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NDA 3134 Supplemental Low Activity Waste Introduction of FFRDC Team Study & Final Draft Report

Bill Bates

FFRDC Team Lead

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NAS Committee Meeting #6

May 16, 2019

Kennewick, WA

SRNL-MS-2019-00095

Pre-Decisional

Introduction of FFRDC Team Study

- **Overview of Team Approach**

- o 6 National Laboratories – EM Laboratory Network
- o Evaluation per 2017 NDAA Section 3134
 - *Processing to Remove Long-lived Constituents (Tc-99, I-129)*
 - Vitrification, Grouting, Steam Reforming, and Other Approaches
 - Risks, Benefits, Costs, Schedules, Regulatory Compliance, and Obstacles to Pursuit
- o Interface with NAS Committee

- **Progress since November**

- o Completed Onsite Performance Evaluation
- o Completed Final Draft Report
 - Comparative Analysis
 - Conclusions

FFRDC Team Status

- **Schedule**
 - o NAS Public Meeting 5/16/2019
 - o Anticipate NAS Report 7/2019
 - o Issue FFRDC Final Report 9/2019

FFRDC Team Presentation Agenda

- **Introduction of FFRDC Team Study & Final Draft Report** Bill Bates
- **Performance Evaluation (PE) Inputs & Overview** Tom Brouns (Cozzi, Guthrie, Soelberg)
 - o What is PE?
 - o Methodology
 - o Input Assumptions
- **Performance Evaluation Results** Tom Brouns
 - o Explain Acceptance Thresholds
 - o Results for Each Technology
- **FFRDC Conclusions** Michael Stone
- **Next Steps** Bill Bates



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NDA 3134 Supplemental Low Activity Waste FFRDC Team Study Overview— Integrated Disposal Facility and Waste Form Performance Evaluation

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Sec. 3134 “Analysis”

- “(2) An analysis of the following:

- (A) *The risks of the approaches described in paragraph (1) relating to treatment and final disposition.*

- (B) *The benefits and costs of such approaches.*

- (C) *Anticipated schedules for such approaches, including the time needed to complete necessary construction and to begin treatment operations.*

- (D) *The compliance of such approaches with applicable technical standards associated with and contained in regulations prescribed pursuant to ...(CERCLA, RCRA, CWA)*

- (E) *Any obstacles that would inhibit the ability of the Department of Energy to pursue such approaches.”*

- In response, the FFRDC Team defined in the program plan a high level analysis approach to:

- o Consider the “...ability of supplemental treatment alternatives to meet the waste acceptance criteria of potential disposal sites, ... their major risks, regulatory impacts, and costs and schedules.”

- For out-of-state disposal, the Team assessed the acceptability of supplemental treatment wasteforms to meet a commercial facility’s waste acceptance criteria
 - For onsite disposal at the Integrated Disposal Facility (IDF), the Team conducted a “Performance Evaluation” to evaluate the likely behavior of the SLAW wasteforms in the disposal environment.





Waste Forms Performance Evaluation for On-Site Disposal (IDF)

- **IDF RCRA Permit and WAC**
 - Currently limits waste forms to ILAW from WTP ILAW glass canisters and 50 Bulk Vit test boxes
 - Describes requirements for Performance Assessment (PA) analysis and a “risk budget tool” to assess impacts to groundwater of disposed wastes and expected to be disposed wastes
 - *Permit specifies process to propose additional wastes for disposal (including secondary wastes)*
 - *Restricts disposal and requires mitigation if results indicate impacts >75% of any performance standard, including federal drinking water standards.*
- **2017 IDF Performance Assessment (Ref. Pat Lee Overview Presentation to NAS, 2/28/18)**
 - For LAW, the draft IDF PA only considers ILAW glass and secondary wastes generated from ILAW processing. There is no consideration of SLAW alternatives such as grout or steam reforming products or their secondary wastes.
- **FFRDC Team identified the need for a Performance Evaluation (PE) to assess the ability of supplemental treatment alternatives to meet the waste acceptance criteria of IDF**
 - PE analysis was modelled after the 2017 IDF PA methods and approach
 - PE represents a limited wasteform release modeling and analysis effort to evaluate the potential performance of each ILAW/SLAW wasteform and their corresponding secondary wastes.

2017 IDF PA Key Analysis Assumptions and Requirements¹

Analysis Assumptions	Requirement (R) or Expectation (E)	2017 IDF PA Analysis
DOE Time of Compliance	1,000 years after facility closure (R)	Compliance period = 2051-3051
Extended time post-compliance period	1,000 – 10,000 years after facility closure (E)	Post Compliance Period = 3051-12051
Peak impacts	Extended run to assess peaks (E)	500,000 years
Points of Compliance 1. Groundwater pathway 2. Air Pathway 3. Inadvertent Intruder	1. 100-m buffer zone surrounding disposed waste (R) 2. Closest offsite receptor (R) 3. Facility (R)	1. Highest concentration 100 m from edge of excavation 2. 20,000 m east-southeast of IDF within first 100 yr after closure; 100 m thereafter 3. Facility
Period of Institutional Control	100 years (E)	Assumed leachate collection and leak detection are operable. No public individual resides within buffer zone

¹ From Table F-8 of SRNL-RP-2018-00687 2019-04-01 DRAFT. Adapted from Tables 1-1 and 2-11 of DOE. 2017. *Performance Assessment for the Integrated Disposal Facility, Hanford Site, Washington IDF Performance Assessment (DRAFT)*. RPP-RPT-59958, Rev. 1. Washington River Protection Solutions, Richland, Washington. (unpublished)



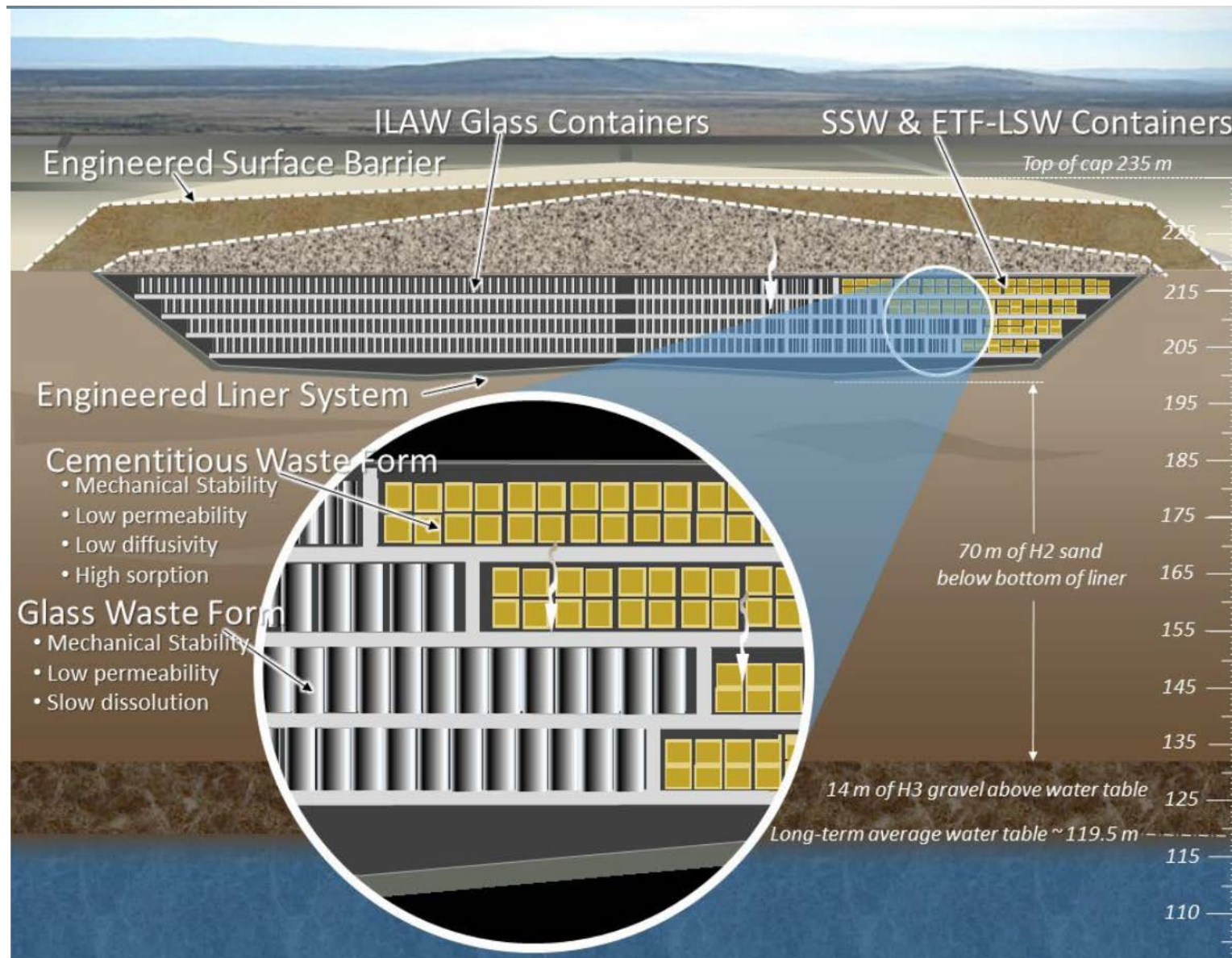
2017 IDF PA Key Analysis Assumptions and Requirements¹ (continued)

Analysis Assumptions	Requirement (R) or Expectation (E)	2017 IDF PA Analysis
Performance Objective and/or Measure 1. All Pathways ¹ 2. Atmospheric ^{1,2,3} 3. Acute Inadvertent Intruder ¹ 4. Chronic Inadvertent Intruder ¹ 5. Groundwater Protection ⁴	1. 25 mrem/yr (R) 2. 10 mrem/yr & 20 pCi m ⁻² s ⁻¹ radon flux at surface (R) 3. 500 mrem (R) 4. 100 mrem/yr (R) 5. ≤4 mrem/yr beta-gamma dose equivalent (R) ≤15 pCi/L gross alpha activity (R) ≤5 pCi/L combined Ra-226 and Ra-228 (R) ≤30 µg/L Uranium (R) ≤8 pCi/L Sr-90 (R) ≤20,000 pCi/L H-3 (R)	
¹ DOE M 435.1-1 Chg 1 ² 40 CFR 61, Subpart H (10 mrem/yr standard) ³ 40 CFR 61, Subpart Q (20 pCi m ⁻² s ⁻¹ radon flux standard) ⁴ 40 CFR 141		

¹ From Table F-8 of SRNL-RP-2018-00687 2019-04-01 DRAFT. Adapted from DOE. 2017. *Performance Assessment for the Integrated Disposal Facility, Hanford Site, Washington IDF Performance Assessment (DRAFT)*. RPP-RPT-59958, Rev. 1. Washington River Protection Solutions, Richland, Washington. (unpublished)



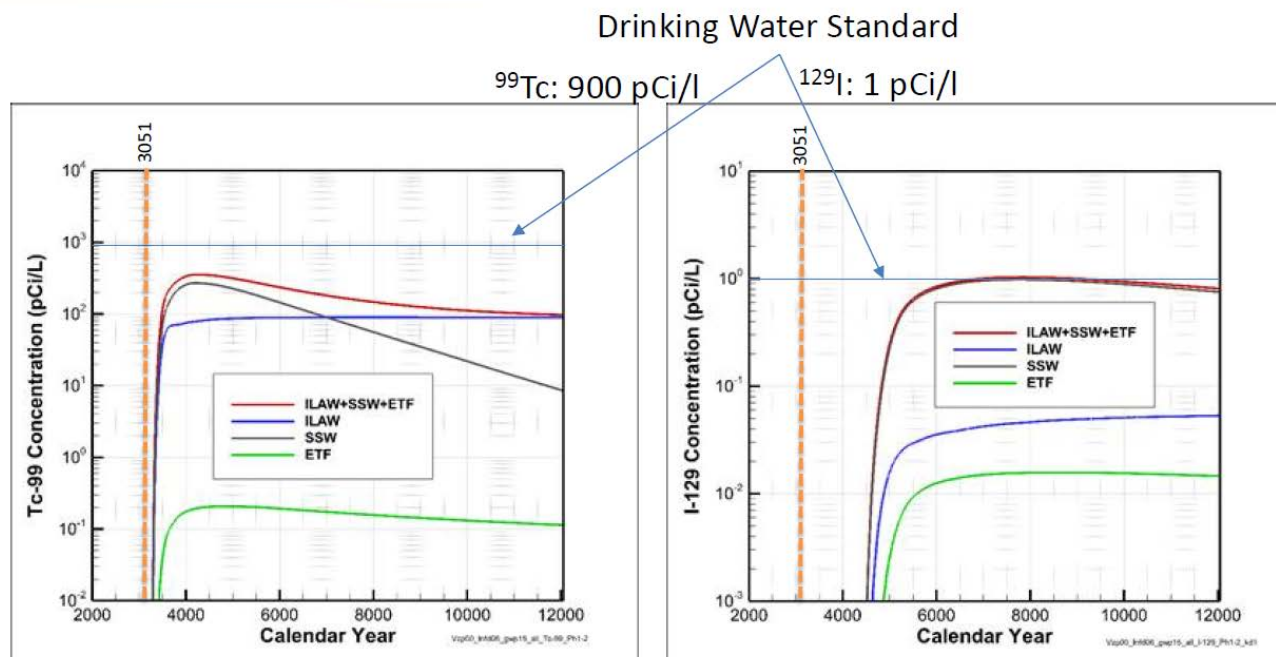
IDF Characteristics – Engineered System



- Groundwater concentrations of Tc and I are driven from solid secondary waste (SSW) (SSW)



Tc & I Concentration >1,000 Years



Groundwater concentrations

Tc-99 driven by SSW initially, then ILAW glass when SSW inventory in IDF is depleted. ILAW source is about 10× below drinking water standard

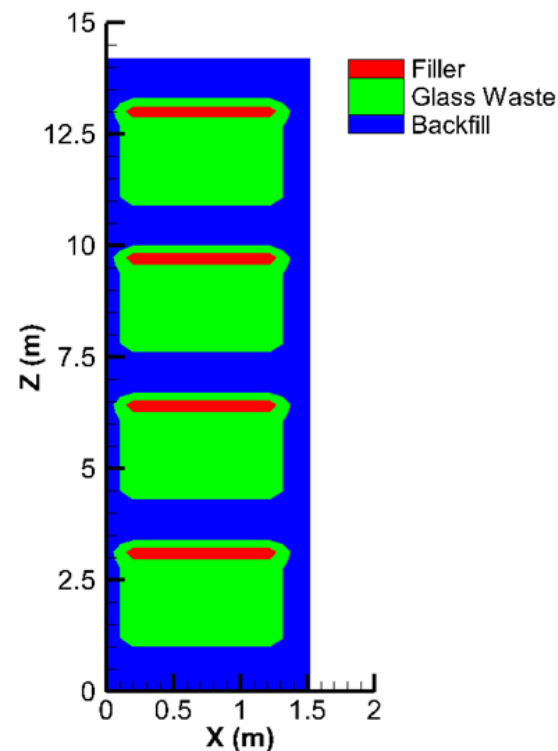
I-129 driven by SSW at all times. ILAW source is about 18× below drinking water standard

11



PE – Analysis Methodology

- **Focused on groundwater pathway and impacts of key radionuclides—Tc-99 and I-129**
 - Groundwater impacts from Tc and I previously shown to be key area of concern for ILAW, SLAW, and secondary wastes from LAW processing.
- **STOMP modeling platform applied for consistency with 2017 IDF PA analysis**
 - eSTOMP (scalable version of STOMP) was used to enable more efficient modeling
 - Benchmark simulations conducted for ILAW Glass and secondary wastes to assure PE was producing equivalent results to the IDF PA for the same model inputs.
- **Simulated a full stack of waste packages within IDF with a unit inventory of Tc-99 and I-129 in each package**
 - Four stacked ILAW Glass canisters, or eight stacked B-25 (secondary waste) boxes, or eight 8.3 m³ (SLAW grout or steam reforming) boxes
 - Model output provided fractional release rate (Ci released/Ci disposed/yr) from bottom of IDF as a function of time
- **Translated eSTOMP-derived peak release rate to peak groundwater concentration using 2017 IDF PA algorithm based on full vadose zone and groundwater transport modeling**



2D simulation domain for the LAW glass simulation with four stacked waste packages



PE – Model Inputs and Assumptions

• Comparison of 2017 IDF PA Base Case and FFRDC PE Assumptions and Inputs

2017 IDF PA		2019 FFRDC PE
IDF System / (Assumption)	Input Parameters	
Surface cap/barrier (500-yr service life)	<u>Infiltration Rate</u> 0.5 mm/yr (0-500 yr) 3.5 mm/yr after 500 yr	Same as PA
Waste Containers (no credit as release barrier)	• ILAW Glass canister (2.5m³ stainless steel cylinder) • Grouted SSW & LSW (55 gal drum or B-25 steel box)	• ILAW/SLAW Glass – same as PA • Grouted SSW & LSW (B-25 steel box) • SLAW Grout or FBSR (8m³ bag in steel box)
Total Inventory (Tc-99, I-129)	Best Basis Inventory (BBI) November 2014 with sensitivity cases for 2002 (EIS) BBI estimates	BBI December 2015 updated to December 9, 2016 tank contents
Inventory Retention and Partitioning Fractions	As defined for various cases in RPP-ENV-58562, Rev. 3.	Same as PA for Glass and grouted SSW and LSW. Adjusted PA values to address Grout and FBSR



Primary LAW + SLAW Waste Form “Systems” for IDF Evaluation

Analysis Case	Primary LAW Waste Forms		Supplemental LAW Waste Forms	
	LAW	Secondary Wastes	SLAW	Secondary Wastes
1 – Glass (Vitrification)	0 - ILAW Glass	LSW - ETF SSW - HEPA filters SSW - GAC absorber	ILAW Glass	LSW - ETF SSW - HEPA filters SSW – GAC absorber
2 - Grout			Cast Stone	SSW – HEPA filters SSW - GAC absorber
3 - Steam Reforming (FBSR)			FBSR Mineral - Macroencapsulated	SSW – HEPA filters SSW - GAC absorber



PE – Model Inputs and Assumptions

- Key Differences – Inventory Distribution

	TC&WM EIS		2017 IDF PA		Integrated Flowsheet (System Plan 8, Base Case)	
Wasteforms	Tc-99 (Ci)	I-129 (Ci)	Tc-99 (Ci)	I-129 (Ci)	Tc-99 (Ci)	I-129 (Ci)
IHLW Glass ¹	382	0.39	-	-	1,530	0.53
ILAW Glass	28,800	9.56	26,400	16.5	12,227	15.0
SLAW Glass or Alternative					11,593	10.5
ETF-LSW	86.3	33.6	0.23	0.064	0.26	0.023
SSW	431	4.65	20.0 ²	12.1	ND ³	ND ³
LAW Melter	Included in LAW Glass	Included in LAW Glass	37.5	<1		
Total Tank Inventory – Best Basis	29,700	48.2	26,500	29.4	25,334	28.7

¹ To be disposed offsite. Not included in IDF PA analysis.

² Does not include ~1.2 Ci of non-Tank Waste inventory

³ Not determined or not available from analysis. FFRDC study used IDF PA split factors as basis for estimating SSW inventories



PE Model Inputs and Assumptions – Inventory Splits for Tc-99 and I-129

- **Used inventory splits from 2017 IDF PA as basis for Tc-99 and I-129 distribution between primary and secondary waste forms for ILAW and SLAW glass processing**
 - Excluded SSW and LSW inventory not originating from LAW Vitrification (e.g., HLW Vit, Pretreatment)
 - Applied same IDF PA percentage of disposed inventory to SLAW glass (e.g., 99.9% of Tc-99 and 78.7% of I-129 partitioned to SLAW glass; 20.5% of I-129 partitioned to GAC, etc.)
- **Adjusted SLAW Glass inventory splits to estimate SLAW Grout and FBSR inventory splits**
 - FBSR
 - *No LSW is produced. Any liquids return to feed to FBSR system*
 - *Moderately lower FBSR processing temperatures with integral carbon addition will reduce I-129 in FBSR offgas stream, compared to vitrification. Assumed partitioning to FBSR GAC will be 10% of levels applied to GAC from vitrification.*
 - *Conservatively assumed Tc-99 partitioning to HEPA will be the same as HEPA from Vitrification*
 - Grout
 - *No LSW is produced. Any liquids (e.g., line flushes) return to feed to grout system*
 - *Assume HEPA and GAC filtration will be used to assure control of radionuclide particulate and organic vapors originating from tank waste*
 - *Low temperature grout process will result in significantly lower levels of Tc-99 and I-129 in grout process offgas stream than from vitrification offgas,*
 - *Assumed GAC will be 1% of levels applied to GAC from vitrification (10% of levels applied to GAC from FBSR).*
 - *Conservatively assumed Tc-99 partitioning to HEPA will be 10% of levels applied to HEPA from Vitrification*

PE Model Inputs and Assumptions – Inventory Splits for Tc-99 and I-129

Tc-99 Inventory – Ci / (% of LAW feed)				
Case	ILAW or SLAW	LSW	SSW (HEPA)	SSW (GAC)
0 – ILAW Glass	12227 (99.93%)	0.062 (0.00052%)	7.93 (0.066%)	- (0%)
1 – SLAW Glass	11793 (99.93%)	0.061 (0.00052%)	7.80 (0.066%)	- (0%)
2 – SLAW Grout	11800 (99.99%)	- (0%)	0.780 (0.0066%)	- (0%)
3 – SLAW FBSR	11793 (99.93%)	- (0%)	7.80 (0.066%)	- (0%)

I-129 Inventory – Ci / (% of LAW feed)				
0 – ILAW Glass	15.0 (78.74%)	0.030 (0.184%)	0.100 (0.620%)	3.30 (20.46%)
1 – SLAW Glass	9.48 (78.74%)	0.022 (0.184%)	0.075 (0.620%)	2.46 (20.46%)
2 – SLAW Grout	12.01 (99.73%)	- (0%)	0.0075 (0.062%)	0.0246 (0.205%)
3 – SLAW FBSR	11.72 (97.33%)	- (0%)	0.075 (0.620%)	0.246 (2.05%)



Selection of Waste Form Release Mechanism and Performance Parameters Modeled

- **2017 IDF PA – Benchmark and Base Case Analysis for the PE**
 - o ILAW Glass
 - o SSW and LSW from LAW vitrification processing
- **Study-specific PE Cases**
 - o ILAW and SLAW glass case
 - o SLAW grout case
 - o SLAW FBSR case
 - o SSW and LSW (as appropriate) associated with all three primary SLAW waste forms (glass, grout, FBSR)
- **Sensitivity cases**
 - o Three sensitivity cases (sets of waste form release parameters) were selected for each waste form
 - o Low performing case - based on recommended range of wasteform performance from laboratory testing
 - o High performing case - based on recommended range of wasteform performance based on laboratory testing.
 - o Projected best case – based on the highest performance observed from laboratory testing, typically recent enhancements to formulations and performance improvements that have been observed, but likely requires additional studies to assure results can be consistently obtained.



Waste Form Release Mechanism and Performance Parameters Modeled: Solidified Secondary Wastes

	Solidified Secondary Wastes		
	LSW	SSW – HEPA	SSW - GAC
Waste	ETF-generated solid residue from liquid waste processing	Spent off-gas HEPA filters. Debris waste.	Spent off-gas carbon absorber (GAC). Non-debris waste.
Waste Form	Solidified (grout)	Macro-encapsulated. Grout surrounding compacted HEPA filters	Solidified (grout)
Mechanism of Release	Diffusion through interstitial pore water of grout matrix and retardation via geochemical interactions with the waste form and disposal environment		
Model	Physical: Diffusive-advective transport		
Code	eSTOMP		
Release Rate Parameters	• Diffusion coefficient (D) for diffusion through grout matrix interstitial pore fluids, • Distribution coefficient (K_d) to describe geochemical interactions that retard diffusion out of the waste form and disposal site materials • Rate parameters selected from 2017 IDF PA base case, plus three FFRDC cases from recent literature		



Grouted LSW Parameters Selected and Sources for the PE

	Technetium		Iodine	
	Diffusivity	Distribution Coefficient, K_d	Diffusivity	Distribution Coefficient, K_d
	(cm ² /s)	(m/L)	(cm ² /s)	(m/L)
PA Base Case	1.6E-9 ^a	0.8 ^b	1.6E-9 ^a	4 ^e
Low Performing	1.6E-9 ^a	210 ^c	1.6E-9 ^a	0 ^f
High Performing	1.6E-9 ^a	1.6E5 ^d	1.6E-9 ^a	1.7 ^g
Projected Best Case	1.6E-9 ^a	1.6E5 ^d	1.6E-9 ^a	810 ^h

^a Based on sodium diffusivity in lime-based grout. Table 3.1 in Cantrell et al. 2016

^b Best value for oxidizing cement. Table 8-4 in Flach et al. 2016

^c Derived from upper range of Tc diffusivity in lime-based grout. Table 3.1 in Cantrell et al. 2016

^d Derived from lower range of Tc diffusivity in lime-based grout. Table 3.1 in Cantrell et al. 2016

^e Best value for oxidizing cement. Table 8-4 in Flach et al. 2016

^f Min value for oxidizing cement. Table 8-4 in Flach et al. 2016

^g Derived from lower range of I diffusivity in lime-based grout. Table 3.1 in Cantrell et al. 2016

^h Derived from hydrated-lime grout with silver zeolite getter. Table 6.7 in Saslow et al. 2017



Grouted SSW Parameters Selected and Sources for the PE

	Technetium		Iodine	
	Diffusivity	Distribution Coefficient, K_d	Diffusivity	Distribution Coefficient, K_d
	(cm ² /s)	(m/L)	(cm ² /s)	(m/L)
Granular Activated Carbon (GAC)				
PA Base Case	NA ^a	NA ^a	5.4E-8 ^g	302 ^h
Low Performing	3.8E-7 ^b	0 ^d	3.8E-7 ^b	0 ^d
High Performing	6.3E-9 ^c	2 ^e	6.3E-9 ^c	4 ⁱ
Projected Best Case	6.3E-9 ^c	2,000 ^f	6.3E-9 ^c	10 ^e
HEPA Filters				
PA Base Case	2.9E-8 ^j	0.8 ⁿ	2.9E-8 ^j	4 ⁱ
Low Performing	2.0E-6 ^k	0 ^d	2.0E-6 ^k	0 ^d
High Performing	1.0E-9 ^l	2 ^e	1.0E-9 ^l	4 ⁱ
Projected Best Case	4.2E-10 ^m	2,000 ^f	4.2E-10 ^m	10 ^e
^a 2017 IDF PA did not analyze Tc release from GAC wasteform. ^b Sample population maximum for grout with sand (mortar). Table 7-2 in Flach et al. 2016 ^c Sample population lower range for grout with sand (mortar). Table 7-2 and 7-4 in Flach et al. 2016 ^d Min value for oxidizing cement. Table 8-4 in Flach et al. 2016 ^e Max value for oxidizing cement. Table 8-4 in Flach et al. 2016 ^f Max value for reducing cement. Table 8-5 in Flach et al. 2016 ^g Geometric mean for grout with sand (mortar). Table 7-2 and 7-4 in Flach et al. 2016 ^h Average Best I K_d for oxidizing grout and GAC. Table 8-4 and Table 8-7 in Flach et al. 2016 ⁱ Best value for oxidizing cement. Table 8-4 in Flach et al. 2016 ^j Geometric mean for grout without sand (paste). Table 7-2 and 7-4 in Flach et al. 2016 ^k Sample population maximum for grout without sand (paste). Table 7-2 in Flach et al. 2016 ^l Sample population lower range for grout without sand (paste). Table 7-2 and 7-4 in Flach et al. 2016 ^m Sample population minimum for grout without sand (paste). Table 7-2 in Flach et al. 2016				



Waste Form Release Mechanism and Performance Parameters Modeled: Primary LAW & SLAW Waste Forms

	LAW Glass	LAW Cast Stone (Grout)	LAW Steam Reforming Mineral Product
Mechanism of Release	Glass surface matrix dissolution	Diffusion through interstitial pore water + retardation via geochemical reactions with waste form and disposal environment	Mineral (sodalites) dissolution, diffusion (monolith), and chemical oxidation (reduced Tc)
Model	Geochemical: Reactive transport	Physical: Diffusive- advective transport	Physical: Diffusive- advective transport Geochemical: Reactive transport
Code	eSTOMP	eSTOMP	eSTOMP



SLAW Glass Parameters Selected and Sources for the PE

Glass	$\bar{k}_0$	$K_g^{(a)}$	η	E_a	σ	r_{LEX}	
	Reported Forward Rate Constant (g/[m ² d])	Converted ^(b) Forward Rate Constant (mol/[m ² s])	Glass Apparent Equilibrium Constant Based on Activity Product $a[\text{SiO}_2(\text{aq})]$	pH Power Law Coefficient	Glass Dissolution Activation Energy (kJ/mol)	Temkin ^a Coefficient	Na Ion-Exchange Rate (mol/[m ² s])
LAWC22 ^d	1.0×10^5		1.80×10^{-3}	0.42 ± 0.02	64 ± 2	1	1.2×10^{-10}
LAWA44 ^b	1.3×10^4	2.2×10^{-3}	1.87×10^{-3}	0.49 ± 0.08	60 ± 7	1	5.3×10^{-11}
ORLEC28 ^f	2.7×10^6		1.3×10^{-4}	0.55 ± 0.02	79 ± 2	1	2.7×10^{-11}
Other LAW Glasses Considered in 2017 IDF PA							
LAWB45 ^c	1.6×10^4		1.79×10^{-3}	0.34 ± 0.03	53 ± 3	1	3.5×10^{-12}
LAWABP1 ^e	3.4×10^6		4.9×10^{-4}	0.35 ± 0.03	68 ± 3	1	3.4×10^{-11}
^a Assumed value of 1. See 2017 IDF PA Equation 4-2							
^b 2017 IDF PA Table 6-3							
^c 2017 IDF PA Table 6-4							
^d 2017 IDF PA Table 6-5. 2017 IDF PA Base Case (approximate). LAW C22 yields a peak fractional release rate of 2.52E-07 yr ⁻¹ , compared to 2.57E-07 yr ⁻¹ used in the PA system level model.							
^e 2017 IDF PA Table 6-6							
^f Neeway et al. 2018, Table ES-1							



SLAW Grout Parameters Selected and Sources for the PE

	Technetium		Iodine	
	Diffusivity	Distribution Coefficient, K_d	Diffusivity	Distribution Coefficient, K_d
	(cm ² /s)	(m/L)	(cm ² /s)	(m/L)
2017 IDF PA Base Case	NA ^a	NA ^a	NA ^a	NA ^a
Low Performing	6.0E-9 ^b	7.6 ^c	6.0E-9 ^b	0 ^f
High Performing	6.0E-9 ^b	480 ^d	6.0E-9 ^b	0.8 ^g
Projected Best Case	6.0E-9 ^b	4,500 ^e	6.0E-9 ^b	1,000 ^h

^a 2017 IDF PA did not analyze a grouted SLAW wasteform.

^b Based on sodium, nitrate, and nitrite diffusivity in SLAW Cast Stone grout. Table 3.1 in Cantrell et al. 2016

^c Derived from upper range of Tc diffusivity in SLAW Cast Stone grout. Table 3.1 in Cantrell et al. 2016

^d Derived from lower range of Tc diffusivity in SLAW Cast Stone grout. Table 3.1 in Cantrell et al. 2016

^e Derived from Tc diffusivity from SLAW Cast Stone with potassium metal sulfide getter. Asmussen et al. 2016

^f Min value for oxidizing cement. Table 8-4 in Flach et al. 2016

^g Derived from lower range of I diffusivity in SLAW Cast Stone grout. Table 3.1 in Cantrell et al. 2016

^h Derived from work with silver zeolite getters by Crawford et al. 2017 and Saslow et al. 2017



SLAW FBSR Parameters Selected and Sources for the PE

	Technetium		Iodine	
	Diffusivity	Distribution Coefficient, K_d	Diffusivity	Distribution Coefficient, K_d
	(cm ² /s)	(m/L)	(cm ² /s)	(m/L)
PA Base Case	NA ^a	NA ^a	NA ^a	NA ^a
Low Performing	1.3E-10 ^b	2 ^c	1.3E-10 ^b	8 ^d
High Performing	1.3E-10 ^b	55 ^c	1.3E-10 ^b	550 ^d
Projected Best Case	1.3E-10 ^b	175 ^c	1.3E-10 ^b	3,000 ^d

^a 2017 IDF PA did not analyze a FBSR SLAW wasteform.

^b Based on sodium diffusivity in FBSR product encapsulated in fly ash and clay geopolymers. Tables G-3, G-4, G-5, G-8, G-9, and G-12 in Jantzen et al. 2013

^c Derived from range of rhenium diffusivities reported in Tables G-3, G-4, G-5, G-8, G-9, and G-12 in Jantzen et al. 2013

^d Derived from range of iodine diffusivities reported in Tables G-3, G-4, G-5, G-8, G-9, and G-12 in Jantzen et al. 2013



Performance Evaluation Results - Technetium

- Projected peak groundwater concentrations only exceeded the Tc-99 MCL of 900 pCi/L for the low performing grout case.
- High performing and projected best cases for glass, grout, and FBSR waste form systems produced peak groundwater concentrations of Tc-99 well below regulatory objectives

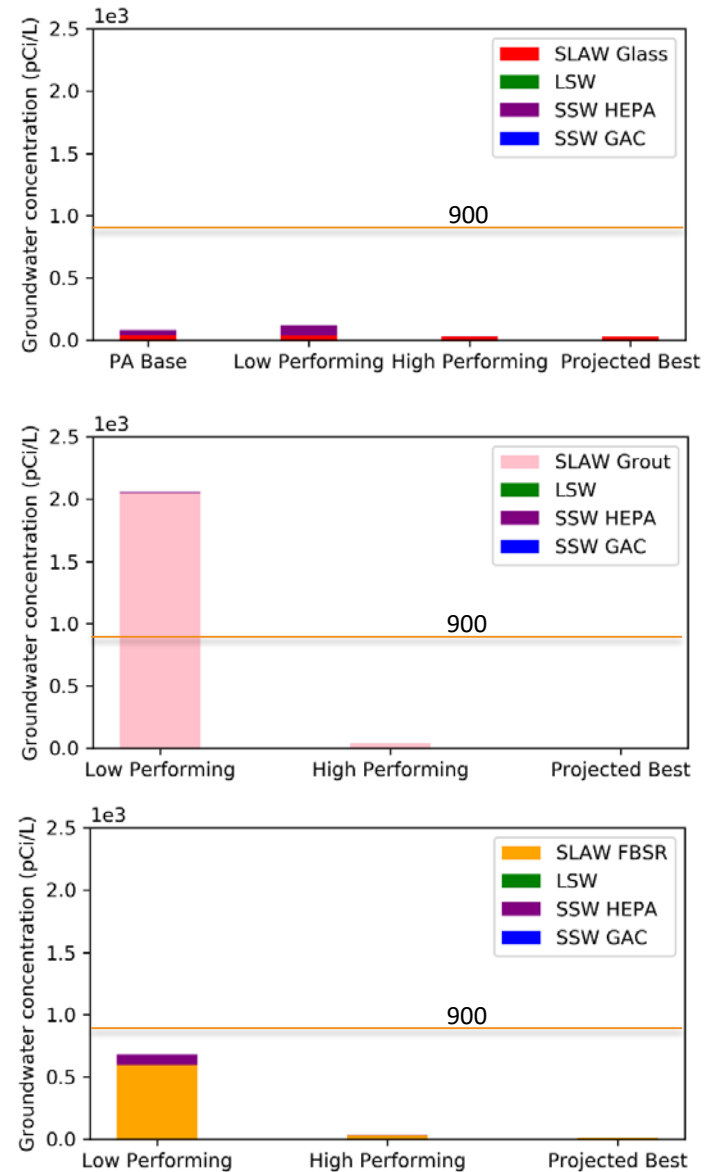


Figure F-14*. Predicted technetium-99 groundwater concentrations for 100 m downgradient compliance well for **a) SLAW Glass**, **b) SLAW Grout**, and **c) SLAW Steam Reforming (FBSR) systems**

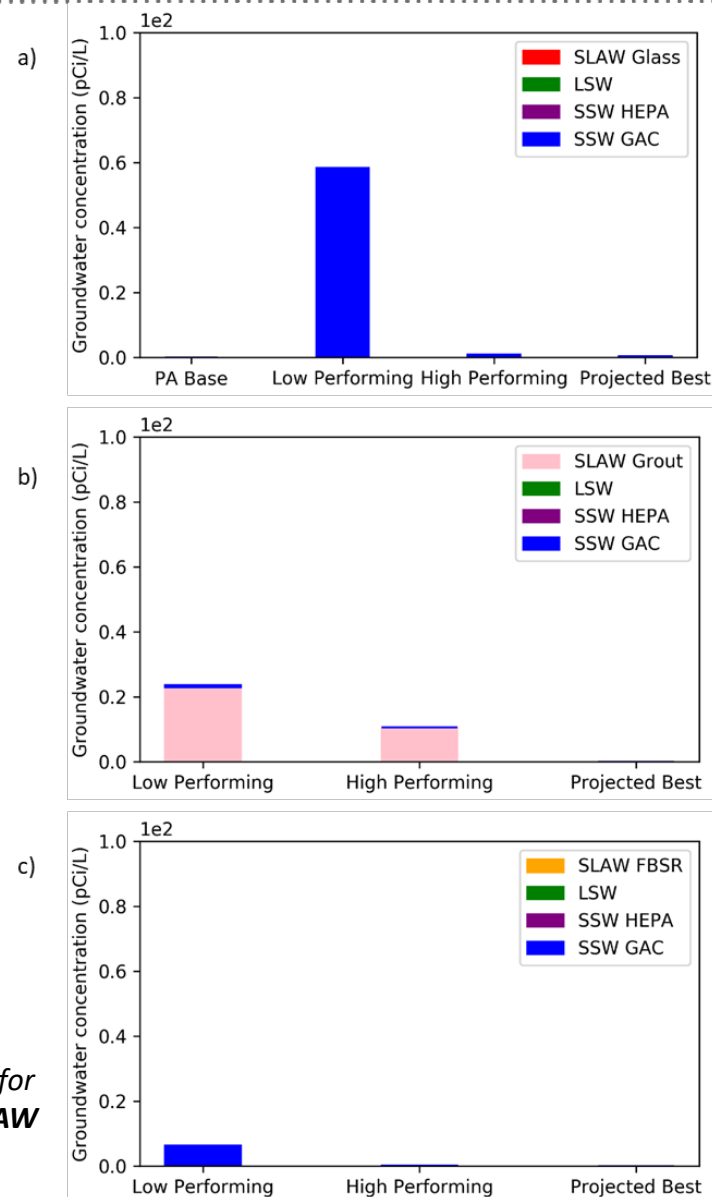
* Updated from draft report to correct SSW HEPA values



Performance Evaluation Results - Iodine

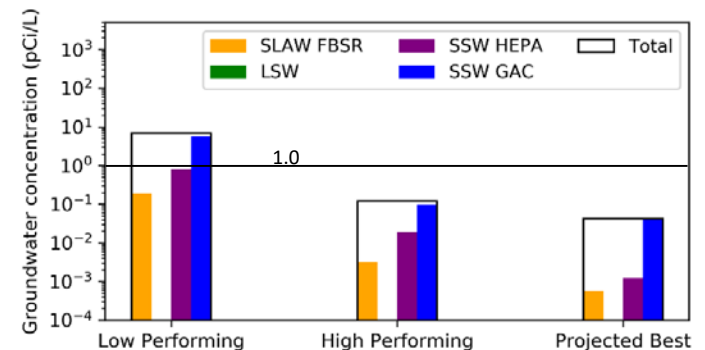
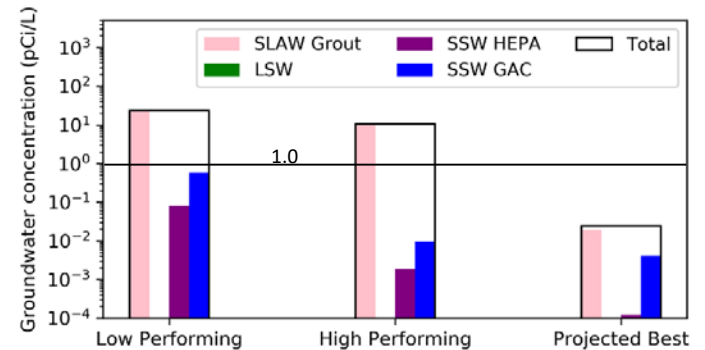
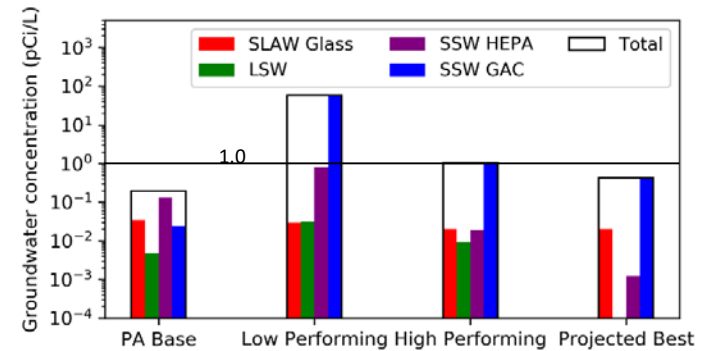
- Projected peak groundwater concentrations exceeded the I-129 MCL of 1 pCi/L for the low performing glass, grout, and FBSR cases, and the high performing grout case.
- High performing and better cases for glass and FBSR, and projected best case for grout produced peak groundwater concentrations of I-129 well below regulatory objectives
 - SSW GAC performance was the primary driver for the glass and FBSR low performing case
 - SLAW Grout performance was the primary driver for the grout low and high performing cases, given greater than 99% of the I-129 is in the SLAW waste form.

Figure F-15. Predicted iodine-129 groundwater concentrations for 100 m downgradient compliance well for **a) SLAW Glass**; **b) SLAW Grout**; and **c) SLAW Steam Reforming (FBSR) systems**.



Performance Evaluation Results - Iodine

- Alternate “log” view of I-129 results to highlight proximity to 1 pCi/L MCL
- Relative contributions of SSW and LSW to total groundwater concentrations in this “stacked bar” view are distorted as a result of the log scale. Caution should be used in interpreting results.



Alternate view of Figure F-15 using log scale on Y axis. Predicted iodine-129 groundwater concentrations for 100 m downgradient compliance well for **a) SLAW Glass**; **b) SLAW Grout**; and **c) SLAW Steam Reforming (FBSR) systems**.



Performance Evaluation Results – Comparison of Projected Best Cases

- The projected best cases of all three waste form systems resulted in peak groundwater concentrations below the MCLs of 900 pCi/L (Tc-99) and 1 pCi/L (I-129)
- Best projected cases for grout and FBSR were lower than the best projected case for glass.
- SSW GAC is the primary contributor to peak groundwater concentrations for I-129 for both FBSR and Glass waste form systems.

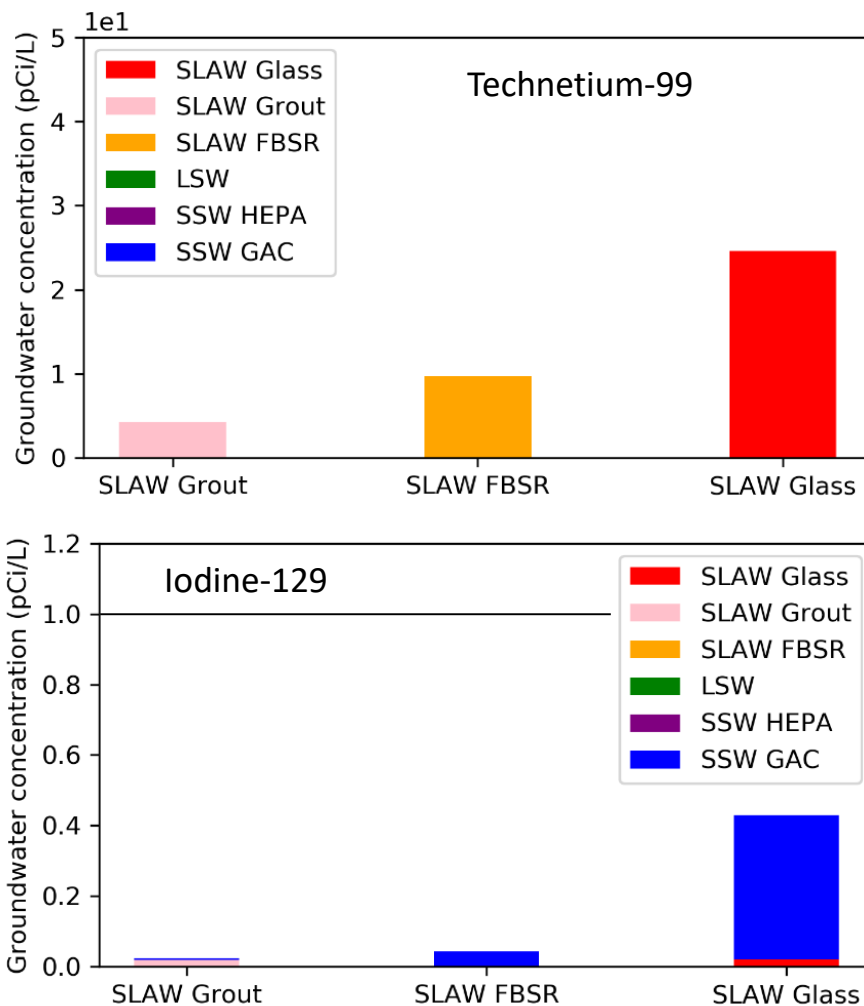
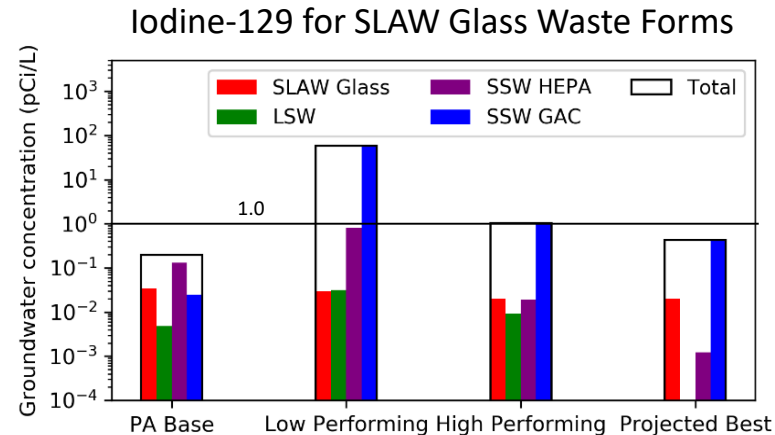
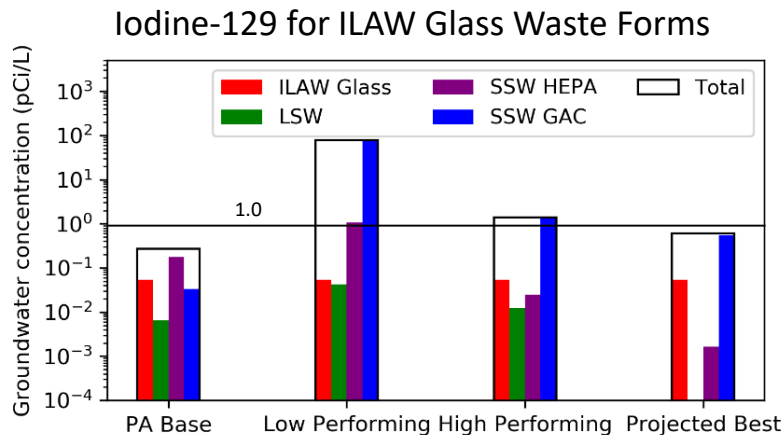


Figure F-16. Best Projected Cases for a) Tc-99 and b) I-129 for all three wasteform systems

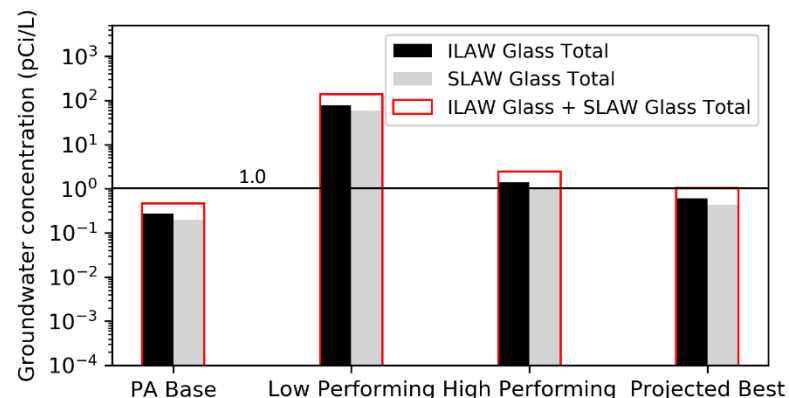


Performance Evaluation Results – Cumulative Groundwater Impacts for ILAW + SLAW



- The total potential impact to groundwater of disposal of immobilized LAW must include both the ILAW fraction produced by LAW Vit at WTP and the immobilized SLAW fraction.
- Shown here is cumulative impact for glass waste form systems only

Iodine-129 for ILAW + SLAW Glass Waste Forms



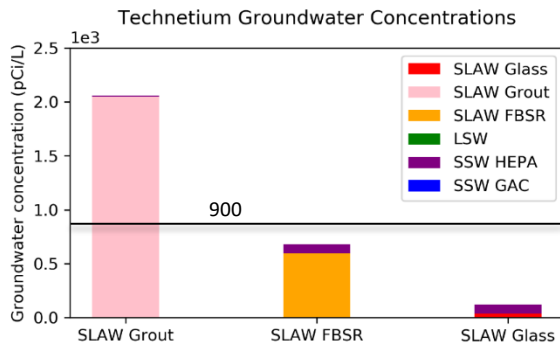
Backup Slides



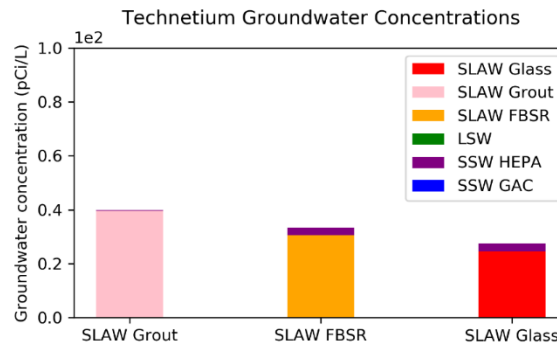
Projected Peak Groundwater Concentrations for All Cases

• Tc-99

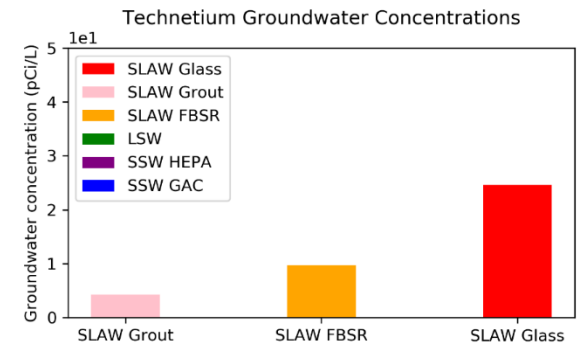
Low Performing



High Performing

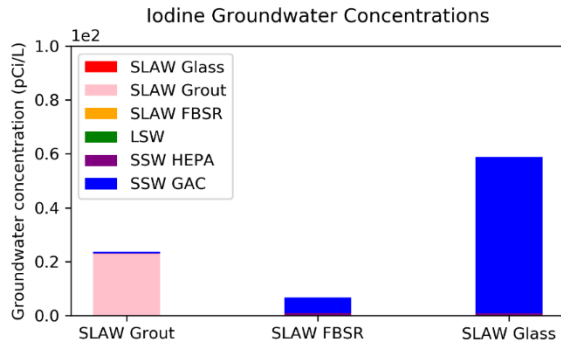


Projected Best

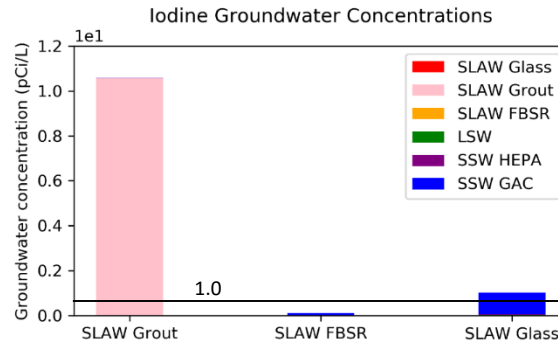


• I-129

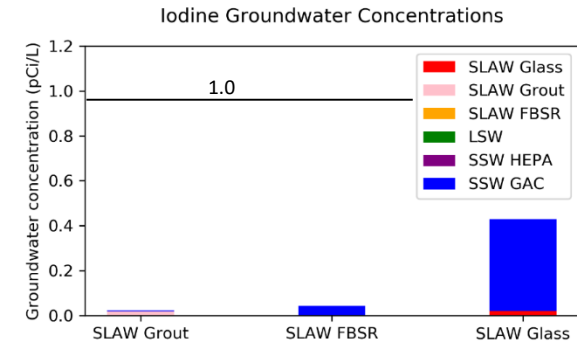
Low Performing

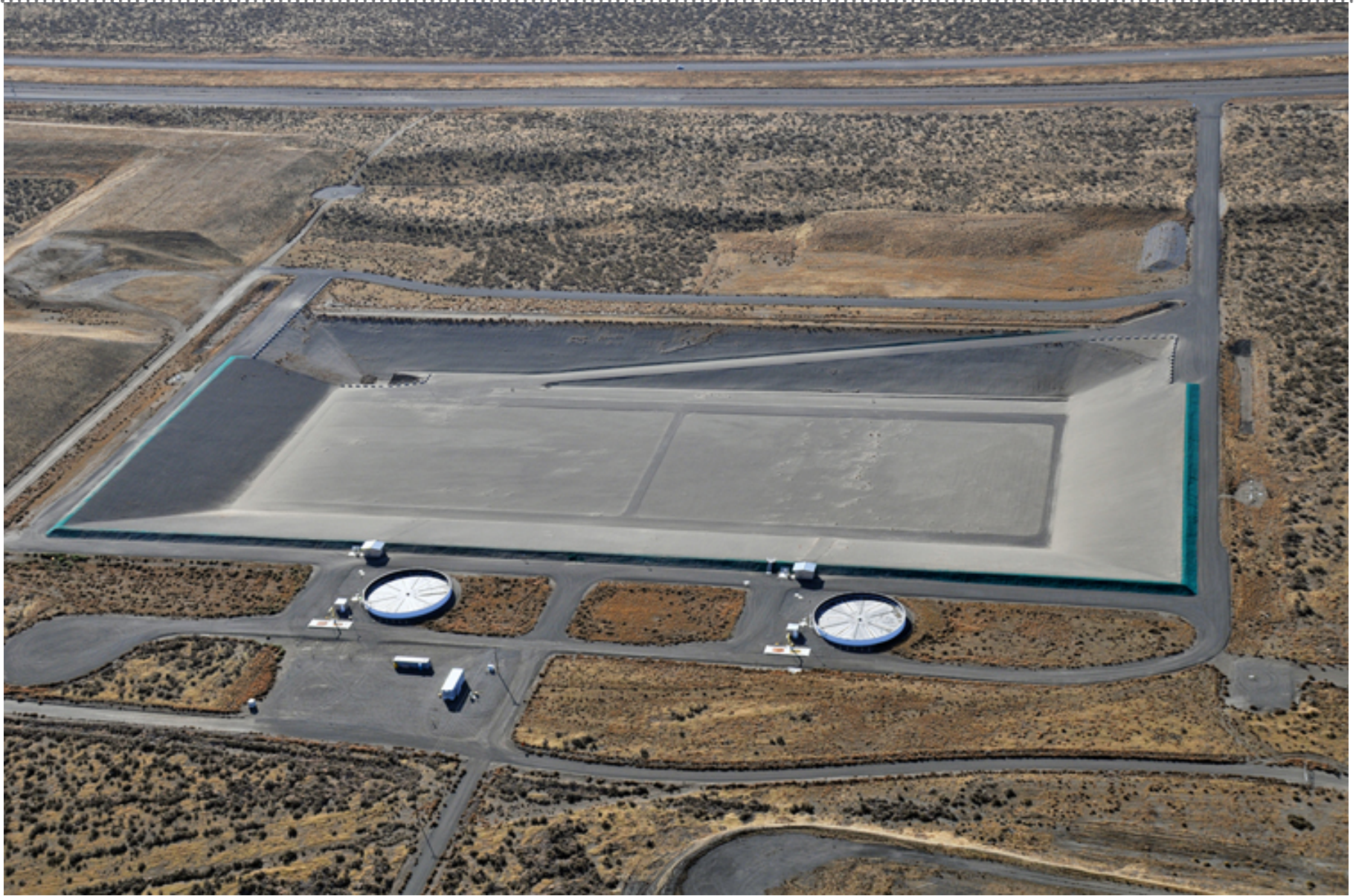


High Performing



Projected Best





NDA 3134 Supplemental Low Activity Waste FFRDC Team Conclusions

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NAS Committee Meeting #6
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Kennewick, WA

SRNL-MS-2019-00095

Pre-Decisional

Conclusions

1. A viable SLAW treatment and disposal option can be developed for each of the three technologies evaluated (vitrification, grouting, and steam reforming).
2. For grouting, both onsite and out-of-state disposal will likely require treatment of select LDR organics if found in the waste, and R&D and/or additional flowsheet studies will be needed to define that LDR treatment.
3. Technetium and iodine removal is not needed for out-of-state disposal of grouted or steam reformed wasteforms.
4. Technetium and iodine removal is not needed for onsite disposal of grouted or steam reformed wasteforms, assuming high performing grouted and steam reformed wasteforms.
5. Grouting and steam reforming offer significant cost benefits over vitrification.
6. No technology was evaluated highest in all NDAA17 study criteria.
7. Near-term decision on SLAW treatment technology is needed to meet DOE mission completion goals.
8. Implementing any of the SLAW treatment technologies will exceed current funding levels when combined with required spending for all WTP and tank projects concurrent with SLAW treatment.



- A viable SLAW treatment and disposal option can be developed for each of the three technologies evaluated (vitrification, grouting, and steam reforming)
 - o The FFRDC team recognizes that the TRL is different for each technology but determined that a viable process flowsheet and final waste disposition path can be developed for all three technologies.
 - o Onsite disposal was deemed feasible for all primary waste forms
 - *Grout and steam reforming may require Tc-99 or I-129 pretreatment if the performance demonstrated in lab-scale testing is not achieved in full-scale process*
 - o Offsite disposal was deemed feasible for grout and steam reforming waste forms
 - *Not evaluated for glass waste forms*
 - *Tc-99 and I-129 pretreatment were not required for offsite disposal*
 - *One “standard” length train every 3 months*



Pre-Treatment Considerations

- **For grouting, both onsite and out-of-state disposal will likely require treatment of select LDR organics if found in the waste, and R&D and/or additional flowsheet studies will be needed to define that LDR treatment**
 - The available information is not sufficient to determine if LDR treatment for organics will be definitely required
 - It was assumed that at least a portion of the waste would need LDR treatment
- **Technetium and iodine removal is not needed for out-of-state disposal of grouted or steam reformed wasteforms**
 - The treated LAW meets the WAC for disposal at WCS without Tc-99 or I-129 removal
- **Technetium and iodine removal is not needed for onsite disposal of grouted or steam reformed wasteforms, assuming high performing grouted and steam reformed wasteforms**
 - The performance evaluation indicated that releases from IDF would meet drinking water standards based on high performing or best results from recent laboratory waste form testing
 - Tc or I removal could be needed if the high performing (steam reforming) or projected best (grout) results cannot be achieved for actual processing flowsheets



Treatment Technology Comparisons

- A viable SLAW treatment and disposal option can be developed for each of the three technologies evaluated (vitrification, grouting, and steam reforming)
- No technology was evaluated highest in all NDAA17 study criteria
 - o See comparative table on next slide
- Grouting and steam reforming offer significant cost benefits over vitrification
 - o The cost differences between the three technologies was significant with grout having a significant cost advantage over steam reforming
 - *Includes organic treatment for grout options*
 - o Vitrification costs were significantly higher than other technologies



Treatment Technology Comparisons

IMMOBILIZATION TECHNOLOGY	RISKS/ OBSTACLES	BENEFITS	COSTS	SCHEDULES	ONSITE REGULATORY COMPLIANCE	OUT-OF-STATE REGULATORY COMPLIANCE
VITRIFICATION	• Most complex process • Most dependent on integrated facility performance ○ Highest throughput risk ○ Most impacted by feed rate variability ○ Lowest single-pass retention • Highest volume and curies secondary waste	• Most technically mature for SLAW feed • High temperature LDR organic/ nitrate destruction • Lowest volume primary waste	Highest: ~\$20 to ~\$36B	10-15 years	• Primary wasteform meets DOE Technical Performance Criteria (TPC) • Primary wasteform meets state permit requirements • May require mitigation for Iodine-129 in secondary waste	• Primary wasteform not evaluated • Secondary wastes meet WAC requirements
GROUTING	• LDR organics likely to require mitigation measures such as waste pretreatment or System Plan feed adjustments • May require Tc treatment for onsite disposal • Highest volume primary waste	• Least complex process • Least dependent on integrated facility performance ○ Lowest throughput risk ○ Greatest stop/start flexibility • Room-temperature process • Lowest volume and curies secondary waste	Lowest: ~\$2B to ~\$8B	8–13 years	• Primary wasteform likely to meet DOE TPC • Further validation of acceptable wasteform performance needed • May require mitigation for I-129	• Meets WAC (assuming LDR organics addressed) and transportation requirements
STEAM REFORMING	• Least technically mature for SLAW feed • Complex process • Requires rigorous process monitoring and control of fluidized bed and solids handling systems	• Lowest cost high temperature LDR organic/ nitrate destruction • Little waste volume increase during treatment • No liquid secondary waste	Middle-range: ~\$6B to ~\$17B	10-15 Years	• Monolithic primary wasteform likely to meet DOE TPC • Primary wasteform likely to meet state permit requirements • Further validation of acceptable wasteform performance needed • May require mitigation for I-129 in secondary waste	• Meets WAC and transportation requirements



Other Items of Note

- **Near-term decision on SLAW treatment technology is needed to meet DOE mission completion goals**
 - The required dates for SLAW in System Plan 8 requires a near-term decision to allow adequate time to design and construct the SLAW facility
- **Implementing any of the SLAW treatment technologies will exceed current funding levels when combined with required spending for all WTP and tank projects concurrent with SLAW treatment**
 - The funding levels required to implement System Plan 8 as described exceed current funding levels without the addition of a SLAW facility



Comparison of FFRDC Study to EIS

- **EIS did not identify a cost delta between vitrification and grout**
 - WTP project costs have increased
 - *The FFRDC's SLAW project costs were based on LAW facility costs*
 - *Preliminary SLAW project costs estimates used by the EIS were lower than LAW despite the greater size and scope for SLAW*
 - *Recent reporting indicates that the costs for the portion of WTP facilities required for DFLAW roughly matches the estimates for all WTP facilities in the EIS*
 - WTP operating cost estimates have increased
 - *The recent estimate for operation of a portion of the WTP facilities during DFLAW exceeds the estimates for full WTP operation used in the EIS*
 - *The FFRDC based SLAW operating costs on updated information on LAW facility costs*
 - Use of commercial containers in FFRDC study for grout waste form reduced the cost of grouting compared to the custom containers assumed in the EIS
- **Offsite disposal options were not available during EIS**
- **Additional research and development of grout and steam reforming systems reduced the expected release rates from these waste forms**



Wrap-Up and Next Steps

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SRNL Nuclear Materials Management Directorate

NAS Committee Meeting #6

May 16, 2019

Kennewick, WA

SRNL-MS-2019-00095

Pre-Decisional

Next Steps

- **Next Steps**
 - o Collect Meeting #6 Feedback
 - o Await NAS Report #3
 - o Finalize and issue FFRDC final report
 - o Support future Public Meetings

