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Greater-Than-Class C Low-Level Radioactive Waste Characterization

Appendix D-3: Characterization of Greater-Than-Class C Low-Level Radioactive Waste from Other Generators

Greater-Than-Class C Low-Level Waste Management Program

September 1994

DOE/LLW-114D-3

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Greater-Than-Class C Low-Level Radioactive Waste Characterization

Appendix D-3: Characterization of Greater-Than-Class C Low-Level Radioactive Waste from Other Generators

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ABSTRACT

The Other Generators category includes all greater-than-Class C low-level radioactive waste (GTCC LLW) that is not generated or held by nuclear utilities or sealed sources licensees or that is not stored at Department of Energy facilities. To determine the amount of waste within this category, 90 LLW generators were contacted; 13 fit the Other Generators category. Based on information received from the 13 identified Other Generators, the GTCC LLW Management Program was able to (a) characterize the nature of industries in this category, (b) estimate the 1993 inventory of Other Generator waste for high, base, and low cases, and (c) project inventories to the year 2035 for high, base, and low cases. Assumptions were applied to each of the case estimates to account for generators who may not have been identified in this study.

SUMMARY

Other Generator waste includes all greater-than-Class C low-level radioactive waste (GTCC LLW) that is not generated or held by nuclear utilities or sealed sources licensees or that is not stored at Department of Energy facilities. In 1993, the GTCC LLW Management Program initiated a study to clarify the number and types of generators that fall within this category and to project the volume and radionuclide activity of GTCC LLW from Other Generators.

Data used to characterize Other Generators were developed by first identifying every possible Other Generator of GTCC LLW, including Nuclear Regulatory Commission licensees, generators who shipped Class C waste to the disposal facility at Barnwell, South Carolina, and generators who paid nonpenalty surcharges between 1990 and 1993. In addition, knowledgeable sources were contacted such as LLW compact commission offices, Agreement State liaison officers, and brokers. This investigation yielded 90 potential generators, who were contacted by telephone. The study confirmed that 13 of the 90 could be classified as Other Generators.

The 13 generators responded to a detailed questionnaire, which yielded such information as business types, waste descriptions, 1993 inventory of GTCC LLW (including volume and activity), radionuclides, and future activity rates. This report includes a general description of the questionnaire and a summary of data gathered.

From these data, the GTCC LLW Management Program projected the 1993 inventory of GTCC LLW held by Other Generators and then projected the total inventory expected through the year 2035. In order to reasonably bound the range of potential generation rates, three cases are projected: high, base, and low. Each case uses a different set of assumptions. For instance, the high case assumes that two generators were missed in the study, three new Other Generators will begin generating GTCC LLW, and future generation rates will be 25% greater than the generators have predicted. The base case assumes no new or missing generators, no early closure of existing generators, and future generation rates will match those predicted by the generators identified in the study. The low case assumes no missed or new generators, no increase in current generation rates, and four existing generators will shut down. All cases assume that waste is packaged, concentration averaged, and similar to that reported by known generators.

The base case projections for the 1993 inventory of Other Generator waste equal 74.2 m^3 packaged volume and 2,738 Ci of activity. The base case projections for the 2035 inventory of Other Generator waste equal 465 m^3 packaged volume and 12,680 Ci of activity. This total includes mixed waste projections. Four of the 13 identified generators report mixed waste generation; three expect to continue generation of mixed waste. Base case projections of Other Generator untreated mixed waste through 2035 total 186 m^3 packaged volume.

The GTCC LLW Management Program has no way to statistically evaluate how well the 13 generators identified represent all organizations within the Other Generator category. Therefore, no confidence limits can be quantified concerning the total volume or total activity of actual and projected GTCC LLW from Other Generators. However, conversations with the various contacts during this study indicate it is almost certain that all large-quantity GTCC LLW generators have been identified.

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1. INTRODUCTION

The Code of Federal Regulations, 10 CFR 61.55, defines the requirements for low-level radioactive waste (LLW) classification. This regulation separates low-level radioactive waste into three classes—A, B, or C. LLW must meet the requirements of one of these classes to be suitable for shallow-land disposal. To determine the waste class, the radionuclide concentrations within the waste are compared to concentration limits for particular radionuclides. The Class C designation is the most restrictive. If radionuclide concentrations in the LLW exceed Class C limits, then the waste is not suitable for shallow-land disposal. LLW that exceeds these limits is referred to as greater-than-Class C (GTCC) LLW.

According to Public Law 99-240, the Low-Level Radioactive Waste Policy Amendments Act of 1985, the U.S. Department of Energy (DOE) is responsible for the disposal of all GTCC LLW generated by radioactive waste generators that have been licensed through the U.S. Nuclear Regulatory Commission (NRC) or Agreement States. Therefore, DOE must be able to project anticipated volumes of GTCC LLW to effectively plan for disposal.

This study characterizes a portion of GTCC LLW designated as Other Generators waste. To help DOE plan for the disposal of all GTCC LLW, this report presents volumes and radionuclide activities of Other Generators waste for both 1993 inventories and projections through 2035.

The term Other Generators waste is taken from DOE/LLW-114 Revision 1, *Greater-Than-Class C Radioactive Waste Characterization: Estimated Volumes, Radionuclide Activities, and other Characteristics*, as one of four categories of waste generators. That report defines Other Generators waste as the category that includes all GTCC LLW that is not generated or held by nuclear utilities or sealed source licensees or that is not stored at DOE facilities. Other Generators include

- ^{14}C manufacturers and users
- Industrial research and development firms
- Fuel fabrication and burnup labs
- Academic nuclear research reactors
- Sealed source manufacturers
- Nonmedical academic institutions.

The purpose of this report is to identify the volumes and radionuclide activities that are currently held in storage or expected to be generated by these types of generators through the year 2035. To meet this purpose, DOE's GTCC LLW Management Program conducted a study in 1993 to better characterize this category of waste generators.

Following is the background and methodology used in this study. Section 2 presents the results of the generator study, including a characterization of the types of industries that fall into the Other Generators category and waste groups reported by the generators. Section 2 also includes data from three site visits undertaken for this study. Section 3 provides high, base, and low case estimates of the volumes and activities of Other Generator GTCC LLW through the year 2035. Section 4 offers a summary and several conclusions based on these projections.

The reader should note that, even though this report estimates volumes of low-level radioactive waste that might require disposal as GTCC LLW, many other factors can influence the actual disposal practices eventually employed. Thus, the estimates in this report are based on the author's interpretation of generator responses, and represent the best estimate of projected GTCC LLW volumes based on current information.

1.1 Background

The Energy Information Administration collected data on GTCC LLW inventories in 1986 by surveying potential GTCC LLW generators.[a] Several areas of uncertainty and data deficiencies were recognized during that survey.

In 1991, the GTCC LLW Management Program attempted to reduce the areas of uncertainty by developing the DOE/LLW-114 report. However, the greatest research effort was centered on LLW generated by nuclear utilities, because it was then assumed that utilities generate the largest volumes and radionuclide activities associated with GTCC LLW. Data for the Other Generators category were not refined at that time. Therefore, this study was undertaken in 1993 to gather more information regarding Other Generators waste.

1.2 Methodology

The GTCC LLW Management Program obtained the names of low-level waste generators that fit the Other Generators category from various sources, including lists of (a) active U.S. Nuclear Regulatory Commission (NRC) licensees (excluding nuclear utilities and those with sealed sources only), (b) organizations that shipped Class C waste to Barnwell, South Carolina, for disposal during 1992, and (c) generators who paid nonpenalty surcharges to DOE between 1990–1993. In addition, discussions were held with informed sources such as waste brokers and processors, state liaison officers, LLW compact commission officers, and the Conference of Radiation Control Program Directors.

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a. Energy Information Administration, *Greater-Than-Class C Low-Level Radioactive Waste and Radioactive Waste Data Form,* NE-869, OMB No. 1901-0290, July 1986.

This effort yielded a list of 90 possible GTCC LLW generators. The GTCC LLW Management Program has no way to statistically evaluate how representative this list may have been; it may not have included all potential GTCC LLW generators. Therefore, no confidence limits can be quantified concerning the total volume or total activity of actual and projected GTCC LLW from Other Generators. However, conversations with the various contacts during this study indicate it is almost certain that all large-quantity GTCC LLW generators have been identified.

The author telephoned all 90 of the identified potential generators or holders of GTCC LLW.[b] All were asked if they were either storing or generating GTCC LLW that matched the Other Generators category. Those who confirmed the presence of Other Generator GTCC LLW at their locations were then asked to respond to a more detailed questionnaire. In the cases where no GTCC LLW existed on site, each respondent was asked to identify any known presence of Other Generator GTCC LLW at any other location within the United States. A few were identified and are included in the list.

From the total of 90 GTCC LLW generators that were contacted, the author confirmed that 13 generators were producing or storing Other Generator waste.[c] These confirmed Other Generators were then asked to fill out a detailed questionnaire. The general nature of the questions is outlined below.[d]

- **Contact information**—Identify the person providing the information and clearly identify the site-specific information pertaining to the generator category.

- **Physical and chemical characteristics**—Describe the physical state of the waste (dry solid, damp solid, sludge, free liquid, gas, etc.) and the materials that are present in the waste, including any solvents or contaminants.

- **Legal classification of the waste**—Identify whether the waste is a Resource Conservation and Recovery Act (RCRA) solid waste (40 CFR 261.2), RCRA hazardous waste (40 CFR 261.3), contains toxic components as defined by the Toxic Substances Control Act (40 CFR 761), or is concentration-averaged before shipping.

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b. Assuming that organizations who shipped Class C waste for disposal may have applied concentration averaging practices (see Appendix E-5), all of the names from the Barnwell disposal facility list, excluding utilities and sealed source licensees, were contacted.

c. This count is less than expected. One reason may be that some generators are very reluctant to divulge information concerning GTCC LLW over the phone to an unknown person. Also, there is no way of knowing how complete the list of potential generators was. Certain databases of Class C generators were not made available to this study because of perceived sensitivities by the generators. In addition, most state offices with LLW management concerns have very little information relating to GTCC LLW, in part because the states are not responsible for the management or disposal of GTCC LLW.

d. The GTCC LLW Data Form consists of approximately 40 pages of questions followed by check-off lists. This information may prove useful to others conducting similar research. To request a blank set of written questions or more complete information on the survey findings, contact the GTCC LLW Management Program at the Idaho National Engineering Laboratory (208) 526-0234.

- **Historical or future inventories of the GTCC LLW**—Identify when generation of the waste began, when generation will (or did) end, quantities of the waste that exist on site in each container configuration that is used, and the future generation rate of the waste.

- **Packaging characteristics**—Provide input for the type of container (if any) that is used for the waste, including capacities, dimensions, construction materials, container weight, internal packaging type (if any), any absorbents used, and external radiation dose rates.

- **Radiological properties**—Identify all radionuclides present in the waste and their respective concentrations that are listed in 10 CFR 61.55.

- **Biological characteristics**—Identify any biological organisms present in the waste.

- **Storage of waste**—Determine if the generator needs to develop additional storage capacity to safely store the GTCC LLW that may exceed the individual generator's existing storage capacity before the availability of disposal services.

To better understand and estimate the characteristics and quantities of GTCC LLW being generated by Other Generators, the author visited three of the facilities that generate the largest quantities of GTCC LLW to observe waste generation processes and storage facilities. Locations included a sealed source manufacturer and two facilities that perform postirradiation spent fuel examination in hot cells (burnup labs). These sites were chosen because, at the time of selection, they were the generators with the largest level of ongoing GTCC LLW generation that welcomed visits to their locations. The visits provided useful information specific to each facility, which helped verify the accuracy and validity of this study. Section 2.3 describes the three site visits. Because the three facilities are not necessarily representative of all facilities included in the Other Generators category, information garnered from these site visits were not used to extrapolate projections for characteristics of Other Generator waste.

The following sections report and analyze the data obtained from those detailed questionnaires.

2. DATA COLLECTED FROM OTHER GENERATORS

2.1 Characterization of Other Generators Industries

The 13 Other Generators identified in this study engage in one of the six business types defined below. The number of generators found in each type is noted in parentheses.

- **Carbon-14 users (5)**—GTCC C-14 waste is generated in the manufacture of C-14 "tagged" chemicals used in research.

- **Industrial research and development firms (1)**—Industrial companies with radioactive materials licenses occasionally assume possession of materials containing radionuclides with the intent of temporary storage. In this case, although the holder of test fuel rods is in the business of manufacturing devices containing sealed sources, the function that generated the waste was research.

- **Fuel fabricators and irradiation research (burnup) laboratories (3)**—Hot cells examine irradiated nuclear fuel rods to identify structural integrity and to ascertain the percentage of U-235 and Pu-239 burnup during operation. The process of examination results in solids contaminated with the various transuranics from the irradiation of enriched fuel. Fuel fabricators have developed mixed oxide fuel pellets containing varying amounts of U-235, Pu-239, Pu-240, and Pu-241.

- **Academic nuclear research reactors (1)**—Material from reactors, such as control rod blades and material from reactor upgrades, contain metals activated with isotopes such as Nb-94 and Ni-63. [Only the largest academic nuclear research reactors were studied (out of 60 total), and only one of those had GTCC LLW.]

- **Sealed source manufacturers (2)**—Waste such as scrap foil and miscellaneous laboratory material containing Am-241 is produced in the manufacture of sealed sources. A few damaged sealed sources are expected to be present in this waste.

- **Nonmedical academic institutions (1)**—Radionuclides such as Tc-99 are used in laboratory research and development. No GTCC LLW was identified at any of the medical academic and professional institutions that were contacted.

Table 1 lists the generators by business type with their waste descriptions. A sequential facility identification number is assigned for convenience in subsequent tables in this report.

Table 1. Business type and waste description for 1993 GTCC LLW inventories of the 13 identified Other Generators.

Facility identification number	Business type	Waste description
1	C-14 user	Organic liquids: solidified waste, tritium
2	C-14 user	Organic liquids: free liquid (25% water; 75% alcohols, acetone, hexane, xylene, etc.)
3	C-14 user	Organic liquids: damp, solidified calcium carbonate
4	C-14 user	Organic liquids: absorbed liquids, alcohols, aromatics, salts, silica gel
5	C-14 user	Organic liquids: free liquid
6	Industrial research and development	Mixed oxide fuel pellets/rods
7	Burnup laboratory	Contaminated solids: hot cell waste (fuel grinds, 25% compactible trash, glass, plastic, metal scrap, equipment)
8	Burnup laboratory	Contaminated solids: hot cell waste (fuel grinds, 25% compactible trash, glass, plastic, metal scrap, equipment)
9	Fuel fabricator	Decontamination waste: concrete blocks, sludge, filters
		Decontamination waste: aqueous liquid
10	University reactor	Activated metals: control blades, miscellaneous in-core components
11	Sealed source manufacturer	Process waste: absorbed liquids, compactible trash, filters, glass, lead, plastic, metal scrap
12	Sealed source manufacturer	Process waste: americium oxide/gold foil, scrap sources, glass
13	Nonmedical academic institution	Process waste: dry technetium salt

2.2 Reported GTCC LLW Inventory Held by 13 Other Generators

This section summarizes the data reported by the 13 identified Other Generators, including waste groups, reported inventories, comparison between 1991 and 1993 data, mixed waste generation, and packaging factors.

Table 2 lists the 1993 inventory volumes and activities of GTCC LLW, as reported by the 13 identified Other Generators and also presents the hazardous classifications, the 10 CFR 61 radionuclides present in the waste, and whether the waste is currently packaged.

The reader should note that this report assumes that all generators are reporting volumes that have already been concentration averaged to dispose of as much of their radioactive waste as much as possible, to avoid the expense of storing and monitoring the waste.

2.2.1 Waste Groups

For this study, the GTCC LLW types are grouped according to the physical form of the waste: (a) activated metals, (b) mixed oxide fuel pellets, (c) decontamination wastes, (d) process wastes, (e) contaminated solids, and (f) organic liquids. Of these groups, the mixed oxide fuel pellets, decontamination waste, and activated metals are not regularly generated; rather, they represent one-time generations.

Table 3 presents the volumes and activities for each of these waste groups. Volumes and activities for waste groups were estimated based on discussions with the generators. The largest waste volume is associated with the contaminated solids group, but the highest waste activity is in the mixed oxide fuel pellets group. The various waste groups are described below.

Activated Metals—Activated metal components described within this study originated from a tank-type, light-water-cooled and moderated research reactor during an upgrade. The components contain Co-60 and Ni-63, and the waste forms exist as unusable control rod blades, a dummy fuel element, and miscellaneous in-core experimental facilities. All of these are presently being stored unpackaged.

Mixed Oxide Fuel Pellets—The solid mixed-oxide metal-clad test fuel rods containing the transuranics Pu-239 and Pu-241 that exceeded Class C limits were an isolated instance of waste generation. The holder assumed possession of the unpackaged waste with the intent of temporary storage.[e]

Decontamination Waste—Decontamination waste consists of concrete blocks, sludge, aqueous solution, and filters containing transuranics, which resulted from facility decontamination efforts.

e. The holder reports that discussions with DOE led to the conclusion that this waste is classified as GTCC LLW, not high-level radioactive waste.

Table 2. Estimates of 1993 GTCC LLW inventories, as reported by the 13 identified Other Generators.

Facility identification number	Business type	Volume (m^3)	Activity (Ci)	Hazardous class	Radionuclides	Packaged?
1	C-14 user	0.66	300	None	C-14	Yes
		0.71	75	40 CFR 261.21	C-14	Yes
2	C-14 user	6.25	165	40 CFR 261.21 40 CFR 261-D	C-14	Yes
3	C-14 user	0.21	1.7	None	C-14	Yes
4	C-14 user	0.019	60	40 CFR 261.24 40 CFR 261-D	C-14	Yes
5	C-14 user	0.0002[a]	2	None	C-14	No
6	Industrial R&D	0.003[a]	1160	None	Pu, U	No
7	Burnup lab	31.3	115	None	TRU, Co-60	Yes
8	Burnup lab	0.66	2.4[b]	None	TRU	Yes
9	Fuel fabr.	7.38	0.23	None	Pu, Am-241	Yes
		0.08	0.4	None	Pu, Am-241	Yes
10	Univ. reactor	0.59[a]	290	None	Co-60, Ni-63	No
11	Sealed source manufacturer	9.40	66.4	40 CFR 261.24	Am-241, Cs-137	Yes
12	Sealed source manufacturer	14.6	500	None	Am-241	Yes
13	Nonmedical academic inst.	0.00001	0.051	None	Tc-99	Yes
Total		>71.9[c]	>2,738[d]			

a. These volumes represent unpackaged waste as held on site. All other volumes listed represent packaged waste.

b. Activity is unknown by the generator. This activity level was estimated by assuming the same Ci/m^3 as that for Facility 7; both facilities are burnup labs.

c. 17.4 m^3 of this total is held by the six holders that are no longer generating GTCC LLW.

d. 1,515 Ci of this total is held by the six holders that are no longer generating GTCC LLW.

Table 3. 1993 inventory volume and activity estimates by waste group, as reported by the 13 identified Other Generators.

Waste group	Volume (m^3)	Activity (Ci)
Activated metals	0.59[a]	290
Mixed oxide fuel pellets	0.003[a]	1,160
Decontamination waste	7.46	0.63
Process waste	24.0	566
Contaminated solids	32.0	117
Organic liquids	7.85[b]	604
Total	71.9	2,738

a. These volumes represent unpackaged waste as held on site. Other volumes listed represent packaged waste.

b. Some of the organic liquids are packaged, while some of the volume remains unpackaged.

Process Waste—Process waste consists of absorbed liquids, cemented liquids, filters, plastic, and metal scrap foil from the manufacture of sealed sources. About one-third of this material is contaminated solids from gloveboxes used during gold, silver, polonium, and americium recovery operations. The waste contains radionuclides Cs-137 and Tc-99, and the transuranic Am-241.

Contaminated Solids–These solid wastes are contaminated on the surface with transuranics and other radionuclides such as Co-60 from irradiated fuel. The solid waste includes compactible trash, plastic, glass, and metal waste from hot cell facilities. This waste is not analyzed for radionuclide content because the analysis costs are too high, and the background radiation levels in the hot cells are too intense to allow an accurate reading. Nevertheless, activity levels of this waste are so high that transfer from the hot cells to the storage areas typically involves shielded handling of the waste containers.

Organic Liquids—Some organic liquids have been solidified with cement, or precipitated as calcium or barium carbonate. Salts or solvents often exist in the mixtures. Some of this waste group is still stored as free liquids. Most of this waste is generated using C-14 as a "tagged" chemical tracer in the testing and manufacture of pharmaceuticals and agricultural chemicals.

2.2.2 Packaging Factors

Ten of the 13 identified Other Generators reported packaged volumes for their GTCC LLW (see Table 2). This section discusses the packaging factors associated with the reported packaged waste volumes.

Packaging factors indicate the volume of a waste package relative to the actual volume of the waste within that package. Appendix E-4 *(Packaging Factors for Greater-Than-Class C Low-Level Radioactive Waste)* of the DOE/LLW-114 Revision 1 report, defines packaging factors as the volume of the container divided by the volume of the untreated waste within. A packaging factor of 2, for instance, indicates that the package volume is twice as large as the volume of the waste within the package.

For example, contaminated solids are placed in a 30-gal drum, which is then overpacked in a 55-gal drum. Given that a 55-gal drum has a volume of 0.212 m^3, and the packaging factor reported by the generator is 2 (see Table 4), the actual waste volume would be 0.106 m^3, or half the volume of the package.

Table 4 is included here to help the reader comprehend the volume of GTCC LLW reported by the 13 known Other Generators, both before and after packaging. These packaging factors are *not* used for calculations within this report, and are the generators' own estimates. Appendix D-1 ("Projection Calculations for Other Generator GTCC LLW") of the DOE/LLW-114 Revision 1 report provides a back-calculation of estimated volumes of unpackaged waste, using these packaging factors. The appendix includes a table that lists the estimated unpackaged volume of the packaged waste shown in Table 2.

2.2.3 Comparison to Earlier Results

The total GTCC LLW volume of 71.9 m^3 reported by the 13 identified Other Generators (see Table 3) is higher than the estimate of 65.4 m^3 made in Revision 0, the 1991 version of the DOE/LLW-114 report. The increase can be attributed to the fact that this study includes several holders of GTCC LLW that were not identified in the 1991 study. Several other differences are noted between the two studies:

- Five Other Generators identified in 1991 no longer possess any GTCC LLW
- Seven Other Generators were identified in both studies; these generators have stored GTCC LLW since at least 1986
- Four Other Generators, newly identified in 1993, claim to have been generating GTCC LLW since before 1986.

Table 4. Container arrangements and the packaging factors for each waste group, as reported by the known generators.

Waste group	Container arrangement	Packaging factor[a]
Activated metals	Not packaged	Not applicable
Mixed oxide fuel pellets	Not packaged	Not applicable
Decontamination waste	4×4×7-ft B25 metal shipping box	Unknown[b]
	10-L plastic bottles	Unknown[b]
Process waste	55-gal drum	1.1
	55-gal drum inside 83-gal drum	1.7
Contaminated solids	30-gal drum	1.1
	30-gal drum inside 55-gal drum	2.0
	55-gal drum inside 80-gal drum	1.5
	1-gal cans loose array inside 55-gal drum	3.0
	1.5-gal can inside 7-in.-outside-diameter × 17-in.-long tube liner	1.1
Organic liquids[c]	1/3 gal of liquid inside 1-gal jar inside 5-gal can inside 55-gal drum	200
	30-gal drum inside 55-gal drum	2.0
	1-gal can inside 55-gal drum	Unknown[b]

a. Packaging factors are based on the generators' reports; these packaging factors are not used for projections.

b. This information was not available from the generator.

c. The container arrangements listed for organic liquids do not reflect the unpackaged volumes reported by Facility 5.

Note: The process waste from sealed source manufacturing and the contaminated solid waste contain approximately 25% compactible trash, so the volume reduction technologies could reduce the total disposal volumes for this waste. The organic liquid waste would be solidified before disposal. However, any possible volume reduction is not reflected in the above packaging factors, nor in any volume projections.

2.2.4 Mixed GTCC LLW Reported by Other Generators

Three of the 13 Other Generators identified in this study either generate or store untreated mixed GTCC LLW (waste that contains both hazardous and radioactive materials). Under current federal regulations, mixed waste cannot be disposed of in LLW disposal facilities.

Three of the current C-14 users (Table 2, Facilities 1, 2, and 4) report the presence of three categories of hazardous materials within their GTCC LLW. These RCRA-regulated categories include ignitable (40 CFR 261.21), toxic (40 CFR 261.24), and listed (40 CFR 261, Subpart D). Chemicals include alcohols, acetone, hexane, xylene, and miscellaneous aromatics. Two generators store them as free liquids inside 30-gal drums overpacked by 55-gal drums. The other generator stores them as absorbed liquids with silica gel in 55-gal drums. The total volume and activity of these three generators' mixed waste held in inventory is 7.0 m^3 and 300 Ci, respectively.

A fourth generator (Table 2, Facility 11) also reported mixed waste in inventory. The mixed waste takes the form of process waste, described as absorbed liquids, 25% by volume compactible trash, filters, glass, lead, plastic, and metal scrap contained in 55- and 83-gal drums. The 83-gal drums contain 55-gal drums overpacked with Oil-Dri[f] absorbent. However, this sealed source manufacturer is no longer generating GTCC LLW. The volume and activity of this generator's inventory of mixed waste is 9.4 m^3 and 66.4 Ci, respectively.

None of the mixed GTCC LLW was found to contain biological organisms. The volume and activity of all mixed GTCC LLW held in inventory in 1993 is 16.4 m^3 and 366.4 Ci, respectively. DOE is currently studying treatment and disposal options for mixed waste.

2.3 Data Gathered from Site Visits

The GTCC LLW Management Program visited three generator sites to help determine the accuracy and validity of this study. Among other things, the program evaluated

- Whether similar GTCC LLW might be generated by similar operations at other companies

- Whether the company might generate GTCC LLW in some other process (future or currently unrecognized)

- Whether each company had a good understanding of what GTCC LLW is and understood RCRA definitions, and how accurate the company's response was to questions concerning GTCC LLW inventory and generation rates.

Visits were made to three generator sites to observe processes currently generating GTCC LLW. The three sites included two burnup laboratories and one sealed-source manufacturer

f. Mention of specific products or manufacturers in this document implies neither endorsement or preference, nor disapproval by the U.S. Government, any of its agencies, or EG&G Idaho, Inc., of the use of a specific product for any purpose.

because, at the time of selection, they were the generators with the largest level of ongoing GTCC LLW generation that welcomed visits to their locations.

As a result of these site surveys, the GTCC LLW Management Program is confident that this study accurately reflects the data from the known generators.

2.3.1 Burnup Laboratories

Both burnup laboratories must store the hot cell waste on site after completing postirradiation spent fuel examination. Although the fuel comes from power reactors, the utilities do not accept the hot cell waste. This material typically is polyethylene, polyvinyl chloride bags, cemented liquid from dissolved fuel (burnup solution), standard laboratory glassware, Dowex anion or cation exchange media, glovebox parts, etc. The variety of the waste material and unknown activities make it difficult to concentration-average the waste.

Because the containers holding the waste inside the hot cells have surface dose rates greater than 50 R/hr, all are remote-handled in the transfer to underground "interim" storage facilities. Modifications to both labs' storage facilities have been necessary because the original design did not allow for storage times of tens of years or more. Storage containers have been modified to reduce the storage packaging factor for more efficient storage use and to improve the container integrity over longer storage periods. Present storage capacity at both locations is expected to be exceeded within eight years.

Neither burnup laboratory performs a 10 CFR 61 analysis on this material because of cost, and because the background radiation in the hot cells area is higher than some Class C limits, useful measurements could not be made. The burnup laboratories assume that all radionuclides present in spent fuel could be present in the waste. The generation of this waste is expected to continue indefinitely. These two sites apparently produce the only burnup laboratory waste that is not owned by or being transferred to DOE.

2.3.2 Sealed Source Manufacturer

The third visit was to a manufacturer of sealed sources used in smoke detectors. Americium oxide in a matrix of gold is the radioactive component of the sources. To manufacture these sources, the americium, gold, and silver are molded into a 1/2-in.-thick, 3-in. rectangular bar, which is then rolled into a thin foil strip from which the sources are punched. The source, a small-diameter thin foil circle, is then mechanically stamped into the recess in an aluminum cylindrical holder. About half of the americium oxide that enters the plant leaves the plant as a product; the other half remains in the plant as scrap foil. The gold and silver in the scrap foil are dissolved, precipitated, and then recycled. The waste is 70% metal scrap and 30% glass materials. Concentrations of Am-241 range from 100 nCi/g to 510,000 nCi/g, with an estimated (by the generator) 500 Ci total activity. This generator estimates that by 1998, the company will exceed the existing storage capacity for GTCC LLW.

When smoke detectors are handled on an individual basis in the retail market, they are exempt from GTCC LLW disposal restrictions. GTCC LLW information gathered in this visit is related to the process waste generated by the manufacture of the sources. This waste is not exempt from disposal restrictions. Since the sealed source manufacturer is the only company that is manufacturing sources within the United States, extrapolation of waste generation information for other sites is not needed.

3. PROJECTIONS OF OTHER GENERATOR GTCC LLW

Projected volumes and activities of GTCC LLW generated by industries in the Other Generators category are based on two factors: (a) responses from generators concerning 1993 inventories and anticipated near-term (within five years) yearly generation rates and existing storage capacity, and (b) assumptions intended to yield reasonable results for high, base, and low case projections of Other Generator GTCC LLW. The following section presents the GTCC LLW generation rates and storage capacities reported by the 13 identified Other Generators. Section 3.2 then applies the high, base, and low case assumptions to develop projected totals of Other Generator GTCC LLW.

3.1 Generator Projections

Six of the 13 Other Generators identified in this study do not anticipate future generation of GTCC LLW. Table 5 lists the seven generators who expect to generate GTCC LLW in the future, the current volume and activity generation rate, and the volume and activity generation rate for five years in the future. Information reported in this table is based on the generators' responses to the questionnaire.

As shown in Table 5, three Other Generators anticipate mixed waste generation within the next five years, totaling 3.32 m^3/yr and 161 Ci/yr.

Table 5. 1993 and five-year generation rates of GTCC LLW, as predicted by the seven identified Other Generators who anticipate future generation of GTCC LLW.

Facility identification number	Business type	1993 packaged volume rate (m^3/yr)	Future (5-year) packaged volume rate (m^3/yr)	1993 activity rate (Ci/yr)	Future (5-year) activity rate (Ci/yr)
1	C-14 user	1.0	1.0[a]	20	25
2	C-14 user	2.3	2.9[a]	60.5	76
3	C-14 user	0.6	0.6	5	5
4	C-14 user	0.019	0.019[a]	60	60
7	Burnup lab	3.5	3.5	20	20
8	Burnup lab	0.05	0.06	0.18	0.2
12	Sealed source manuf.	1.0	1.0	45	45
Total		8.47	9.08	211	231

a. Expected to be mixed waste.

3.1.1 Anticipated Storage Capacity

Four of the seven generators who anticipate further generation of GTCC LLW expect to fill their existing onsite storage capacity within 10 years. They expect to be able to extend their licenses to store larger amounts of activity and construct more onsite storage capacity as needed. Table 6 shows the year that the active generators estimate they will fill their existing storage capacities.

Table 6. Year that seven active generators expect to fill existing storage capacities.

Facility identification number	Business type	Onsite storage at capacity (calendar year)
1	C-14 user	Beyond 2035
2	C-14 user	1998
3	C-14 user	Beyond 2035
4	C-14 user	Beyond 2035
7	Burnup lab	1995
8	Burnup lab	2001
12	Sealed source manufacturer	1998

3.2 Case Projections

The previous section reported the data gathered from questioning the 13 generators identified within the Other Generators category. Seven of the 13 expect to continue waste generation. However, these generators are not necessarily the only generators that may fit the category. Therefore, this study tries to bound the probable range of GTCC LLW by developing high, base, and low case projections of Other Generator GTCC LLW. The base case assumptions represent the conditions for the most probable volumes of GTCC LLW, while the high case conditions would create a larger total volume of GTCC LLW. The low case represents a probable lower bound for GTCC LLW volumes. The following section presents the assumptions for each case.

3.2.1 Assumptions

All three case projections share some common assumptions. The specific assumptions for each case are presented below.

- Future waste forms will be very similar to the currently generated waste
- All generators with stated future generation will continue to package their waste the same way they have been packaging it, and the current packaging methods are suitable for disposal

- No new mixed waste generators will arise or be identified

- All reported waste inventories are assumed to be concentration averaged; all future waste will continue to be concentration averaged in the same manner.

High Case Assumptions

- All existing generators will be able to construct additional needed storage capacity, so they will not be forced to shut down due to lack of storage capacity

- Future GTCC LLW production rates will be 25% greater than generators have estimated

- There will be no future shutdowns of any existing generators

- Two existing generators were not identified in this study, each currently holding an average of 6.0 m^3 of packaged GTCC LLW with 200 Ci, and are expected to generate in the future at an average rate of 1.9 m^3/yr packaged volume and 38 Ci/yr activity

- Three new generators will arise from activities such as decommissioning and decontamination, each generating in the future at an average rate of 1.9 m^3/yr and 38 Ci/yr for one-half of the time until the year 2035

- No further compaction of waste will occur (the high case packaging factors from Appendix E-4 were applied to Facilities 5, 6, and 10).

Base Case Assumptions

- All existing generators will be able to construct additional needed storage capacity, so they will not be forced to shut down due to lack of storage capacity

- Production rate increases will be as estimated by the generators (see Table 5)

- There will be no future shutdowns of any existing generators

- This study identified all current generators

- No new generators will begin operation in the future

- Packaging factors are the base-case values in Appendix E-4 of DOE/LLW-114 Revision 1 report for Facilities 5, 6, and 10.

Low Case Assumptions

- No generator will be able to add more storage on site when the existing storage capacity is filled; therefore, four of the existing generators will be forced to shut down at that time, including three small companies that will cease generation within five years as a result of increased storage fees and stricter regulations

- Generation rates will not increase relative to the 1993 rates
- This study identified all current generators
- No new generators will begin generating waste
- Packaging factors are the low-case values in Appendix E-4 of DOE/LLW-114 Revision 1 report for Facilities 5, 6, and 10.

These three sets of assumptions are applied to the Table 5 data to calculate reasonable estimates of Other Generator GTCC LLW for the high, base, and low cases.

3.2.3 1993 Inventory of Other Generator GTCC LLW

Using the packaged volumes reported by the generators in Table 2[g] and the assumptions for each case, the total packaged volume and activity was calculated for the 1993 inventory of Other Generator GTCC LLW for the high, base, and low cases. Three generators, however, reported volumes of unpackaged waste: reactor activated metals from Facility 10, liquids from Facility 5, and fuel pellets and rods from Facility 6. Before these volumes could be used to make volume projections for the total 1993 inventory of Other Generator GTCC LLW, they were converted to packaged volumes. The packing factors reported in Appendix E-4 were applied to the various cases to yield packaged volumes. Table 7 lists the unpackaged waste type and the packaging factors applied to each type.

Table 8 shows the 1993 estimated volume and activity for each case. All estimates assume the waste has been packaged and concentration averaged.

3.2.4 Projections of Other Generator GTCC LLW

Using the assumptions given for each case and the generator predictions for future volume and activity rates per year from Table 5, the study then calculated the total volume and activity for Other Generator GTCC LLW for the high, base, and low cases through the year 2035. As mentioned above, all projections assume the waste has been concentration averaged and packaged. Table 9 combines both the 1993 inventory and the estimated projections to determine the volume and activity of Other Generator GTCC LLW that will require disposal in the year 2035.

Base case projections of Other Generator untreated mixed GTCC LLW through 2035 total 186 m^3 packaged volume. See Appendix D-1 and DOE/LLWE-2 (both appendices to the DOE/LLW-114 Revision 1 report) for further information on mixed waste projections.

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g. Unpackaged volumes have been back-calculated for each case and are presented in Appendix D-1 for use in the event that wastes must be repackaged for disposal.

Table 7. Packaging factors applied to unpackaged waste to estimate 1993 inventory of Other Generator GTCC LLW.

Unpackaged waste type	Packaging factors from Appendix E-4: High case	Base case	Low case	Equivalent component from Appendix E-4
Reactor activated metals (Facility 10)	10	5	4	Boiling water reactor control rod blades
Liquids (Facility 5)	3	0.2	0.1	Liquids
Fuel pellets and rods (Facility 6)	1[a]	1[a]	1[a]	Pressurized water reactor primary sources
Total				

a. A packaging factor of 1 was applied for all three cases as a best estimate for the waste fuel pellets and rods held at Facility 6.

Table 8. Estimated packaged volumes and activities of 1993 inventory of Other Generator GTCC LLW.

Case	Concentration-averaged packaged volume (m^3)	Activity (Ci)
High	89.2	3,138
Base	74.2	2,738
Low	73.6	2,738

Table 9. Estimated volumes and activities of 2035 cumulative inventory of Other Generator GTCC LLW.

Case	Concentration-averaged packaged volume (m^3)	Activity (not adjusted for decay) (Ci)
High	866	19,707
Base	465	12,680
Low	167	6,962

4. SUMMARY AND CONCLUSIONS

The 13 generators identified in this study reported a 1993 inventory of GTCC LLW totaling 71.9 m^3 volume (packaged and unpackaged) with activity levels at 2,738 Ci. However, the reported volumes do not necessarily equal actual volumes, given that this study may not have identified all existing Other Generators. Therefore, assumptions were developed for high, base, and low cases to reasonably bound the possible range of Other Generator GTCC LLW. After applying the high, base, and low case assumptions described in this study, the base case (which is the most likely case to occur) for the 1993 inventory of Other Generator GTCC LLW is an estimated total of 74.2 m^3 packaged volume containing about 2,738 Ci of activity.

The projections for low, base, and high case total volumes take into account current inventories, expected future generation rates, possible number of generators missed during this study, possible number of generators quitting or beginning generation in the future, and time to exceed current onsite storage capacities. All cases assume that waste is packaged, concentration averaged, and similar to that reported by known generators. This study estimates that by the year 2035, Other Generator GTCC LLW will total 465 m^3 packaged volume with activity levels of about 12,680 Ci for the base case.

Four of the 13 identified generators report mixed waste generation; three expect to continue generation of mixed waste. Base case projections of Other Generator untreated mixed waste through 2035 total 186 m^3 packaged volume. This amount is included in the total projections for Other Generator GTCC LLW.

The GTCC LLW Management Program has no way to statistically evaluate how well the 13 generators identified represent all organizations within the Other Generator category. Therefore, no confidence limits can be quantified concerning the total volume or total activity of actual and projected GTCC LLW from Other Generators. However, conversations with the various contacts during this study indicate it is almost certain that all large-quantity GTCC LLW generators have been identified.

This category contributes a significant portion of GTCC LLW, as shown in Section 6 of the DOE/LLW-114 report, Rev. 1. Therefore, Other Generator waste should be carefully considered when planning for the eventual disposal of all GTCC LLW.