Low Level Radioactive Waste Disposition – LLW Treatment/Management Data Input

Fuel Cycle Research & Development

Prepared for
U.S. Department of Energy
Used Nuclear Fuel
Robert H. Jones, SRNL
June, 2013
Revision 0
FCRD-UFD-2013-000195

REVISIONS

Revision Number	Date	Major Sections Affected	Description
0	June 2013		Initial issue

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

BOP	Balance of Plant
DOE-NE	Department of Energy Office of Nuclear Energy
FCRD	Fuel Cycle Research and Development
FY	fiscal year
GTCC	greater than Class C
GWd/MT	giga-watt days per metric ton
HEPA	high efficiency particulate air
LLW	low level waste
MPC	multi-purpose canister
PA	performance assessment
UFD	Used Fuel Disposition

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

This report was prepared by the Used Fuel Disposition (UFD) Campaign of the Fuel Cycle Research and Development (FCRD) program. The Low Level Waste Disposition work package of the UFD Campaign is tasked with evaluating disposal options for secondary waste generated by alternate fuel cycles. In support of this task, volume estimates of Class A, B and C low level waste (LLW) and greater than Class C (GTCC) waste resulting from several alternate fuel cycles have been provided in the past [Jones 2011]. These estimates did not provide the radionuclide content of the waste streams which is needed to support future generic performance assessment (PA) models for LLW disposal and trade studies being conducted by the Separations and Waste Forms and Fuel Cycle Options Campaigns to assess the technical and economic benefits of various secondary waste treatment alternatives.

Radionuclide inventory data is not available for secondary waste streams from the specific alternate fuel cycles being considered since there is no historical basis of operations. Accordingly, spreadsheet models have been developed to estimate the radionuclide inventory contained in secondary waste generated by potential alternate fuel cycle processes, namely the Co-Extraction, New-Extraction and UREX+1b recycling processes. An initial waste treatment scenario (Scenario 1) was evaluated in FY 2012 with the radionuclide inventory models to support the waste treatment trade studies being conducted by the Separations and Waste Forms and Fuel Cycle Options Campaigns [Jones 2012]. The report prepared in FY 2012 as input to the waste treatment studies included data on all three recycling processes (i.e. Co-Extraction, New-Extraction and UREX+1b) for six different fuel types for a total of 18 cases.

Since that time, the Department of Energy Office of Nuclear Energy (DOE-NE) issued Task Order 9 to the industry teams of AREVA and Energy*Solutions* to provide a better understanding of secondary wastes generated by the Co-Extraction process [DOE-NE]. Subsequent to the completion of Task Order 9, the UFD Campaign was tasked with preparing a report comparing the industry waste estimates to each other and to the prior UFD waste estimates [Jones 2013]. During the process of preparing that report, several errors were discovered in the prior UFD estimates that produced on overly conservative estimate. The prior UFD estimates were revised to eliminate the conservative errors [Jones 2013b].

The scope of the waste treatment studies has also been better defined in FY 2013 to focus the studies on the Co-Extraction process for two specific fuel types:

- 60 GWd/Mt burnup cooled for 5 years and
- 60 GWd/MT burnup cooled for 30 years

These parameters were selected to align with the fuel types and recycling process used for Task Order 9 and summarized in the UFD comparison report.

This report updates the input to the waste treatment studies by incorporating the revised UFD waste estimates for Co-Extraction for the fuel types listed above. This report has a secondary benefit in supporting the UFD Task Order 9 waste comparison report by providing an additional source of data for comparison to the industry waste estimates. This report is not intended to provide a detailed description of the radionuclide inventory spreadsheet models. A separate report provides a more detailed description of the spreadsheet models [Jones 2012b].

2.0 DESCRIPTION OF THE SCENARIO EVALUATED

Input to the waste treatment studies being conducted by the Separations and Waste Forms and Fuel Cycle Options Campaigns was provided in FY 2012 [Jones 2012]. The FY 2012 input described an initial waste treatment scenario (Scenario 1) evaluated by the radionuclide inventory models. The radionuclide inventory models incorporate many input parameters that can be varied to define a multitude of waste treatment scenarios to be evaluated. Except for Waste Package Parameters, all of the model parameters described in the FY 2012 input for Scenario 1 and listed below are still applicable for Scenario 2.

- Waste Volume-to-Mass Conversion Factors
- Radionuclide Concentration Factors
- Radionuclide Concentration Environmental Factors
- Waste Classification Parameters
- Waste Blending Categories
- Used Fuel Parameters
- Waste Treatment Parameters

These parameters are described in greater detail in Section 2.0 of the FY 2012 input document [Jones 2012].

The Waste Package Parameters for Scenario 1 were those recommended in Reference 4 [Jones 2012b]. These parameters do not agree with those used for prior UFD waste estimates; therefore, they were changed in Scenario 2 to agree with the prior waste estimates to provide a better comparison to the prior estimates. Table 2.0-1 shows the changes made from Scenario 1 to Scenario 2.

Table 2.0-1
Changes Made to Waste Package Parameters [1]

Waste Package	Bulk Packing Efficiency		Treated Packing Efficiency	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
LLW Drum	90	80	98	100
Standard LLW Box	90	80	98	100
Solidified LLW Box	98	100	98	100
Engineered LLW Container	90	80	98	100
High Integrity Container	90	80	98	100
GTCC Drum	90	80	98	100
Standard GTCC Box	90	80	98	100
Engineered GTCC Container	90	80	98	100
Mixed LLW Drum	90	50	98	100
Mixed Solidified LLW Box	98	100	98	100
Mixed Engineered LLW Container	90	80	98	100
Mixed High Integrity Container	90	80	98	100
Mixed GTCC Drum	90	80	98	100
Mixed Standard GTCC Box	90	80	98	100
Mixed Engineered GTCC Container	90	80	98	100

1. Other waste package parameters such as interior and exterior volumes are unchanged.

Scenario 1 has also been revised to incorporate corrections made to the UFD secondary waste estimates and to align with the current scope of the waste treatment studies. Changes to the as-generated waste volumes for the following waste streams were made to Scenario 1 to produce the revised scenario (Scenario 2) for use in the waste treatment trade studies.

- Fuel Receipt - multi-purpose canisters (MPCs)
- Waste Handling - job control waste
- Analytical - job control waste
- Balance of Plant (BOP) - job control waste
- BOP - facility ventilation filters (roughing and high efficiency particulate air (HEPA) filters)

These changes are summarized below. For greater detail on these changes, see Reference 6.

Assumptions for Task Order 9 related to the receipt of used fuel at the recycling facility state that short cooled fuel (i.e. 5 years) is received in bolted lid, reusable transportation casks and that long cooled fuel (i.e. 50 years) is received in MPCs. The assumptions further state that 100% of the MPCs are considered unusable after opening and require disposal as radioactive waste. Scenario 2 considers two different fuel types:

- 60 GWd/Mt burnup cooled for 5 years (short cooled fuel)
- 60 GWd/MT burnup cooled for 30 years (long cooled fuel)

Scenario 1 was based on the original UFD secondary waste estimates which assumed receipt of all used fuel in MPCs but with only a 10% disposal rate. Scenario 2 incorporates the Task Order 9 assumptions related to MPC disposal for short cooled and long cooled fuel.

The UFD secondary waste estimates for Co-Extraction are derived from the UFD secondary waste estimates for the UREX+1b process. The original Co-Extraction estimates did not adjust the UREX+1b estimates for job control waste from Waste Handling, Analytical and BOP to account for the reduced facility size, staffing, sampling requirements, etc. associated with Co-Extraction versus UREX+1b. As a result, the Co-Extraction waste estimates for these waste streams were overly conservative. The as-generated volume of the job control waste streams from Waste Handling, Analytical and BOP have been adjusted to agree with the revised UFD secondary waste estimates [Jones 2013b].

The original Co-Extraction estimates did not adjust the UREX+1b estimates for facility ventilation filters from BOP to account for the reduced facility size associated with Co-Extraction versus UREX+1b. As a result, the Co-Extraction waste estimate for facility ventilation filters was overly conservative. The as-generated volume of facility ventilation filters from BOP has been adjusted to agree with the revised UFD secondary waste estimates [Jones 2013b].

3.0 RADIONUCLIDE INVENTORY RESULTS

The radionuclide inventory models for Scenario 1 were reconfigured for Scenario 2 to incorporate the as-generated volume adjustments and assumptions related to receipt of used fuel in MPCs described in Section 2.0. The scenario was evaluated for the two fuel types being considered:

- 60 GWd/Mt burnup cooled for 5 years and
- 60 GWd/MT burnup cooled for 30 years

Tables summarizing the results are provided in Appendix A. There are a total of 4 tables, two separate tables for mixed (hazardous and radioactive) waste and non-mixed (non-hazardous but radioactive) waste for each fuel type. Each table provides the waste volume, waste mass and radionuclide content (in terms of Curies and mass) for both as generated waste and treated waste. Final packaged waste volume is also provided by waste package type. This information is provided for each waste classification category (i.e. Class A, B, C and GTCC) as well as the total based on the following 3 approaches to blending:

- None: Sum of the individual waste streams from each process function by waste classification
- Separate: Sum of the waste streams blended separately for operational, job control and maintenance waste streams for each process function
- Process Function: Sum of the waste streams blended across the entire process function

Tables 3.0-1 compares the final packaged waste volumes and radionuclide concentrations for each fuel type to each other and to the UFD secondary waste estimates provided in Reference 6. An additional case is also shown that eliminates the MPC waste stream from the 60 GWd/MT, 30 year cooled fuel case to provide a more “apples-to-apples” comparison to the 60 GWd/MT, 5 year cooled case.

The packaged waste volumes and radionuclide concentrations shown in Table 3.0-1 are based on summing the individual waste streams from each process function (identified as “None” above). This approach is used since it is similar to the methodology used to produce the original UFD secondary waste estimates (i.e. the UFD estimates did not consider blending of waste streams). Figures 3.0-1 and 3.0-2 that follow provide a graphical representation of the waste volumes contained in Table 3.0-1.

Table 3.0-1
Comparison of Final Packaged Waste Volume for the Co-Extraction Process

Sceanrio	Parameter	Units [2]	Class A	Class B	Class C	Total Class A/B/C	GTCC	Total	Mixed Class A	Mixed Class B	Mixed Class C	Total Class A/B/C	Mixed GTCC	Total
EAS/FOEAS (short cooled fuel) [1]	Waste Volume	m^3				6068.6	259.5	6328.1				28.60	44.80	73.40
		% of Total				95.9	4.1					38.96	61.04	
EAS/FOEAS (long cooled fuel) [1]	Waste Volume	m^3				6668.6	259.5	6928.1				28.60	44.80	73.40
		% of Total				96.3	3.7					38.96	61.04	
60 GWd burnup 5 years cooling	Waste Volume	m^3	3,091.0	1,685.7	1,156.7	5,933.5	832.1	6,765.6	17.13	43.37	0.60	61.10	0.13	61.23
		% of Total	45.7	24.9	17.1	87.7	12.3		27.98	70.82	0.99	99.79	0.21	
	Radionuclide Content	Curies	62.2	868.8	36,880.4	37,811.4	15,411.5	53,222.9	0.33	18.90	0.51	19.73	3.14	22.87
		% of Total	0.1	1.6	69.3	71.0	29.0		1.45	82.61	2.22	86.27	13.73	
		Curies/m^3	0.0	0.5	31.9	6.4	18.5		0.02	0.44	0.84	0.32	24.53	
60 GWd burnup 30 years cooling	Waste Volume	m^3	3,673.0	1,573.0	741.5	5,987.5	1,232.7	7,220.2	59.79	0.71	0.60	61.10	0.13	61.23
		% of Total	50.9	21.8	10.3	82.9	17.1		97.64	1.16	0.99	99.79	0.21	
	Radionuclide Content	Curies	67.9	429.4	11,982.0	12,479.3	7,531.6	20,010.8	1.15	5.13	0.19	6.48	1.16	7.63
		% of Total	0.3	2.1	59.9	62.4	37.6		15.02	67.25	2.55	84.82	15.18	
		Curies/m^3	0.0	0.3	16.2	2.1	6.1		0.02	7.21	0.32	0.11	9.05	
60 GWd burnup 30 years cooling (No MPC Waste)	Waste Volume [4]	m^3	3,673.0	1,573.0	741.5	5,987.5	632.7	6,620.2	59.79	0.71	0.60	61.10	0.13	61.23
		% of Total	55.5	23.8	11.2	90.4	9.6		97.64	1.16	0.99	99.79	0.21	
	Radionuclide Content	Curies	67.9	429.4	11,982.0	12,479.3	5,818.1	18,297.3	1.15	5.13	0.19	6.48	1.16	7.63
		% of Total	0.4	2.3	65.5	68.2	31.8		15.02	67.25	2.55	84.82	15.18	
		Curies/m^3	0.0	0.3	16.2	2.1	9.2		0.02	7.21	0.32	0.11	9.05	

1. EAS/FOEAS data is derived from FCRD-USED-2010-000033, Revision 3, June 2013, Appendix E [Jones 2013b]
2. "% of Total" is the percent of the total of all waste (i.e. Class A, B and C plus GTCC).
3. Waste volumes are based on the sum of individual waste streams from each process function. The waste volumes shown do not reflect the results of blending waste streams (see Section 3.0 text).
4. The GTCC waste volume for 60 GWd/MT, 30 year cooled fuel is reduced by the volume of packaged waste associated with MPCs (600 m^3).

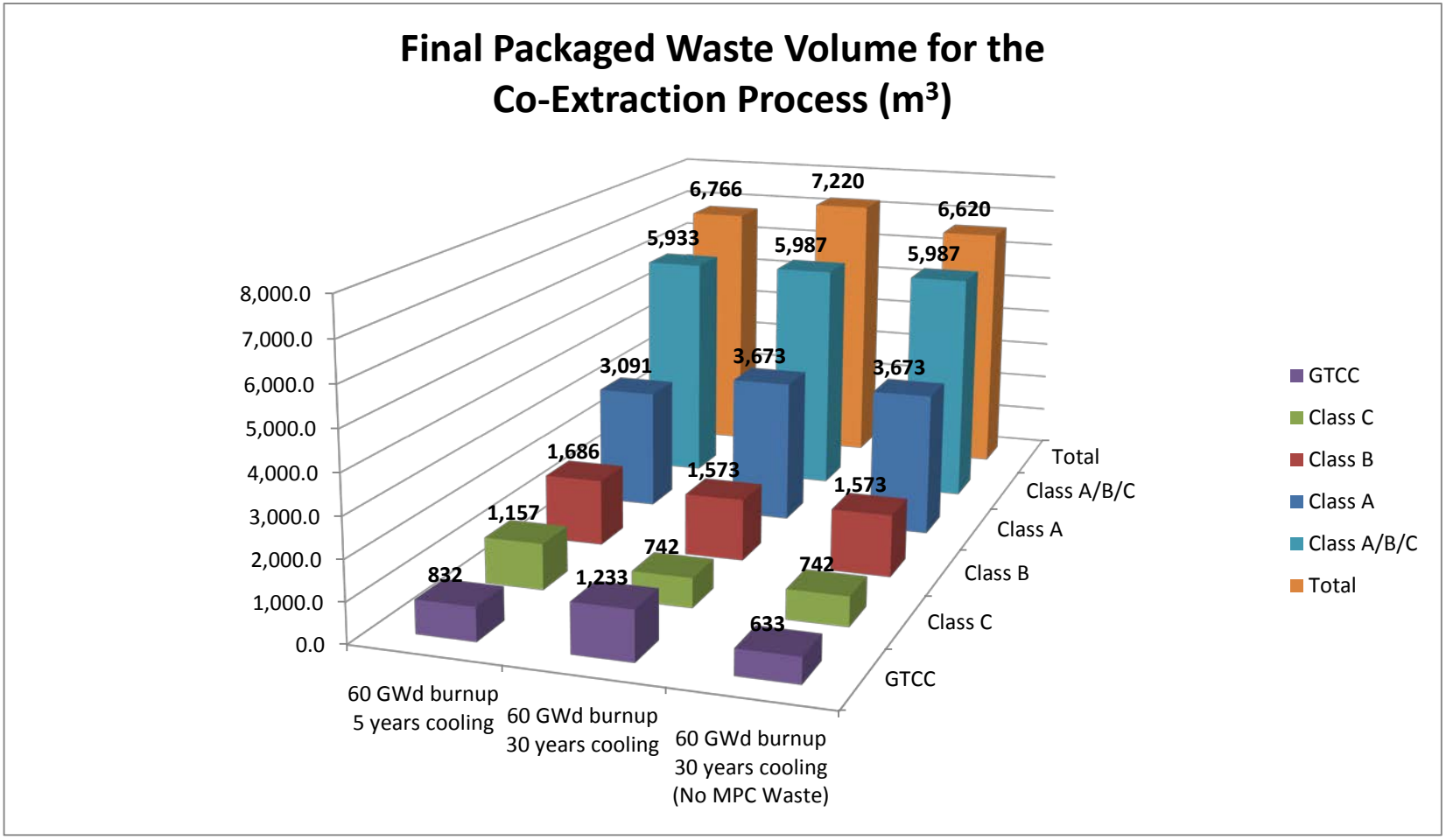

Figure 3.0-1
Final Packaged Waste Volume for the Co-Extraction Process (m^3)

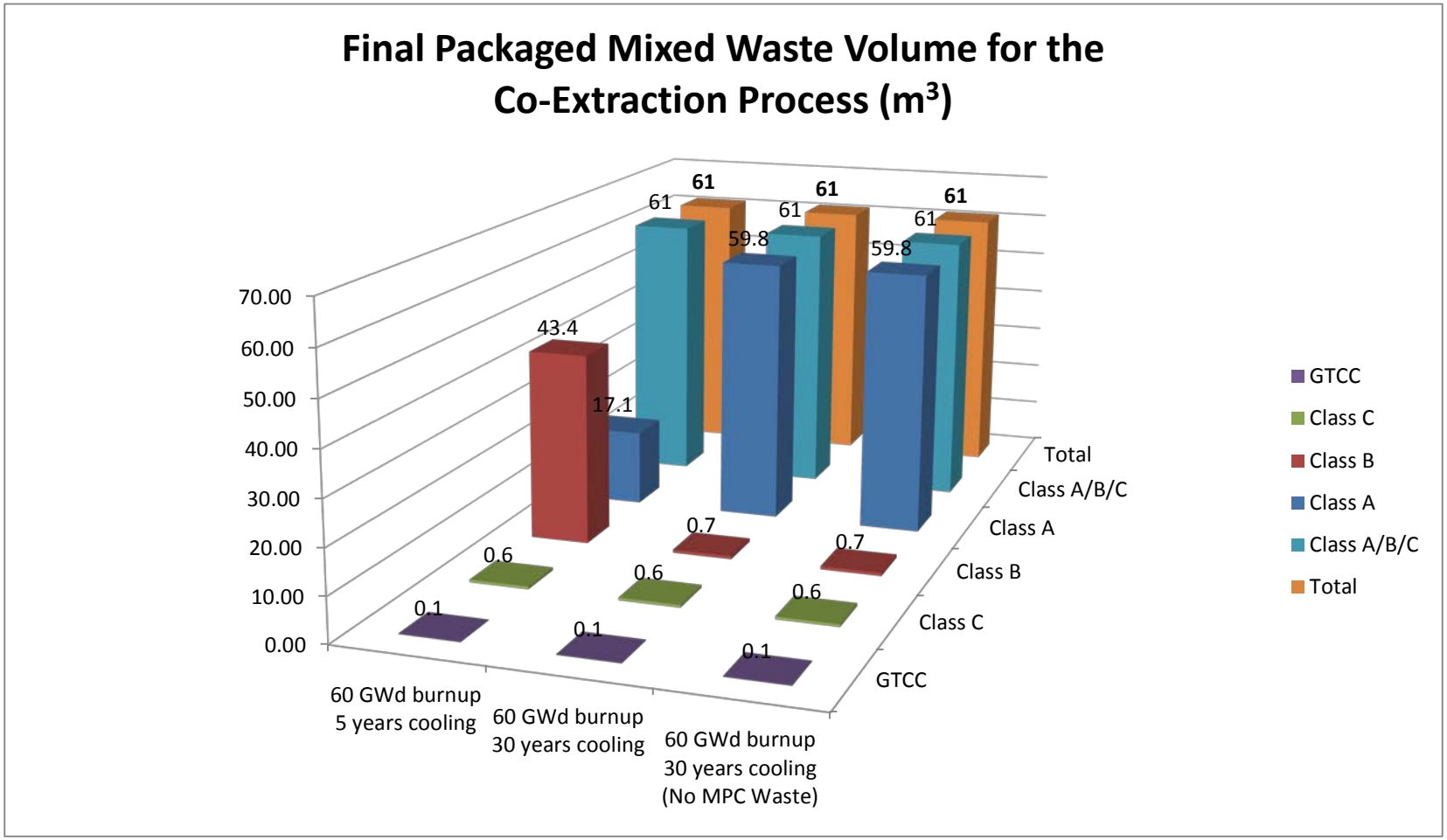

Figure 3.0-2
Final Packaged Mixed Waste Volume for the Co-Extraction Process (m^3)

THIS PAGE INTENTIONALLY LEFT BLANK

4.0 REFERENCES

1. Department of Energy Office of Nuclear Energy (DOE-NE), Task Order 9, *Improving the Estimates of Waste from Recycling*
2. Jones, Robert H. June 2011. FCRD-USED-2010-000033, *Low Level Waste Disposition - Quantity and Inventory*, Revision 2
3. Jones, Robert H. November 2012. FCRD-UFD-2012-000185, *Low Level Waste Disposition - LLW Treatment/Management Data Input*, Revision 1
4. Jones, Robert H. November 2012b. FCRD-UFD-2012-000186, *Low Level Waste Disposition - Low Level Waste Radionuclide Inventory*, Revision 1
5. Jones, Robert H. Jr., Carter, Joe T. June 2013, FCRD-UFD-2013-000178, *Comparison of Waste Estimates from Recycling and Fuel Fabrication*
6. Jones, Robert H. June 2013b. FCRD-USED-2010-000033, *Low Level Waste Disposition - Quantity and Inventory*, Revision 3

THIS PAGE INTENTIONALLY LEFT BLANK

Appendix A

Summary Data for Co-Extraction

THIS PAGE INTENTIONALLY LEFT BLANK

Overall Summary of Waste Stream Data for the Co-Extraction Process Based on 60 GWd/MTIHM Used Nuclear Fuel Cooled for 5 years

Basis	Parameter	Units	Total By Summing Individual Waste Streams (summed by bulk volume, treated volume and packaged volume)					Total By Summing Blended Operational, Job Control and Maintenance Waste Streams (includes remaining non-blendable waste streams)					Total by Summing Waste Streams Blended Across the Entire Process Function (includes remaining non-blendable waste streams)				
			Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total
As Generated	Waste Volume	m^3	11,824.18	1,532.75	2,831.87	2,880.08	19,068.87	8,804.27	1,712.05	5,333.63	3,218.93	19,068.87	8,804.27	1,712.05	5,320.47	3,232.09	19,068.87
		% of Total	62.01	8.04	14.85	15.1		46.17	8.98	27.97	16.88		46.17	8.98	27.9	16.95	
	Waste Mass	kilograms	2,258,818.71	1,888,907.68	445,382.41	412,346.27	5,005,455.06	1,832,069.81	1,932,495.44	766,871.77	474,018.03	5,005,455.06	1,832,069.81	1,932,495.44	741,280.77	499,609.03	5,005,455.06
		% of Total	45.13	37.74	8.9	8.24		36.6	38.61	15.32	9.47		36.6	38.61	14.81	9.98	
	Radionuclide Content	Curies	130.93	30,276.81	7,403.66	15,411.52	53,222.91	75.25	30,729.48	7,126.00	15,292.19	53,222.91	75.25	30,729.48	7,108.96	15,309.23	53,222.91
		% of Total	0.25	56.89	13.91	28.96		0.14	57.74	13.39	28.73		0.14	57.74	13.36	28.76	
	Radionuclide Content	grams	2,960.04	416,911.66	1,301.33	11,931.61	433,104.65	3,021.98	417,246.15	1,235.07	11,601.44	433,104.65	3,021.98	417,246.15	1,219.91	11,616.61	433,104.65
		% of Total	0.68	96.26	0.3	2.75		0.7	96.34	0.29	2.68		0.7	96.34	0.28	2.68	
Treated	Waste Volume	m^3	3,038.62	1,645.74	886.28	782.01	6,352.64	2,265.25	1,597.97	1,609.87	879.55	6,352.64	2,265.25	1,585.10	1,600.00	902.29	6,352.64
		% of Total	47.83	25.91	13.95	12.31		35.66	25.15	25.34	13.85		35.66	24.95	25.19	14.2	
	Waste Volume Reduction	%	74.30	-7.37	68.70	72.85	66.69	74.27	6.66	69.82	72.68	66.69	74.27	7.42	69.93	72.08	66.69
	Waste Mass	kilograms	2,268,038.11	6,012,480.28	516,082.41	412,346.27	9,208,947.06	1,867,709.81	6,003,522.64	863,696.57	474,018.03	9,208,947.06	1,867,709.81	5,996,949.24	822,106.97	522,181.03	9,208,947.06
		% of Total	24.63	65.29	5.6	4.48		20.28	65.19	9.38	5.15		20.28	65.12	8.93	5.67	
	Radionuclide Content	Curies	62.21	868.82	36,880.37	15,411.52	53,222.91	75.25	1,019.35	36,836.13	15,292.19	53,222.91	75.25	954.94	36,883.50	15,309.23	53,222.91
		% of Total	0.12	1.63	69.29	28.96		0.14	1.92	69.21	28.73		0.14	1.79	69.3	28.76	
	Radionuclide Content	grams	2,952.54	414,031.48	4,189.01	11,931.61	433,104.65	3,021.98	414,335.61	4,145.62	11,601.44	433,104.65	3,021.98	414,329.30	4,136.76	11,616.61	433,104.65
		% of Total	0.68	95.6	0.97	2.75		0.7	95.67	0.96	2.68		0.7	95.66	0.96	2.68	
Packaged	Volume - LLW Drum	m^3	0.00	0.00	0.60		0.60	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00
		% of Total	0	0	100	0											
	Volume - Standard LLW Box	m^3	2,845.63	0.00	0.00		2,845.63	2,690.63	0.00	0.00		2,690.63	2,690.63	0.00	0.00		2,690.63
		% of Total	100	0	0	0		100	0	0	0		100	0	0	0	
	Volume - Engineered LLW Container	m^3	213.61	115.83	125.13		454.56	140.93	106.37	206.27		453.57	140.93	106.37	206.27		453.57
		% of Total	46.99	25.48	27.53	0		31.07	23.45	45.48	0		31.07	23.45	45.48	0	
	Volume - High Integrity Container	m^3	0.00	69.88	1,011.08	63.00	1,143.96	0.00	21.19	2,345.21	13.50	2,379.89	0.00	0.00	2,361.75	13.50	2,375.24
		% of Total	0	6.11	88.38	5.51		0	0.89	98.54	0.57		0	0	99.43	0.57	
	Volume - Solidified LLW Box	m^3	31.80	1,500.00	19.92		1,551.72	0.00	1,500.00	19.92		1,519.92	0.00	1,500.00	0.00		1,500.00
		% of Total	2.05	96.67	1.28	0		0	98.69	1.31	0		0	100	0	0	
	Volume - GTCC Drum	m^3				604.18	604.18				932.34	932.34				960.77	960.77
		% of Total	0	0	0	100		0	0	0	100		0	0	0	100	
	Volume - Standard GTCC Box	m^3				9.08	9.08				0.00	0.00				0.00	0.00
		% of Total	0	0	0	100											
	Volume - Engineered GTCC Container	m^3				155.85	155.85				156.84	156.84				156.84	156.84
		% of Total	0	0	0	100		0	0	0	100		0	0	0	100	
	Volume - Total	m^3	3,091.04	1,685.71	1,156.72	832.12	6,765.59	2,831.56	1,627.56	2,571.39	1,102.68	8,133.20	2,831.56	1,606.37	2,568.01	1,131.11	8,137.06
		% of Total	45.69	24.92	17.1	12.3		34.81	20.01	31.62	13.56		34.8	19.74	31.56	13.9	
	Waste Volume Increase (relative to treated waste volume)	%	1.73	2.43	30.51	6.41	6.50	25.00	1.85	59.73	25.37	28.03	25.00	1.34	60.50	25.36	28.09
	Overall Waste Volume Reduction (relative to as generated waste volume)	%	73.86	-9.98	59.15	71.11	64.52	67.84	4.93	51.79	65.74	57.35	67.84	6.17	51.73	65	57.33

Overall Summary of Mixed Waste Stream Data for the Co-Extraction Process Based on 60 GWd/MTIHM Used Nuclear Fuel Cooled for 5 years

Basis	Parameter	Units	Total By Summing Individual Waste Streams (summed by bulk volume, treated volume and packaged volume)					Total By Summing Blended Operational, Job Control and Maintenance Waste Streams (includes remaining non-blendable waste streams)					Total by Summing Waste Streams Blended Across the Entire Process Function (includes remaining non-blendable waste streams)				
			Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total
As Generated	Waste Volume	m^3	9.44	65.72	0.48	0.06	75.70	9.44	65.72	0.48	0.06	75.70	9.44	65.72	0.48	0.06	75.70
		% of Total	12.47	86.81	0.63	0.08		12.47	86.81	0.63	0.08		12.47	86.81	0.63	0.08	
	Waste Mass	kilograms	8,809.50	16,996.97	536.60	723.20	27,066.27	8,809.50	16,996.97	536.60	723.20	27,066.27	8,809.50	16,996.97	536.60	723.20	27,066.27
		% of Total	32.55	62.8	1.98	2.67		32.55	62.8	1.98	2.67		32.55	62.8	1.98	2.67	
	Radionuclide Content	Curies	0.33	18.90	0.51	3.14	22.87	0.33	18.90	0.51	3.14	22.87	0.33	18.90	0.51	3.14	22.87
		% of Total	1.45	82.61	2.22	13.73		1.45	82.61	2.22	13.73		1.45	82.61	2.22	13.73	
	Radionuclide Content	grams	0.49	1.88	0.54	0.90	3.81	0.49	1.88	0.54	0.90	3.81	0.49	1.88	0.54	0.90	3.81
		% of Total	12.96	49.36	14.13	23.55		12.96	49.36	14.13	23.55		12.96	49.36	14.13	23.55	
Treated	Waste Volume	m^3	8.73	34.59	0.35	0.13	43.81	8.73	34.59	0.35	0.13	43.81	8.73	34.59	0.35	0.13	43.81
		% of Total	19.94	78.96	0.81	0.29		19.94	78.96	0.81	0.29		19.94	78.96	0.81	0.29	
	Waste Volume Reduction	%	7.50	47.36	25.79	-100.00	42.13	7.50	47.36	25.79	-100.00	42.13	7.50	47.36	25.79	-100.00	42.13
	Waste Mass	kilograms	8,901.90	17,276.37	596.00	864.00	27,638.27	8,901.90	17,276.37	596.00	864.00	27,638.27	8,901.90	17,276.37	596.00	864.00	27,638.27
		% of Total	32.21	62.51	2.16	3.13		32.21	62.51	2.16	3.13		32.21	62.51	2.16	3.13	
	Radionuclide Content	Curies	0.33	18.90	0.51	3.14	22.87	0.33	18.90	0.51	3.14	22.87	0.33	18.90	0.51	3.14	22.87
		% of Total	1.45	82.61	2.22	13.73		1.45	82.61	2.22	13.73		1.45	82.61	2.22	13.73	
	Radionuclide Content	grams	0.49	1.88	0.54	0.90	3.81	0.49	1.88	0.54	0.90	3.81	0.49	1.88	0.54	0.90	3.81
		% of Total	12.96	49.36	14.13	23.55		12.96	49.36	14.13	23.55		12.96	49.36	14.13	23.55	
Packaged	Volume - Mixed LLW Drum	m^3	17.13	0.75	0.60		18.49	17.47	1.01	0.71		19.18	17.47	1.01	0.71		19.18
		% of Total	92.66	4.08	3.27	0		91.06	5.25	3.69	0		91.06	5.25	3.69	0	
	Reserved																
	Volume - Mixed Engineered LLW Container	m^3	0.00	42.61	0.00		42.61	0.00	42.61	0.00		42.61	0.00	42.61	0.00		42.61
		% of Total	0	100	0	0		0	100	0	0		0	100	0	0	
	Volume - Mixed High Integrity Container	m^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		% of Total															
	Volume - Mixed Solidified LLW Box	m^3	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00
		% of Total															
	Volume - Mixed GTCC Drum	m^3				0.13	0.13				0.16	0.16				0.16	0.16
		% of Total	0	0	0	100		0	0	0	100		0	0	0	100	
	Volume - Mixed Standard GTCC Box	m^3				0.00	0.00				0.00	0.00				0.00	0.00
		% of Total															
	Volume - Mixed Engineered GTCC Container	m^3				0.00	0.00				0.00	0.00				0.00	0.00
		% of Total															
	Volume - Total	m^3	17.13	43.37	0.60	0.13	61.23	17.47	43.62	0.71	0.16	61.96	17.47	43.62	0.71	0.16	61.96
		% of Total	27.98	70.82	0.99	0.21		28.19	70.41	1.14	0.26		28.19	70.41	1.14	0.26	
	Waste Volume Increase (relative to treated waste volume)	%	96.18	25.36	70.62	0.00	39.77	100.00	26.09	100.00	25.00	41.42	100.00	26.09	100.00	25.00	41.42
	Overall Waste Volume Reduction (relative to as generated waste volume)	%	-81.47	34.01	-26.62	-100	19.11	-85	33.62	-48.43	-150	18.16	-85	33.62	-48.43	-150	18.16

Overall Summary of Waste Stream Data for the Co-Extraction Process Based on 60 GWd/MTIHM Used Nuclear Fuel Cooled for 30 years

Basis	Parameter	Units	Total By Summing Individual Waste Streams (summed by bulk volume, treated volume and packaged volume)					Total By Summing Blended Operational, Job Control and Maintenance Waste Streams (includes remaining non-blendable waste streams)					Total by Summing Waste Streams Blended Across the Entire Process Function (includes remaining non-blendable waste streams)				
			Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total
As Generated	Waste Volume	m^3	13,726.68	1,488.52	1,400.52	2,933.16	19,548.87	13,876.61	1,712.05	1,758.28	2,201.94	19,548.87	13,876.61	1,712.05	1,745.12	2,215.10	19,548.87
		% of Total	70.22	7.61	7.16	15		70.98	8.76	8.99	11.26		70.98	8.76	8.93	11.33	
	Waste Mass	kilograms	2,512,642.54	1,882,972.61	273,456.27	393,983.64	5,063,055.06	2,481,329.75	1,932,495.44	309,903.61	339,326.26	5,063,055.06	2,481,329.75	1,932,495.44	284,312.61	364,917.26	5,063,055.06
		% of Total	49.63	37.19	5.4	7.78		49.01	38.17	6.12	6.7		49.01	38.17	5.62	7.21	
	Radionuclide Content	Curies	67.90	10,040.22	2,371.15	7,531.56	20,010.84	94.58	10,070.48	2,454.07	7,391.71	20,010.84	94.58	10,070.48	2,447.55	7,398.23	20,010.84
		% of Total	0.34	50.17	11.85	37.64		0.47	50.33	12.26	36.94		0.47	50.33	12.23	36.97	
	Radionuclide Content	grams	3,102.67	416,933.45	1,559.69	17,695.08	439,290.89	3,381.79	417,246.15	1,812.16	16,850.78	439,290.89	3,381.79	417,246.15	1,796.99	16,865.95	439,290.89
		% of Total	0.71	94.91	0.36	4.03		0.77	94.98	0.41	3.84		0.77	94.98	0.41	3.84	
Treated	Waste Volume	m^3	3,605.67	1,558.10	574.03	1,094.84	6,832.64	3,533.33	1,743.00	572.21	984.10	6,832.64	3,533.33	1,743.00	549.46	1,006.85	6,832.64
		% of Total	52.77	22.8	8.4	16.02		51.71	25.51	8.37	14.4		51.71	25.51	8.04	14.74	
	Waste Volume Reduction	%	73.73	-4.67	59.01	62.67	65.05	74.54	-1.81	67.46	55.31	65.05	74.54	-1.81	68.51	54.55	65.05
	Waste Mass	kilograms	2,553,562.54	5,974,844.61	344,156.27	393,983.64	9,266,547.06	2,516,969.75	6,077,775.44	332,475.61	339,326.26	9,266,547.06	2,516,969.75	6,077,775.44	284,312.61	387,489.26	9,266,547.06
		% of Total	27.56	64.48	3.71	4.25		27.16	65.59	3.59	3.66		27.16	65.59	3.07	4.18	
	Radionuclide Content	Curies	67.90	429.39	11,981.98	7,531.56	20,010.84	94.58	10,070.48	2,454.07	7,391.71	20,010.84	94.58	10,070.48	2,447.55	7,398.23	20,010.84
		% of Total	0.34	2.15	59.88	37.64		0.47	50.33	12.26	36.94		0.47	50.33	12.23	36.97	
	Radionuclide Content	grams	3,102.67	414,045.77	4,447.37	17,695.08	439,290.89	3,381.79	417,246.15	1,812.16	16,850.78	439,290.89	3,381.79	417,246.15	1,796.99	16,865.95	439,290.89
		% of Total	0.71	94.25	1.01	4.03		0.77	94.98	0.41	3.84		0.77	94.98	0.41	3.84	
Packaged	Volume - LLW Drum	m^3	0.00	0.00	0.60		0.60	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00
		% of Total	0	0	100	0											
	Volume - Standard LLW Box	m^3	3,352.98	0.00	0.00		3,352.98	4,275.74	0.00	0.00		4,275.74	4,275.74	0.00	0.00		4,275.74
		% of Total	100	0	0	0		100	0	0	0		100	0	0	0	
	Volume - Engineered LLW Container	m^3	288.24	66.12	201.86		556.22	140.93	106.37	206.27		453.57	140.93	106.37	206.27		453.57
		% of Total	51.82	11.89	36.29	0		31.07	23.45	45.48	0		31.07	23.45	45.48	0	
	Volume - High Integrity Container	m^3	0.00	6.85	519.12	13.50	539.47	0.00	259.88	637.39	13.50	910.76	0.00	259.88	632.74	13.50	906.11
		% of Total	0	1.27	96.23	2.5		0	28.53	69.98	1.48		0	28.68	69.83	1.49	
	Volume - Solidified LLW Box	m^3	31.80	1,500.00	19.92		1,551.72	0.00	1,500.00	19.92		1,519.92	0.00	1,500.00	0.00		1,500.00
		% of Total	2.05	96.67	1.28	0		0	98.69	1.31	0		0	100	0	0	
	Volume - GTCC Drum	m^3				555.94	555.94				463.03	463.03				491.46	491.46
		% of Total	0	0	0	100		0	0	0	100		0	0	0	100	
	Volume - Standard GTCC Box	m^3				9.08	9.08				0.00	0.00				0.00	0.00
		% of Total	0	0	0	100											
	Volume - Engineered GTCC Container	m^3				654.19	654.19				756.84	756.84				756.84	756.84
		% of Total	0	0	0	100		0	0	0	100		0	0	0	100	
	Volume - Total	m^3	3,673.02	1,572.97	741.50	1,232.71	7,220.20	4,416.67	1,866.25	863.57	1,233.37	8,379.86	4,416.67	1,866.25	839.00	1,261.80	8,383.72
		% of Total	50.87	21.79	10.27	17.07		52.71	22.27	10.31	14.72		52.68	22.26	10.01	15.05	
	Waste Volume Increase (relative to treated waste volume)	%	1.87	0.95	29.18	12.59	5.67	25.00	7.07	50.92	25.33	22.64	25.00	7.07	52.70	25.32	22.70
	Overall Waste Volume Reduction (relative to as generated waste volume)	%	73.24	-5.67	47.06	57.97	63.07	68.17	-9.01	50.89	43.99	57.13	68.17	-9.01	51.92	43.04	57.11

Overall Summary of Mixed Waste Stream Data for the Co-Extraction Process Based on 60 GWd/MTIHM Used Nuclear Fuel Cooled for 30 years																	
			Total By Summing Individual Waste Streams (summed by bulk volume, treated volume and packaged volume)					Total By Summing Blended Operational, Job Control and Maintenance Waste Streams (includes remaining non-blendable waste streams)					Total by Summing Waste Streams Blended Across the Entire Process Function (includes remaining non-blendable waste streams)				
Basis	Parameter	Units	Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total	Class A	Class B	Class C	GTCC	Total
As Generated	Waste Volume	m^3	74.78	0.38	0.48	0.06	75.70	74.78	0.38	0.48	0.06	75.70	74.78	0.38	0.48	0.06	75.70
		% of Total	98.79	0.5	0.63	0.08		98.79	0.5	0.63	0.08		98.79	0.5	0.63	0.08	
	Waste Mass	kilograms	24,180.87	1,625.60	536.60	723.20	27,066.27	24,180.87	1,625.60	536.60	723.20	27,066.27	24,180.87	1,625.60	536.60	723.20	27,066.27
		% of Total	89.34	6.01	1.98	2.67		89.34	6.01	1.98	2.67		89.34	6.01	1.98	2.67	
	Radionuclide Content	Curies	1.14	5.14	0.19	1.16	7.63	1.14	5.14	0.19	1.16	7.63	1.14	5.14	0.19	1.16	7.63
		% of Total	14.96	67.31	2.55	15.18		14.96	67.31	2.55	15.18		14.96	67.31	2.55	15.18	
	Radionuclide Content	grams	0.80	1.57	0.54	0.90	3.81	0.80	1.57	0.54	0.90	3.81	0.80	1.57	0.54	0.90	3.81
		% of Total	21.03	41.28	14.13	23.55		21.03	41.28	14.13	23.55		21.03	41.28	14.13	23.55	
Treated	Waste Volume	m^3	42.87	0.46	0.35	0.13	43.81	42.87	0.46	0.35	0.13	43.81	42.87	0.46	0.35	0.13	43.81
		% of Total	97.85	1.05	0.81	0.29		97.85	1.05	0.81	0.29		97.85	1.05	0.81	0.29	
	Waste Volume Reduction	%	42.68	-22.55	25.79	-100.00	42.13	42.68	-22.55	25.79	-100.00	42.13	42.68	-22.55	25.79	-100.00	42.13
	Waste Mass	kilograms	24,556.77	1,621.50	596.00	864.00	27,638.27	24,556.77	1,621.50	596.00	864.00	27,638.27	24,556.77	1,621.50	596.00	864.00	27,638.27
		% of Total	88.85	5.87	2.16	3.13		88.85	5.87	2.16	3.13		88.85	5.87	2.16	3.13	
	Radionuclide Content	Curies	1.15	5.13	0.19	1.16	7.63	1.15	5.13	0.19	1.16	7.63	1.15	5.13	0.19	1.16	7.63
		% of Total	15.02	67.25	2.55	15.18		15.02	67.25	2.55	15.18		15.02	67.25	2.55	15.18	
	Radionuclide Content	grams	0.83	1.54	0.54	0.90	3.81	0.83	1.54	0.54	0.90	3.81	0.83	1.54	0.54	0.90	3.81
		% of Total	21.8	40.51	14.13	23.55		21.8	40.51	14.13	23.55		21.8	40.51	14.13	23.55	
Packaged	Volume - Mixed LLW Drum	m^3	17.18	0.71	0.60		18.49	17.55	0.92	0.71		19.18	17.55	0.92	0.71		19.18
		% of Total	92.88	3.85	3.27	0		91.49	4.82	3.69	0		91.49	4.82	3.69	0	
	Reserved																
	Volume - Mixed Engineered LLW Container	m^3	42.61	0.00	0.00		42.61	42.61	0.00	0.00		42.61	42.61	0.00	0.00		42.61
		% of Total	100	0	0	0		100	0	0	0		100	0	0	0	
	Volume - Mixed High Integrity Container	m^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		% of Total															
	Volume - Mixed Solidified LLW Box	m^3	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00
		% of Total															
	Volume - Mixed GTCC Drum	m^3				0.13	0.13				0.16	0.16				0.16	0.16
		% of Total	0	0	0	100		0	0	0	100		0	0	0	100	
	Volume - Mixed Standard GTCC Box	m^3				0.00	0.00				0.00	0.00				0.00	0.00
		% of Total															
	Volume - Mixed Engineered GTCC Container	m^3				0.00	0.00				0.00	0.00				0.00	0.00
		% of Total															
	Volume - Total	m^3	59.79	0.71	0.60	0.13	61.23	60.16	0.92	0.71	0.16	61.96	60.16	0.92	0.71	0.16	61.96
		% of Total	97.64	1.16	0.99	0.21		97.11	1.49	1.14	0.26		97.11	1.49	1.14	0.26	
	Waste Volume Increase (relative to treated waste volume)	%	39.48	54.11	70.62	0.00	39.77	40.35	100.00	100.00	25.00	41.42	40.35	100.00	100.00	25.00	41.42
	Overall Waste Volume Reduction (relative to as generated waste volume)	%	20.05	-88.86	-26.62	-100	19.11	19.55	-145.09	-48.43	-150	18.16	19.55	-145.09	-48.43	-150	18.16