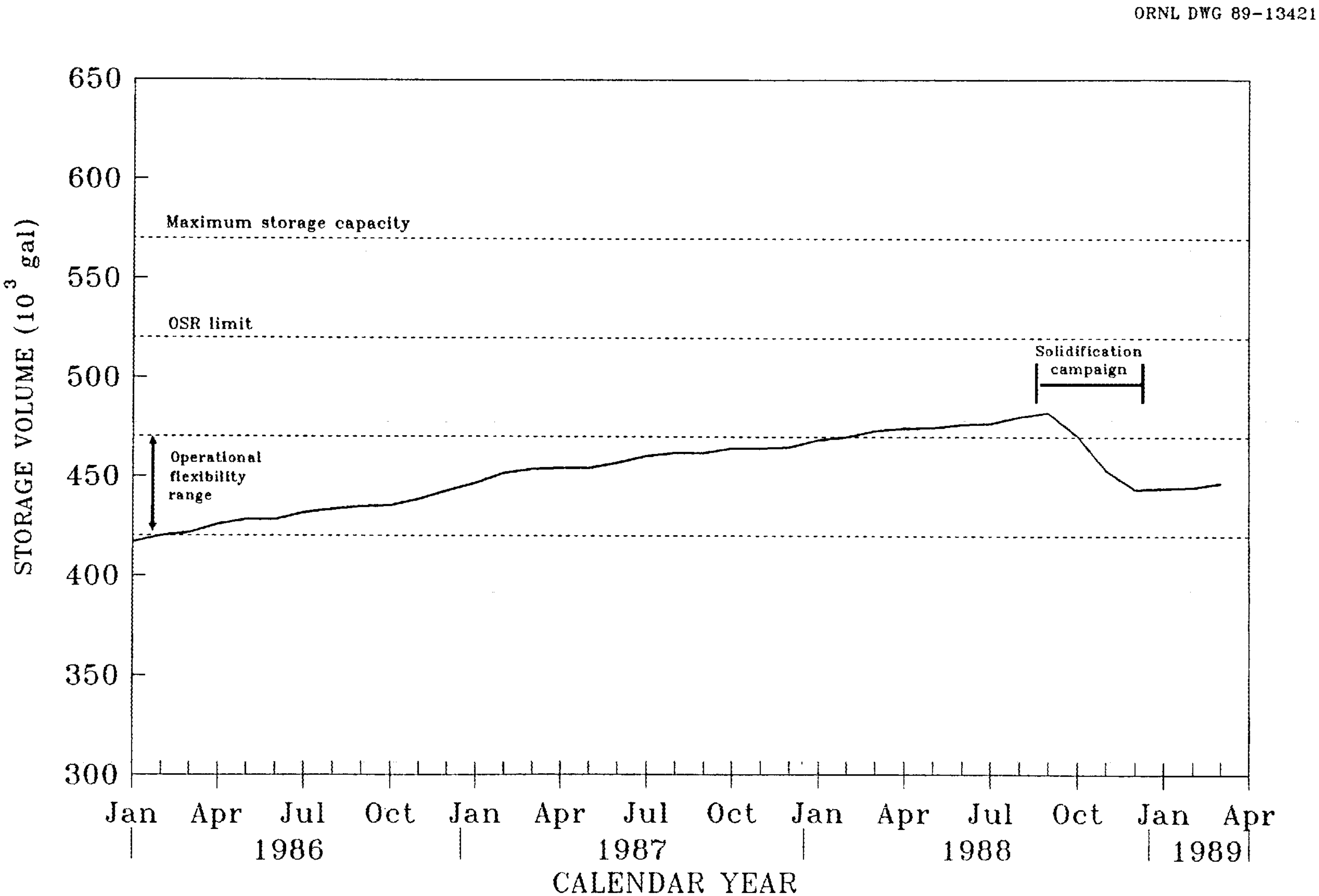

Fig. 6. Historical LLLW concentrate generation (1986–1988).

Table 7. Generation of LLLW concentrate since 1986

Month	Volume (gal) in 1986	1987	1988	1989
January	5308	3925	3912	473
February	2855	4988	1690	524
March	2405	1994	3097	280
April	4032	625	1396	
May	2363	0	280	
June	0	2489	1739	
July	3900	2553	426	
August	2484	1459	3496	
September	1217	0	3509	
October	1768	1690	130	
November	3567	0	276	
December	4470	330	306	
Total	34,369	20,053	20,257	
Average	2864	1671	1688	

completed to determine the viability of in-tank evaporation and its effect on storage volume availability. As determined by these studies, in-tank evaporation is expected to free approximately 3000 gal per year per storage tank. This rate is based on the following assumptions: (1) 80% on-line time, (2) saturation temperature of 50°F, (3) bone-dry input air to the tanks, and (4) outlet air that is saturated with water. At an ambient temperature of 90°F, this liquid evaporation rate increases to about 10,000 gal per year per tank.[3]

In-tank evaporation is scheduled to begin in FY 1990. This process is expected to continue until the saturation limits of the salt components (predominantly $NaNO_3$) in the storage tanks are reached. Preliminary estimates indicate that approximately 40% of the volume in the MVSTs can be evaporated without precipitating these materials.[9]

4. CONTINGENCY OPTIONS

Currently, there is not sufficient storage volume to contain the LLLW concentrate to be generated in the next 10 years, assuming that it continues at its current rate or increases significantly (as would be expected). In addition, accident scenarios may be visualized in which the storage volume is further reduced. These scenarios include unforeseen generation of LLLW concentrate and a tank failure. Certain conditions may occur that would threaten the available storage space for dilute LLLW (e.g., heavy rainfall, unforeseen generation of dilute LLLW, or possibly failure of both evaporators). In any case, some action would need to be taken to alleviate the storage-volume situation.

Several options have been identified as suitable approaches in the event that the available tank storage space on either side of the evaporator should decrease beyond the operability limit. These options are: (1) use of the inactive gunite tanks for storage of dilute LLLW, (2) use of the tank vaults for storage of concentrated LLLW, (3) construction of new storage tanks, (4) shutdown/partial shutdown of selected generators, (5) additional solidification campaigns, and (6) use of a mobile resin treatment unit. These options, as well as their applicability to specific situations and their overall feasibility, will be discussed in detail in this section. Analyses of accident scenarios and the applied options are covered in Sect. 5.

4.1 GUNITE TANKS

The six gunite tanks (capacity, 170,000 gal each) are located in the South Tank Farm, west of the 4500 Complex and adjacent to Central Avenue. These tanks were constructed in 1943 and removed from active service in 1978. In 1984, most of the contents of the tanks were pumped out and permanently disposed of by hydrofracture. Each tank has an associated dry well; all dry wells are in working condition and are routinely tested to determine possible tank leakage by the Environmental and Health Protection Division (E&HP). The off-gas ventilation system is still in operation, and the tanks are constantly vented.[10] Table 8 contains the liquid and sludge volumes as measured in the tanks in the 1988 sampling campaign conducted by the Remedial Actions group.[8]

Table 8. Residual volumes of liquids and sludges in the gunite tanks

Tank	Liquid volume (gal)	Sludge volume (gal)
W-5	9,939	4,895
W-6	74,171	4,895
W-7	7,417	4,895
W-8	22,251	2,522
W-9	12,312	2,522
W-10	67,941	6,230

The use of the gunite tanks should be considered only in an emergency situation since they are inactive. Thus, these tanks are not recommended as an alternative unless all other options have been explored. In addition, their use is limited to the storage of dilute LLLW; they cannot be used for concentrated LLLW because of piping configurations.

Tanks W-9 and W-10 could be used to store waste temporarily. Equipment for sluicing the sludge from them, installed during hydrofracture operations, could be used to gain access to these two tanks in an emergency situation. The cooperation of RAP personnel would be required, since the tanks are under their jurisdiction. Access to these two tanks could be accomplished quickly; however, the removal of liquids from the tank(s) would require some equipment repair and/or replacement. Specifically, piping would need to be installed in order to utilize existing pumps. These modifications would take approximately 1 week to complete, and the cost is roughly estimated at $10K. In addition to these piping modifications, a strategy document for using the gunite tanks in an emergency situation should be developed.[11]

The other tanks, W-5, W-6, W-7, and W-8,could be accessed with some piping changes, but again, this is not suggested as an option except in an emergency situation. Section 5.3 discusses accident scenarios and circumstances in which the gunite tanks might be used.

4.2 TANK VAULTS

Tank vaults in the MVST and evaporator areas may need to be used for the storage of LLLW concentrate in the case of an emergency.

The Melton Valley area has two vaults, each containing four storage tanks. The vaults are vented and serve as secondary containment for the tanks. Their walls are made of reinforced concrete and are lined inside with 16-gauge 304L stainless steel to a height of 7 ft. The liner is welded and was tested at the time of welding in accordance with inspection procedures. Each vault has a SS-lined void capacity of about 100,000 gal and a sump that would enable liquid in the vault to be pumped to an MVST as storage space becomes available.[12] These vaults could be used for the storage of liquid concentrate in the case of an emergency.

The evaporator area has two tank vaults, one which holds tanks W-21 and W-22 and one containing tank W-23. Each vault is made of reinforced concrete and has a stainless steel liner. Since these vaults are older (operations at the evaporator facility started in 1965) and the gunite tanks are available as an emergency option for storage of dilute LLLW, their use as emergency storage space was considered impractical.

4.3 NEW STORAGE TANKS

One option that will alleviate the storage capacity problem at ORNL is the construction of new tanks. The obvious advantage of this option is the additional concentrate storage capacity that new tanks would provide. If four new tanks identical to the present MVSTs were constructed, this would amount to approximately 200,000 gal of extra storage space.

Another advantage afforded by the construction of new tanks concerns the front end of the evaporator system. While additional tank storage space on the collection side of the evaporator will not directly affect the storage volume for LLLW concentrate, indications are that it would influence the rate of concentrate generation. Studies have shown that additional feed-side capacity in the LLLW system would enable the reduction of concentrate generation by as much as 30%.[7]

Several disadvantages are associated with the construction of new storage tanks, namely, the cost of construction and maintenance and the time required to complete the task. Table 9 lists the estimated costs of constructing new storage tanks. Based on the construction costs of the MVST system, one new concentrate storage tank would cost

Table 9. Estimated total costs of one, two, and four new concentrate storage tanks

Subtotal	Estimated cost ($$10^3$)[a]		
	One tank	Two tanks	Four tanks[b]
Equipment and construction	4321	5262	6686
Engineering	665	831	923
Contingency	1219	1551	1900
Total	6205	7644	9509

[a]Costs escalated from FY 86-3 costs to FY 89-2 costs (see ref. 13).
[b]Extrapolated from data (in ref. 13).

approximately $ 6 million (1989 dollars), while four new tanks would cost approximately $9.5 million.[13] In either case, the project would need to be funded as a line item; consequently, the period for construction would be approximately 6 years. The WHPP is expected to be operational in 10 years. In summary, this option is not favorable because of the high cost and the length of implementation.

4.4 SHUTDOWN OF GENERATORS

Halting the generation of LLLW at specific sources is one option that may be employed if the availability of storage space for either dilute or concentrated LLLW is depleted. In terms of situations affecting the available storage for dilute LLLW, curtailment of LLLW generation at certain sources would be necessary for only short periods of time, whereas long-term halts in LLLW generation would be necessary to affect the concentrate-side storage availabilities.

Of course, those facilities which generate LLLW when treating waste liquids or gases for release to the environment are unable to shut down for any length of time since such operations are critical in maintaining a safe environment at ORNL. Facilities that operate in this capacity include the PWTP and 3039 Stack Facility. The PWTP treats the process liquid waste generated at ORNL and, in doing so, generates an LLLW stream. A caustic scrubber unit in the 3039 Stack Facility produces a spent scrubber solution that is slightly radioactive. Several facilities have off-gas filter pits and sumps that collect rainwater and groundwater, which are sent to the LLLW system. The reactors (HFIR, ORR, and BSR) periodically generate LLLW streams when regenerating their pool demineralizer columns.

The largest generator, in addition to those mentioned above, is the Isotopes Area. This area generates LLLW on a regular basis, mainly as a result of decontamination and cleanup of hot cells; LLLW is infrequently generated by the processes being performed in this area. As mentioned previously, the Isotopes Area purifies and packages radioisotopes for various uses, including research, medical, and national defense purposes. If these facilities were forced to stop generating LLLW for long periods, it would have a severe effect on ORNL in terms of current and future funding levels, as well as having a detrimental effect on the institutions relying on the availability of these isotopes.

A 4-month period is estimated as the length of time in which dilute LLLW would need to be stored because of failure of both evaporators. This scenario (analyzed in detail in Sect. 5.3.1) would affect the available storage capacity of dilute LLLW; therefore, the time frame was assumed to be a reasonable short-term period in considering the halt of LLLW generation. Table 10 lists both those generators who can and those who cannot stop the generation of LLLW for 4 months or less. As seen in the table, approximately 20% of the normal generation rate of dilute LLLW can be curtailed for this length of time. If the situation were quite severe, Bldg. 3150 and a portion of the Isotopes Area could curtail generation of dilute LLLW for a few months without suffering severe consequences, thus reducing the normal generation by approximately 40%.

Long-term curtailment of LLLW generation must be considered if the concentrate storage situation is to be affected by this action. However, the majority of the LLLW generation cannot be curtailed for extended periods of time because of the detrimental effect such a step would have on the funding levels of these facilities. In addition, those facilities described in the beginning of this section which maintain the quality of water and gas discharged to the environment cannot shut down for any length of time. Table 11 lists those generators who can theoretically stop generation of LLLW for several years. The generation rate of dilute LLLW that can theoretically be curtailed for extended periods of time is approximately 12% of the normal generation rate. This corresponds to about 7% of the LLLW concentrate generation, assuming a volume reduction factor (VRF) of 20.

The ORNL Remedial Action personnel are responsible for the decontamination and decommissioning (D&D) of the inactive LLLW collection and storage tanks at ORNL.

Table 10. Generators who are able/unable to stop LLLW generation for 4 months

Generator	Volume of dilute LLLW (gal/month)[a]
Generators unable to stop LLLW generation	
4500 Complex[b]	615
Isotope Area[b]	3,773
FPDL (Bldg. 3517)	3,150
Reactor Complex[b]	178
HFIR[b]	1,396
PWTP (Bldg. 3544)[b]	652
3039 Stack[b]	3,275
Others	4,832
Total	17,871
Generators theoretically able to stop LLLW generation for 4 months	
4500 Complex	989
Isotope Area	1,001
Reactor Complex	1,200
HFIR	1,600
Others	21
Total	4,811

[a]Average monthly generations based on 1988 data.

[b]Generators whose LLLW is partially or completely the result of air- or water-treatment operations.

Table 11. Generators who are able/unable to stop LLLW generation for extended periods of time

Generator	Average generation (gal/month)[a]
Generators unable to stop generation	
PWTP (Bldg. 3544)[b]	652
3039 Stack[b]	3,275
Bldg. 3074	352
HFIR[b]	2,996
FPDL (Bldg. 3517)	3,150
Bldg. 2026	84
REDC[b]	1,742
Reactor Complex[b]	1,378
4500 Complex[b]	655
Isotopes Area[b]	4,613
Others[b]	2,394
Total	21,291
Generators theoretically able to stop generation	
4500 Complex	949
Isotopes Area	1,101
Others	880
Total	2,930

[a]Average monthly generations based on 1988 data.

[b]Generators whose LLLW is partially or completely a result of air or water treatment operations.

Currently, there are 33 inactive tanks, most of which contain radioactively contaminated liquids and sludge. Table 12 lists the tanks and the amounts of liquid and sludge they contain.[8] A 7-year schedule for these remediation activities is planned to begin in FY 1992.[3] These activities are expected to generate about 650,000 gal of dilute liquid and sludge waste over the 7-year period. The LLLW system will be used to evaporate the liquid and is expected to reduce the volume by approximately a factor of 8. Thus, during this period, 120,000 gal of concentrated liquid and sludge will be added to the MVST storage system. If short-term curtailment of LLLW generation should be necessary during this campaign, it is expected that the D&D activities would be temporarily halted in addition to halting the generation of routine LLLW.

In the case of an emergency involving the availability of concentrate storage volume, a delay in the RAP schedule of inactive tank cleanup could have a significant effect on the situation. However, these D&D activities are being completed in order to meet current regulatory standards and, as such, may not be subject to extreme changes in schedule. The full extent of altering these schedules is beyond the scope of this document, although, if warranted, the D&D schedules should be considered a possible "candidate" for curtailment in contingency planning.

4.5 SOLIDIFICATION CAMPAIGNS

Immobilization of low-level waste in concrete grout is a common practice for disposing of commercial nuclear reactor waste. As such, it is a well-established technology. In 1986, when the available LLLW concentrate storage capacity at ORNL was quickly being depleted, a proposal to utilize this solidification technology in treating the accumulating LLLW concentrate was accepted by DOE.

The first solidification campaign, the Emergency Avoidance Solidification Campaign (EASC), in which 47,000 gal of LLLW concentrate was immobilized in a cement-based matrix, was completed at the end of CY 1988. The solidification was done by L&N Technologies, a contracted vendor, who provided the equipment necessary to contain and mix the LLLW, as well as the grout mixture. L&N personnel performed the solidification procedures in a newly constructed building adjacent to the MVST site.

Table 13 gives a brief summary of the costs associated with the first solidification campaign. Capital expenditures made during this campaign included the costs of the building and ventilation system to contain the solidification equipment and the decant system, which provided piping and pumps for transfer of the liquid waste from the tanks

Table 12. Contents of inactive tanks and projected LLLW volume to be generated upon cleanup of tanks

Tank	Liquid volume (gal)	Sludge volume (gal)	Estimated volume of LLLW generated (gal)
W-1A	26	0	26
W-1	1,057	0	1,057
W-2	567	0	567
W-3	34,946	2,510	69,892
W-4	18,728	4,382	37,455
W-5	9,939	4,895	19,878
W-6	74,171	4,895	138,342
W-7	7,417	4,895	14,834
W-8	22,251	2,522	44,502
W-9	12,312	2,522	24,624
W-10	67,941	6,230	135,881
W-11	752	64	1,504
W-13	455	0	455
W-14	679	0	679
W-15	370	0	370
W-19	a		
W-20	a		
WC-17	367	(Trace)	367
T-1	10,950	785	21,900
T-2	10,958	1,196	21,916
T-3	2,036	2,006	4,072
T-4	9,287	1,321	18,573
T-9	1,276	476	2,552
T-30	39	0	39
TH-1	274	0	274
TH-3	115	0	115
TH-4	15,274	5,687	30,548
7560	a		
7562	378	b	378
Total	302,566	44,387	600,804

[a]These tanks are empty.
[b]Unknown.

Table 13. EASC costs for 1988

Activity	Cost ($1000)
Capital facilities	
LW solidification facilities	740
MVST decant system	505
General plant equipment	205
Project and operational planning	
Preplanning	875
Operational planning	920
Post-analysis	100[a]
Solidification	
Solidification	540[a]
Waste-form certification	300
Waste-form characterization	200
Other	375
Interim storage	
Casks (70 at $6500 each)	460
Facility and O&M	250
Total	5470

[a]Estimated.

to the vendor equipment. Other costs associated with the EASC included those for planning before, during, and after the solidification; the waste-form characterization and certification expenses; and storage. The total cost of the solidification campaign was approximately $5.47 million.[14]

An additional solidification campaign is projected to cost approximately $2.5 million, or about $50 per gallon of liquid concentrate solidified. This cost is projected, assuming no major facility or safety/QA changes are needed, ~50,000 gal of LLLW concentrate is solidified, and the final waste forms are stored in interim storage as are the first solidified waste forms. The above-described expenses from the first EASC that would be incurred in performing a second campaign include the waste-form characterization and certification costs, partial planning costs, and interim storage costs.

Implementation of an additional solidification campaign is projected to take about 18 to 24 months. The majority of this time is needed for the following tasks:

1. vendor contract preparation,
2. concentrated LLLW characterization,
3. solidified waste-form certification, and
4. environmental assessments to meet regulatory requirements.

Additional solidification campaigns similar to the previous EASC should be considered as the most viable option in contingency planning for two reasons. First, a solidification campaign releases a significant volume of storage space and has the advantage over other options of being a "permanent" solution, whereas other options, such as storage of LLLW concentrate in vaults, are only temporary. Second, because capital expenditures have already been made, subsequent solidification campaigns are economically attractive.

In the case of a contingency and depending on the available storage space situation at the time of the emergency, action may need to be taken immediately. At present, the implementation of an additional solidification campaign would require about 20 months. In order to decrease this implementation period, any future vendor contract should incorporate considerations to allow for additional campaigns to be performed, thus decreasing the time needed to prepare for these campaigns.

4.6 MOBILE ION-EXCHANGE RESIN TREATMENT UNIT

Various resins may be used to remove radionuclides from radioactively contaminated liquid waste streams. A mobile treatment unit could be used to treat ORNL's dilute LLLW waste stream in emergency situations involving a deficiency in available dilute LLLW tank storage volume. Once treated, the liquid would probably be transferred to the PWTP for further treatment. The radioactively loaded resin would then need to be treated and disposed of. This section discusses the possibility of a mobile resin treatment unit serving as a contingency option.

Various types of resins are available for the removal of radionuclides from liquid waste streams. In order to apply this technology to the dilute LLLW generated here at ORNL, R&D using the various resins and surrogate waste streams would need to be performed to select the most efficient resin. In addition, resin loadings and disposal options would need to be studied. The expense in applying this technology would include R&D, operational, equipment, and shielding costs and could easily reach a total of $3 million. If ORNL were to purchase an ion-exchange processing unit, the total time required to implement the technology could approach 5 to 8 years. This time could be reduced if ORNL were to rent an ion-exchange unit from one of many vendors.

It is much more feasible to predict that resin treatment could be used on a specific facility's waste stream rather than on the dilute LLLW stream (which is a combination of waste streams from many facilities at ORNL). In addition, the cost would be quite high, and several years of R&D would need to be invested to determine the best approach for implementing a resin treatment unit. As such, it is not a plausible contingency alternative and will not be considered further as an option in this document.

5. ANALYSIS OF SCENARIOS

The LLLW concentrate storage tanks in Melton and Bethel valleys have a combined operating capacity of 570,000 gal. The Operational Safety Requirements (OSR) unused storage space limit has been established as 50,000 gal, which is equivalent to 520,000 gal of used storage space.[12] System operations are very difficult at that storage level; consequently, an operational flexibility range has been defined to facilitate operation within specified limits that range from 100,000 to 150,000 gal of unused storage tank space (or 420,000 to 470,000 gal of used storage space).

At the current LLLW production rates, the available concentrate storage volumes will quickly be depleted. This "normal" LLLW production will be analyzed as a scenario. Unexpected events might further increase the cumulative LLLW storage volume to a level that will surpass the safe storage limits of the tanks. To systematically analyze various conditions that can potentially lead to operational difficulties, each of the following credible scenarios will be considered as the basis for identifying and ranking available contingency options:

1. normal operation and generation of LLLW, and
2. two scenarios affecting the LLLW concentrate storage system: unforeseen generation of LLLW concentrate and loss of a concentrate storage tank.

The "normal operation" scenario is presented in Sect. 5.1, and the LLLW concentrate scenarios are analyzed in Sect. 5.2.

Not only is LLLW stored as concentrate after it has been evaporated, but the dilute LLLW is stored temporarily before it is evaporated. In the past, the volume of storage space required to handle this waste stream was not of concern because several evaporator service tanks were available for storage as needed. Now, however, tank W-22 serves a dual capacity as both a dilute LLLW storage tank and the evaporator feed tank. Accident scenarios that could affect the available feed-side storage volume for the LLLW will also be analyzed. The scenarios that have been put forth are: (1) evaporator failure, (2) heavy rainfall, and (3) unforeseen generation of dilute LLLW.

All of the scenarios mentioned above will be applied to the "normal operation" of the plant, which is introduced in the following section. The accident scenarios and the contingency options selected as best with regard to mitigating these scenarios are presented in detail in Sects. 5.2 and 5.3.

5.1 BASE SCENARIO: NORMAL OPERATION

This scenario is the base case for the analysis of the waste storage system. Credible accident scenarios will be considered as applied to the "normal operation" scenario. Section 5.1.1 describes this scenario and the associated conditions, all of which will contribute to the generation of LLLW concentrate throughout the time frame of this analysis.

5.1.1 Definition of Normal Operation

Normal operation refers to those conditions under which LLLW is produced from: (1) the daily operation of ORNL facilities, (2) the restart of the HFIR, (3) the nonroutine D&D of hot-cell facilities, (4) the D&D of the inactive LLLW tanks by RAP personnel, (5) the in-tank evaporation that will take place in the MVSTs, and (6) one additional solidification campaign.

5.1.1.1 Daily Operation

A regression analysis was applied to the remaining LLLW storage capacity vs time for the last 3 years of operation of the LLLW system.[15] The analysis indicated that approximately 2040 gal of storage space is used every month. This approximation does not include the waste generated by the HFIR facility, since it has not been operating during this time frame. Accordingly, the projection of LLLW storage space availability for this report analysis will be assumed to decrease at the constant rate of 2040 gal/month, modified by the projected generation of LLLW concentrate because of HFIR, hot-cell D&D work, and inactive tank D&D work, which are described in the following sections.

5.1.1.2 Restart of HFIR

The restart of HFIR has been scheduled for the first half of 1989. Based on historical data, it is estimated that this action will contribute an additional 100 gal of LLLW concentrate per month to the LLLW storage system.[16] This volume is assumed to be constant throughout the entire period to which this contingency plan applies, that is, until 1999.

5.1.1.3 Decontamination and Decommissioning of Hot Cells

The hot cells in several isotope facilities are scheduled to be decontaminated during the next year. The decontamination activities are expected to generate approximately 60,000 gal of dilute waste.[17] A conservative VRF of 8 was assumed to be achievable for this waste. Therefore, about 7500 gal of LLLW concentrate would be generated by these activities. This is the only nonroutine D&D of the hot-cell facilities assumed to take place in the 10-year report projection.

5.1.1.4 Decontamination and Decommissioning of the Inactive Tanks

It is estimated that the cleanup of the inactive tanks will produce approximately 660,000 gal of liquid waste, of which 618,000 gal can be attributed to the supernatant and rinsing liquids and 42,000 gal to sludge. The liquid will be transferred to the evaporator and the sludge to the MVSTs. An evaporator VRF of 8 is applied to this liquid waste in the calculations and projections, thus giving an estimated 120,000 gal of waste (sludge and LLLW concentrate) to be added to the LLLW concentrate storage system from FY 1992 to FY 1998.[3]

5.1.1.5 In-Tank Evaporation of the Melton Valley Storage Tanks

According to information obtained in boildown experiments performed on supernatant from the MVST W-29, the concentration of dissolved solids in the MVSTs has not reached saturation, the point at which the solids would begin to precipitate.[3] Hence, further concentration of the liquid by evaporation appears to be a viable technology to reduce the amount of LLLW concentrate currently being stored in the MVSTs.

The MVSTs were designed with a tank ventilation system for the purging of radiolytic gases. The sparge system consists of five draft tubes into which air may be introduced. The design rate of sparge air flow for each tank is 100 ft^3/min. If the tank sparging system is operated on a continuous basis at this design rate, an appreciable amount of water can be evaporated from the tanks.

In-tank evaporation (ITE) in the MVSTs is scheduled to begin operation in early FY 1990. The initial assumption is that during FY 1990, approximately 14,000 gal of water will be evaporated while operating at a temperature of 50°F, which corresponds to 3000 gal per tank per year, with the startup of the six tanks staggered. This evaporation rate is calculated, assuming a 100% efficiency, based on the maximum amount of water that "bone-dry" air can extract upon reaching saturation. Table 14 shows the schedule of the ITE operations. During the second fiscal year of operation, it is assumed that the air temperature is increased to 90°F and six of the eight MVSTs are being evaporated simultaneously. This mode of operation will proceed until, at some point, the current inventory and additional LLLW concentrate added until that time will be evaporated to the saturation limit of the dissolved solids. At this point (in the table, the fifth year of operation at 100% efficiency), the evaporation rate will decrease to 40% of the incoming LLLW concentrate.

Table 14. In-tank evaporation schedule

Fiscal year	Volume evaporated (gal) 100% efficiency	50% efficiency
1990	14,250	7,125
1991	60,000	30,000
1992	60,000	30,000
1993	60,000	30,000
1994	24,000	30,000
1995	40% of yearly generated	30,000
1996	40% of yearly generated	30,000
1997	40% of yearly generated	30,000
1998	40% of yearly generated	30,000
1999	40% of yearly generated	40% of yearly generated

Often, unknown factors are encountered in extrapolating laboratory-scale data to the operation of a full-scale plant. The above evaporation rates are based on 100% evaporation efficiency, that is, the bone-dry air is capable of absorbing moisture up to its saturation limit. In order to account for possible unforeseen influences, the assumed evaporation efficiency used for the projections in this report was set at 50% of the theoretical maximum evaporation efficiency. Table 14 also shows the schedule of in-tank evaporation, assuming 50% efficiency.

5.1.1.6 Solidification Campaign

In addition to the ITE, one solidification campaign is currently being planned and is scheduled to be implemented in late FY 1990. This campaign is included in the definition of "normal operation" for this report.

5.1.2 Analysis of Contingency Options Under Normal Operation

The "normal operation" scenario is defined as a combination of the conditions discussed in Sects. 5.1.1.1 through 5.1.1.6. Figure 7 shows the progressive accumulation of LLLW concentrate if solidification and ITE are not completed, but the rate of generation continues as predicted in Sects. 5.1.1.1 and 5.1.1.4. This curve, which is

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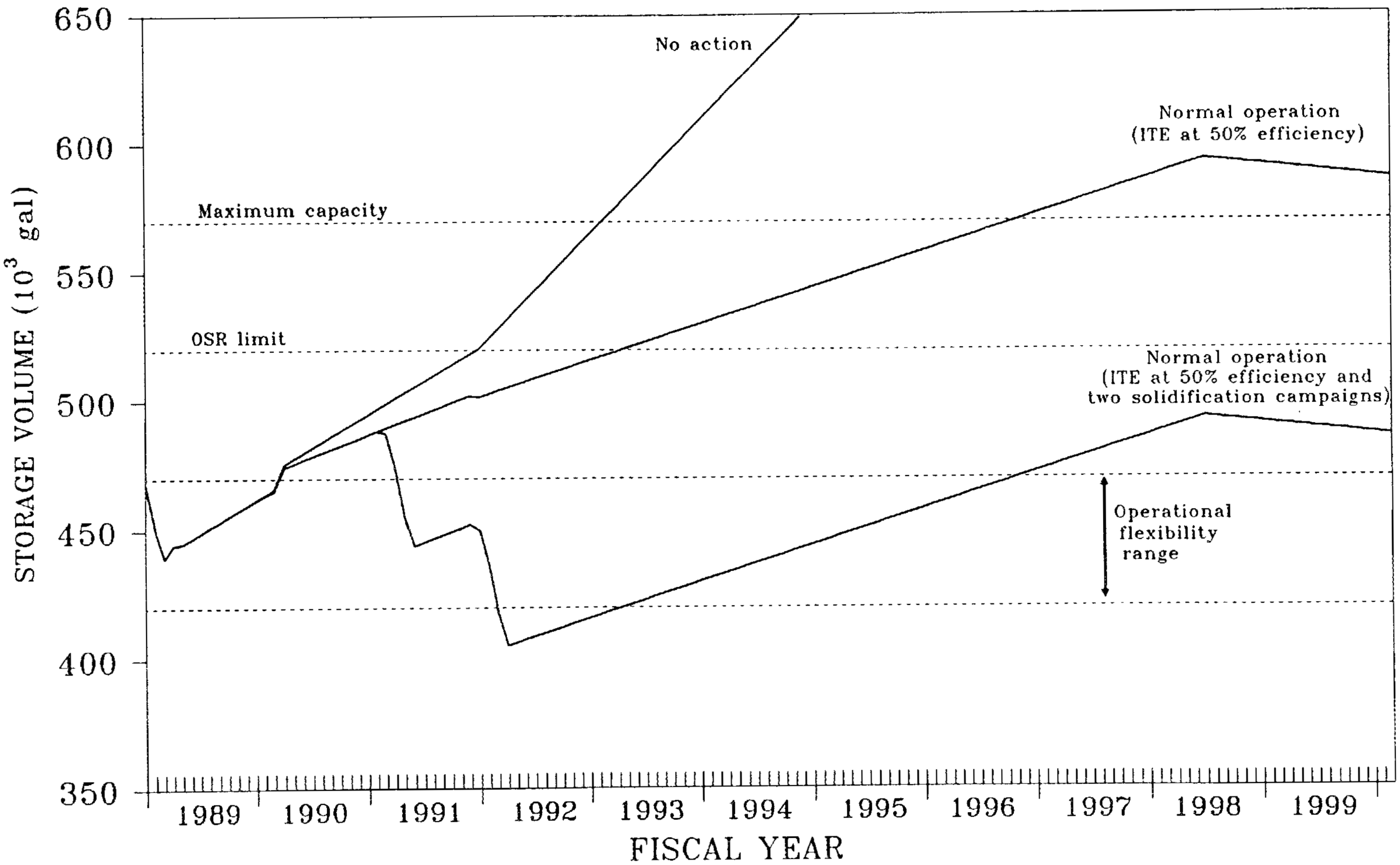

Fig. 7. Production of LLLW concentrate if no action is taken, with ITE, and with two solidification campaigns in addition to ITE.

represented in the figure as "no action," demonstrates the results of storing LLLW concentrate if nothing is done to alleviate the storage capacity situation. Obviously, this is an unacceptable situation.

The second curve in Fig. 7, labeled "normal operation," shows the accumulation of LLLW concentrate if ITE and a single solidification campaign are imposed on the "no action" curve. Turndown of the curve in FY 1998 reflects termination of the LLLW concentrate generation from inactive tank D&D and continued use of the ITE to evaporate a volume of concentrate in excess of the generation rate for a few years. This curve would eventually turn up again. Although this is a more acceptable situation, the predicted accumulation of LLLW over the next several years will still exceed the storage capacity limits set by the OSR. Therefore, this scenario will be analyzed with the application of the various contingency options.

Several contingency options, as discussed in Sect. 4, apply only to managing situations involving the storage of dilute LLLW. These options will not be considered in the "normal operation" scenario since normal operation does not threaten the available storage capacity for dilute LLLW. Options that may be applied to the accumulation of LLLW concentrate during normal operation are (1) construction of new tanks, (2) shutdown of generators, (3) use of MVST vaults, and (4) solidification campaigns.

The first contingency option, construction of new storage tanks, would not be a viable alternative because of the length of time needed for planning and construction of new tanks. As discussed in Sect. 4.3, the estimated time needed to plan for and construct new tanks is 6 years; hence, an alternative must be identified and implemented within the next several years. Of course, all of the accident scenarios analyzed in the following sections would be alleviated if more storage space were available.

A few facilities identified in Sect. 4.4 could halt the generation of LLLW for several years; however, based on the estimated savings in concentrate storage space, 3400 gal/year, their shutdown would not have a significant effect on the system. Further, the implications of stopping work in these areas make the option extremely undesirable.

As mentioned in Sect. 4.4, the RAP D&D of the inactive tanks is expected to generate an extremely large volume of LLLW concentrate. Space would be available to contain the LLLW concentrate until startup of the WHPP. Consequently, the suspension of those D&D activities long enough to affect the normal operation scenario is unlikely.

The MVST vaults can contain approximately 200,000 gal of liquid; however, since they serve as secondary containment to the MVSTs, it would not be advisable to utilize them as storage capacity except in a severe emergency. It will be several years before the MVSTs are filled to capacity, and the interim period will be used to improve the LLLW concentrate storage situation. Therefore, reaching a severe emergency situation in which the tank vaults may need to be used is extremely unlikely.

Solidification of the supernatant from MVSTs W-29 and W-30 was successfully completed in late CY 1988, indicating the technical feasibility of this alternative. The "normal operation" curve in Fig. 7 illustrates the need for additional solidification campaigns. The solidification campaign expected to take place in early FY 1991 is shown in the "normal operation" curve in Fig. 7. Planning for this campaign has already begun, but one campaign to solidify 50,000 gal of concentrate will not be sufficient to alleviate the storage problem until 1999. It is, therefore, prudent to conduct another solidification campaign before FY 1996. The third curve shows two consecutive campaigns (50,000 gal each) separated by a 6-month period (the time estimated to be necessary between campaigns for operational and planning purposes). This scenario is the most advisable in terms of economical and technical considerations.

Figure 8 summarizes the contingency options as they apply to the "normal operation" scenario. Other scenarios in the following sections are analyzed as accidents that might occur in the course of normal operation (with two solidification campaigns) as illustrated in the third curve of Fig. 7.

5.2 LLLW CONCENTRATE ACCIDENT SCENARIOS

5.2.1 Unforeseen Generation of LLLW Concentrate

5.2.1.1 Definition of Accident

An unusually large volume of LLLW concentrate was produced in 1985 as the result of construction work on the cell ventilation system in Building 3517. The process waste generated during this project was treated at the PWTP. Because of the high levels of radioactivity in the wastewater, the ion-exchange columns at the PWTP had to be regenerated frequently, thus producing an unusually large LLLW concentrate volume of 30,000 gal in a short period.[11,18] Therefore, one accident scenario was defined as the unexpected generation of 30,000 gal of LLLW concentrate.

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SCENARIO	CONTINGENCY OPTIONS	ANALYSIS OF IMPLEMENTATION OF OPTIONS
Normal operation	Stop/curtail LLLW generation	Would not significantly affect storage situation.
	Use of gunite tanks	Not applicable.
	Use of MVST vaults	Not desirable option but could be implemented in a severe emergency.
	Construct new tanks	Cost $9.5M for four tanks; 5 years to complete; line-item project; not desirable due to long implementation period and high cost.
	Solidification campaigns	Two solidification campaigns, 50,000 gal each, would maintain amount of LLLW stored below the OSR limit of 520,000 gal.

Fig. 8. Summary of analysis of contingency options for the normal operation scenario.

5.2.1.2 Analysis of Contingency Options

Four options outlined in Sect. 4 might be applied in this type of scenario: (1) shutdown of generators, (2) use of the MVST vaults, (3) construction of new tanks, and (4) an additional solidification campaign.

Halting generation of LLLW at those facilities which can discontinue their generation without experiencing extremely adverse effects, even for several years, would not have any appreciable effect on the volume of LLLW concentrate being collected. However, depending on the available storage volume at the time of the accident and the feasibility of implementing other options, this option might work as a temporary aid to decrease the accumulation of LLLW concentrate. In addition to halting the generation of routine LLLW, the RAP D&D schedule could possibly be adjusted to reduce the amount of LLLW concentrate generated.

The use of the MVST vaults to contain this concentrate, or subsequently generated concentrate, is advisable only if the storage capacity has been depleted to the OSR limit. The vaults, if used, should serve only as a temporary solution.

Construction of new tanks is not a feasible answer if a large generation of LLLW concentrate were to occur. However, if the tanks had either been constructed or were in the process of being constructed, the situation would be rectified.

In either of the above situations, a third solidification campaign would be necessary to maintain the accumulated LLLW concentrate at an acceptable level. Solidification is the only option that would permanently restore the storage situation to a permissible level. Therefore, should such an accident occur, the immediate action should be to prepare for an additional solidification campaign. This scenario reinforces the need for a vendor contract to be in place. Figure 9 summarizes the analysis of the various options as applied to the scenario of unforeseen concentrate generation.

5.2.2 Loss of Concentrate Storage Tank

5.2.2.1 Definition of Accident

A plausible accident scenario affecting either the MVSTs or the evaporator service tanks is a tank failure. In either of these situations, the volume of liquid in the tank would be contained in the vault. Realistically, if any of these tanks were to leak, it would be a relatively slow process. A tank rupture that would quickly release all the liquid waste is highly unlikely. Each of the vaults has a sump where the liquid would be collected and could be pumped back to the original tank or to other tanks, if the leak were severe.

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SCENARIO	CONTINGENCY OPTIONS	ANALYSIS OF IMPLEMENTATION OF OPTIONS
Unforeseen generation of LLLW concentrate	Stop/curtail LLLW generation	Curtailment of LLLW generation for 4 months would reduce the volume of dilute LLLW generated by about 5000 gal/month.
	Use of gunite tanks	Not applicable.
	Use of MVST vaults	Use this option if the available storage volume in the MVSTs is unable to accommodate the generation.
	Construct new tanks	Not applicable.
	Solidification campaigns	An additional solidification campaign will have to be performed in order to maintain the used storage space under the OSR limit of 520,000 gal.

Fig. 9. Summary of contingency options for the "unforeseen generation of LLLW concentrate" scenario.

5.2.2.2 Analysis of Contingency Options

The contingency option, "use tank vaults," would, of course, be in place. Curtailment of the generation of LLLW could be implemented but would not, as mentioned previously, have a significant effect on the storage capacity.

New storage tanks, that had been or were being built during the loss of one storage tank, of course, would provide for enough storage capacity to contain the liquid waste.

Again, solidification of the liquid waste seems to be the most appropriate solution. Figure 10 shows the effect of the loss of a tank on the cumulative LLLW concentrate storage volume. Such a loss would require two additional 50,000-gal solidification campaigns (as shown in the figure), one to remove the liquid in the leaking tank and one to account for the loss of the tank, which is represented by the decrease of the maximum capacity, OSR limit, and operational flexibility limit. Figure 11 shows a summary of the contingency options analyses.

5.3 LLLW DILUTE ACCIDENT SCENARIOS

5.3.1 Evaporator Failure

5.3.1.1 Definition of Accident

This accident scenario was defined as the failure of both in-line evaporators. Historically, one evaporator has been down for some period of time; therefore, it was considered feasible that the other evaporator could fail concurrently. Because these vessels are radioactively contaminated, they are quite difficult to access and repair. A third evaporator is kept ready and is currently in storage, but it has been estimated that 4 months would be necessary for its installation; hence, the time frame for this scenario is 4 months.[19]

The average generation rate of dilute LLLW is about 30,000 gal per month; therefore, in 4 months, approximately 120,000 gal of dilute LLLW would accumulate on the feed side (dilute LLLW) of the evaporator system.

5.3.1.2 Analysis of Contingency Options

Shutdown of generation of LLLW at the sources is the first conceivable alternative. In addition to the normal LLLW generation, nonroutine generation of LLLW - specifically the D&D of inactive tanks - would be curtailed. If implemented immediately, this approach would reduce the amount of dilute feed generated over the 4-month period to

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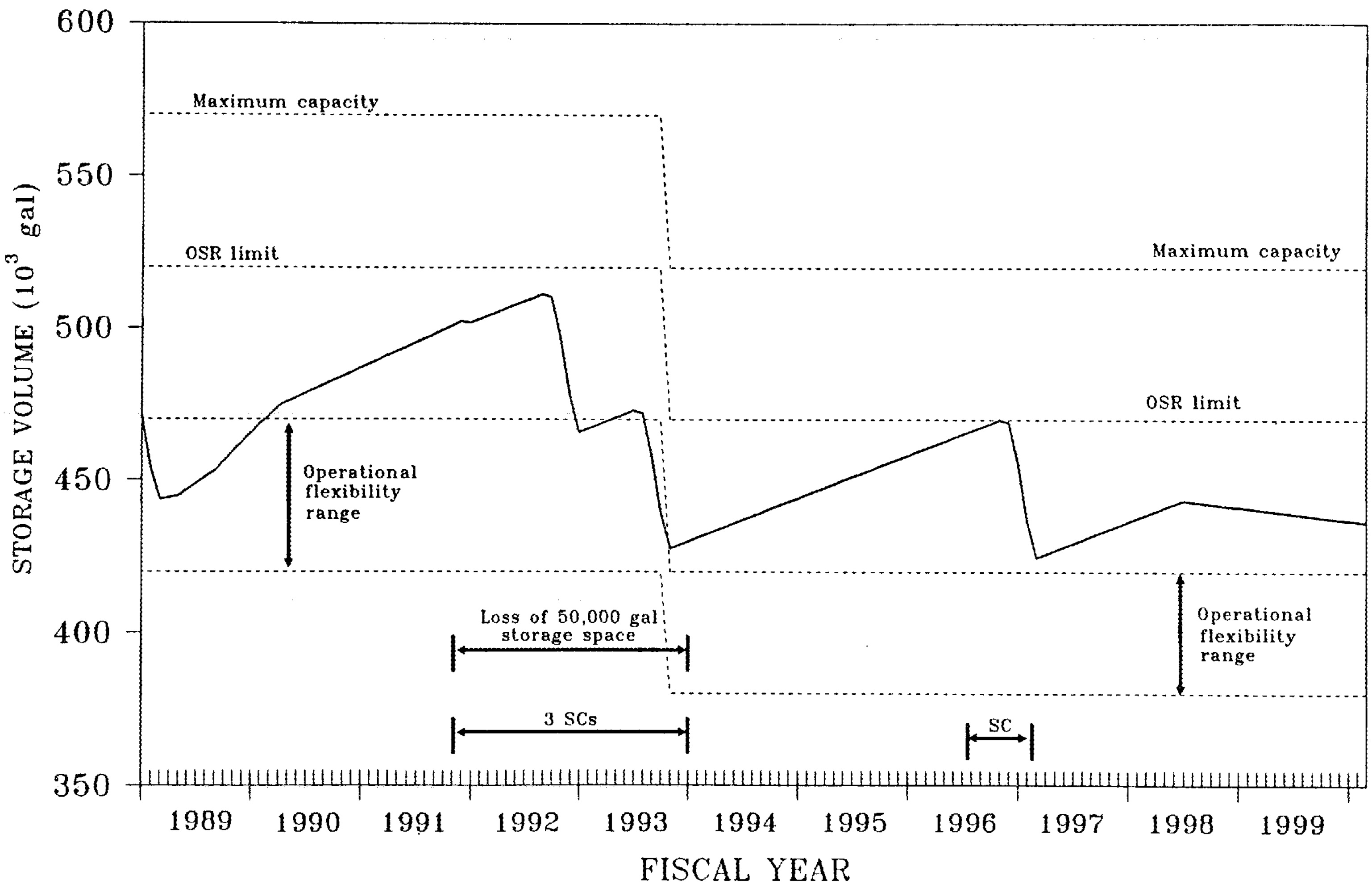

Fig. 10. Effect of loss of concentrate storage tank on the LLLW concentrate storage situation.

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SCENARIO	CONTINGENCY OPTIONS	ANALYSIS OF IMPLEMENTATION OF OPTIONS
Loss of a 50,000-gal concentrate storage tank	Stop/curtail LLLW generation	Curtailment of LLLW generation for 4 months would reduce the volume of dilute LLLW generated by about 5000 gal/month.
	Use of gunite tanks	Not applicable.
	Use of MVST vaults	Tank vault would serve as containment for the liquid waste from the leaking tank.
	Construct new tanks	Not applicable.
	Solidification campaigns	Two additional solidification campaigns would be needed, one to dispose of the liquid from the leaking tank, and a second campaign to make up for the lost tank.

Fig. 11. Summary of contingency options for the scenario loss of 50,000-gal tank.

about 100,000 gal. However, the collection and transfer system, which includes the evaporator feed tank W-22, could not contain this volume.

The most suitable alternative to consider for containing the dilute LLLW for a short period of time is use of the gunite tanks. Section 4.1 discusses the details of these tanks and the condition of each. The use of a single gunite tank would provide more than adequate storage capacity in an emergency situation such as this. Once the evaporator system is operational again, it would take only 1 month for the evaporator to process the 120,000 gal of LLLW. Figure 12 summarizes the options considered for the "evaporator failure" scenario.

5.3.2 Heavy Rainfall

A 6-in. rainfall during a 24-h period is an event that can occur approximately once every 20 years, according to the frequency of maximum precipitation shown in Fig. 13.[20] A correlation between rainfall and dilute LLLW accumulation at the sources has been made. Each inch of rain has been estimated to contribute about 2000 gal of dilute LLLW; thus, the accumulation of dilute LLLW due to a 6-in. rainfall would be approximately 12,000 gal per day, or 24,000 gal over a 2-d period.

It was determined that this scenario would not cause a storage problem on the collection side because the average available space (25,000 gal) in the evaporator feed tank W-22 could contain such a generation. In addition, the system's evaporation rate is approximately 600 gal/h; therefore, if necessary, the evaporator facility could process about 14,000 gal on a daily basis.

5.3.3 Unforeseen Generation of Dilute LLLW

It is quite possible that a large and unexpected generation of dilute LLLW could occur in a facility at ORNL. The volume produced by such an event is not likely to surpass the 24,000 gal of dilute LLLW assumed to be generated from a heavy rainfall, as described in the previous Sect. 5.2.2. As such, it would not be necessary to implement any emergency action for the reasons given above.

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SCENARIO	CONTINGENCY OPTIONS	ANALYSIS OF IMPLEMENTATION OF OPTIONS
Evaporator failure	Stop/curtail LLLW generation	Curtailment of LLLW generation for 4 months would reduce the amount of dilute LLLW generated by about 5000 gal/month.
	Use of gunite tanks	Use of the gunite tanks would be required if the curtailment of LLLW generation did not provide the necessary available storage volume.
	Use of MVST vaults	Not applicable.
	Construct new tanks	Not applicable.
	Solidification campaigns	Not applicable.

Fig. 12. Summary of contingency options for the scenario evaporator failure.

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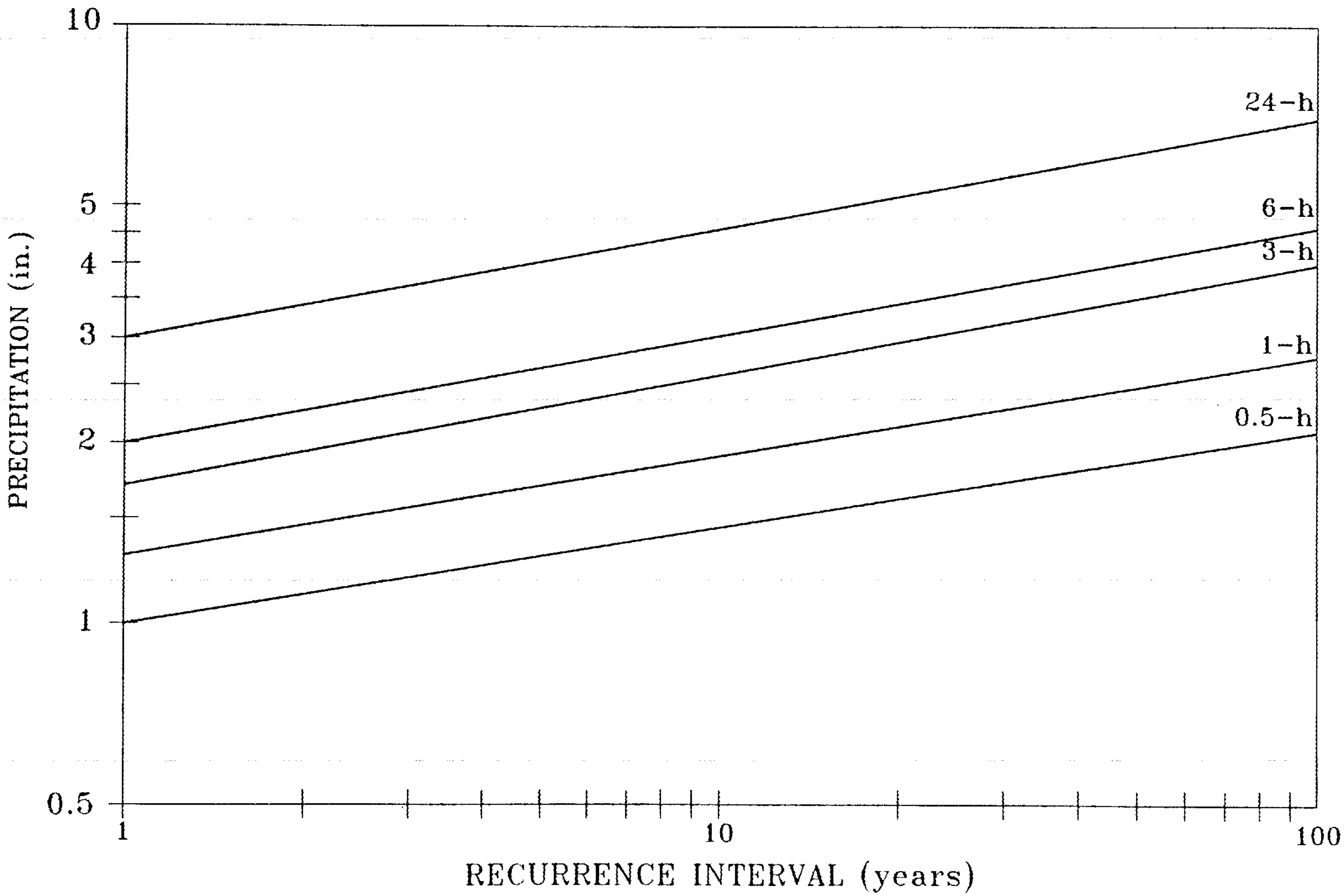

Fig. 13. Frequency of maximum precipitation of selected durations.

6. CONCLUSIONS AND RECOMMENDATIONS

The progressive accumulation of LLLW concentrate during the next 10 years is expected to exceed the currently available concentrate storage space if no corrective action is taken. Normal operation (discussed in detail in Sect. 5.1 as the expected generation of LLLW concentrate), including in-tank evaporation operation at 50% efficiency and one solidification campaign, was examined as the first "scenario." Assumptions concerning the generation of concentrate (due to regular activities at ORNL and additional RAP cleanup activities) and the expected in-tank evaporation capabilities were made to predict the accumulation of LLLW concentrate over a 10-year period. Even with the addition of one solidification campaign, as currently planned for and included in the normal operation definition, the accumulation of LLLW is predicted to exceed the limit set on the usable concentrate storage volume by FY 1993. Implementation of a second 50,000-gal solidification campaign (i.e., one campaign in addition to that already planned) is expected to maintain the LLLW concentrate storage volume below the OSR limit until FY 2000, when the WHPP is expected to become operational. Therefore, the solidification option is recommended for the "normal operation" scenario. Figure 14 is a summary of the recommended, ordered options to be applied in the analyzed scenarios.

Several scenarios pertain to the availability of LLLW concentrate storage space. These scenarios include (1) concentrate storage tank rupture (loss of capacity) and (2) unexpected generation of LLLW concentrate. In each case, the recommended action is additional solidification campaigns: two additional campaigns for the first scenario (one campaign applied to the waste in the ruptured tank, and a second campaign to assuage for the loss of a tank) and one additional campaign for the second scenario. In the case of the concentrate storage tank rupture (loss of capacity), the tank vault - operating as the secondary containment - would automatically contain the LLLW concentrate, thus serving as temporary storage space and automatically being the first option in Fig. 14. The use of the tank vaults may also be considered as the second option for the scenario, resulting in excessive generation of the LLLW concentrate. In either case, documentation detailing the use of the tank vaults in such a situation is recommended as the first step in implementing this as a contingency option.

The remaining three scenarios deal with the accumulation of dilute LLLW, thus affecting the LLLW storage capacity prior to the evaporator. To begin with, a scenario was analyzed in which both evaporators would be simultaneously unworkable for any

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Options \ Scenario	Normal Operation	Evaporator Failure	Loss of Concentrate Storage	Generation of LLLW Concentrate
Solidification Campaign	1		1	1
Use of Old Tanks		2		
Construct New Tanks			3	3
Use Tank Vaults			2	2
Shutdown/Curtail Generators		1		

Fig. 14. Summary of ranked contingency options for the various scenarios.

reason. Maintenance or replacement of either evaporator is a time-consuming operation, primarily because of the radiation exposure such work entails. The dilute LLLW being generated would need to be stored for this "downtime" until at least one evaporator was again operational. A reasonable downtime has been estimated as about 4 months, and approximately 125,000 gal of dilute LLLW would be generated during this period. Several options should be implemented as necessary. Temporary shutdown of generators (including the RAP cleanup of the inactive tanks) is the primary option and should be implemented immediately if such a situation were to arise. However, if this strategy is insufficient to facilitate the storage of dilute LLLW, the second recommended option is to use the gunite tanks for short-term storage of the dilute LLLW. In foreseeing the possibility of using the gunite tanks for storage of dilute LLLW, it is recommended that some documentation proceed for approval to use these tanks in an emergency. Again, Fig. 14 summarizes and ranks the options available for the given scenario.

The remaining two scenarios, a heavy rainfall (which would increase the volume of dilute LLLW to be evaporated) and an unexpected, excessive generation of dilute LLLW, have been shown, in Sects. 5.3.2 and 5.3.3, respectively, to be capably handled by the existing dilute storage capacity. The expected concentrate generation from such incidents would not significantly impact the storage of LLLW concentrate.

It is recommended that the contingency plans presented in this report be reviewed and updated, as appropriate, to reflect any changes in the WHPP plan and schedule.

The LLLW solidification campaign is the preferred option for most of the credible scenarios considered, although at this time it requires a relatively long lead time (2 years) and is somewhat costly ($2.5M for a 50,000-gal campaign, or $50 per gal of LLLW concentrate solidified). It is recommended that a long-term contract with a vendor be drawn up in order to decrease the lead time for a solidification campaign in the event of an emergency and/or to facilitate the process for further solidification campaigns.

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