<u>FFRDC Team Working Draft Documents – 2017 NDAA 3134 Hanford Supplemental Low Activity Waste Treatment at the Hanford Reservation</u>

The following attached documents have been developed by the FFRDC Team and represent “working draft” information regarding assessment methodologies, technologies, and approaches under consideration and review per the FFRDC Program Plan developed for this study.

The FFRDC Team recognizes that under the NDAA 3134 language, the collaboration with the NAS is critical to achieving the intended goal of the study. As such, working draft information is being shared.

It is important for readers to understand that much of what is presented in these working draft documents has not been peer reviewed or technically edited and is not intended to imply any final conclusions or represent a complete analysis. Peer reviews and subsequent revision and refinement will be completed during the fall of 2018 and spring 2019. Until a final report is issued, all information presented is considered Pre-Decisional DRAFT.

The intent of sharing the working draft documents is to stimulate dialog with the NAS Committee members and to ultimately obtain constructive feedback, comments, and technical ideas to improve on these draft documents and technical concepts as they mature into the ultimate final report(s).

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NDAA – Hanford Supplemental LAW Evaluation

Cost Estimate Status

William Ramsey & Frank Sinclair

NDAA Evaluation of Supplemental LAW Options
Public National Academy of Science Meetings:
Richland, WA
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Introduction and Purpose

- Per the 2017 NDAA, the FFRDC team is to develop cost estimates of treatment options for Hanford Supplemental LAW

- As part of this activity, SRNL is developing Rough Order of Magnitude (ROM) cost estimates to include Pre-Process Operations, Capital Projects, Transportation/Disposition Logistics, Life-Cycle Operations, and D&D. Considerations include facility sharing of site overheads.

- Three primary treatment technologies

  Vitrification
  Fluidized Bed Steam Reforming
  Grouting

- Two disposal sites

  Hanford WA, Integrated Disposal Facility (IDF)

  Offsite Commercial Facility (WCS)

Overview

- Cost estimating follows the process technology and pre-treatment flowsheets as well as the transportation/disposal cost (for offsite) disposal, where applicable.

- Work performed indicative of Estimate Class 5: Concept Screening
  - AACE International Recommended Practice 18R-97 key guidance

- Not all variants will be estimated. Key focus points include:
  - Technology complexity, history, and maturity.
  - The projected range within a given technology (between variant).

- Final disposal location is a significant factor for Grout and FBSR.

- Transportation/disposal logistics and cost are treated as individual field to better reflect the impacts and provide comparison.
  - Detailed description (in conjunction with Cochran et al.) in final report.

Iterative process with multiple technology variants and transportation disposal options.

Key Points

- *Significant variation between different technologies*
  - Consistent between estimating effort and SME ranking process
  - Risk analysis workshop under review
- *Analogs selected for each base technology*
- *Technology type appears significantly more impactful than sub-variants*
- *Transportation and off-site disposal included*
  - Largest impact to Grout and FBSR options
  - Disposal is significant cost for either technology with respect to life-cycle
  - Cost estimate includes recent quotes
- *Support from SMEs in detailing transportation, regulations, and disposal cost noted and appreciated.*

Iterative process involving technology and regulatory SME input, Development and Construction experience, and Operations & Logistics expertise.

Class 5 estimates developed from SME flowsheets with at least 2 iterations per SME team plus May (variant comparison) and October (risk) FFRDC group meetings.

- Identification / Utilization of Analog Facility for Primary Process

Vitrification	*WTP-LAW w/ EMF (Hanford)*	
	Vit Case I:	*2X capacity of existing LAW w/ enhanced off-gas*
	Vit Case II:	*2 double capacity melters with enhanced off-gas*
Grout	*Saltstone (SRS)*	
	Grout Case I:	*PT w/ disposal at IDF, packaged form, additional load-out / logistics*
	Grout Case II:	*PT w/ disposal at WCS, packaged form, load-out through to TX*
FBSR	*IWTU (Idaho)*	
	FBSR Case I:	*2 IWTU process lines - grouted monolithic waste form*
	FBSR Case II:	*Same scale as base, but with mineral product to offsite disposal*

Methodology, continued

Class 5 estimate as per characteristics (Classification Matrix for the Process Industries) and DOE Capital Facility guidance and history.

End Usage:	Concept Screening, Evaluation of Alternatives, Resource and Long-Range Capital Planning
Methodology:	Capacity Factored, Judgement, Analogy
Purpose:	Identification of key cost factors

- Analogs for each technology exist – at varying levels of construction and operations.
  - WTP >> Saltstone > IWTU with respect to degree of compatibility basis
- Class 5 estimates are consistent with downselects versus direct comparisons,
  - Example, DWPF estimates for cold crucible versus joule heated refractory lined melter.
- Technology development requirements and scaling not consistent with Class 4 or Class 3 (which are more appropriate for budget planning and authorization).
- Transport and offsite disposal much better than ROM, more akin to Class 2.
- Intent was to evaluate flowsheet coherence and primary cost components.

Methodology, continued

Iterative process involving technology and regulatory SME input, Development and Construction experience, and Operations & Logistics expertise.

- Systems approach based on recent DOE activity for ancillary facilities including,

Pre-Process	500K gallon blend tank ubiquitous for all technologies In-tank strontium removal possible for grout (off-site disposition cost) Organic strikes and Tc/I removal options for grout
New Unit Operations	None for glass (minor deviation on off-gas treatment)
Post-Process	Optional grouting to convert FBSR product to monolith 8.4 cubic meter package for grout/FBSR handling / shipping
Balance of Facilities	Not a major discriminator versus overall capital cost Glass > FBSR > Grout
Control Room	IWTU (FBSR) cost includes control room Grout option increased to upgrade versus Saltstone Vitrification assumed to use WTP control room
Laboratory	WTP lab shift technicians added for each technology

Methodology, continued

Iterative process involving technology and regulatory SME input, Development and Construction experience, and Operations & Logistics expertise.

- Start-Up, Operations, Transport/Handling Logistics, etc. handled on annual basis

Transportation	For grout / FBSR products (preferred method – rail)
Disposal	Commercial facility pricing based on volume and radiological input
D&D	TBD – will be estimated as function of TPC & OPEX (on order of 10%)
G&A	overhead and general services

Notes: Handling and site logistics (load-out) separated from transportation

Strontium strike (in tank farms) option considered to reduce disposal cost

Lab overhead and services cost share will not differentiate in this methodology - driven by WTP-PT, WTP-LAW, and WTP-HLW

Equivalent duration for processes reduces impacts

Disposal Fees (no other costs)

- For regular monthly deliveries & defined quantities, WCS did not object to 25% discount from current pricing, for this study:
  - $1370/m^3$ for Class A MLLW and
  - $5220/m^3$ for the Class B and C MLLW

Classification of Waste Forms to be Disposed at WCS (measured as number of months of output from WTP PT and LAW PS)					Disposal Fees
Variant	Class A	Class B	Class C	GTCC	
Grout Case II	0	408	33	0	$1.9 B
FBSR Case II	0	302	139	0	$1.3 B

Disposal cost estimate significantly better than Class 5, however, quantity (FBSR), timeliness, & package/handling details exist

Railroad Shipping Costs (no other costs)

- Railroad shipping rates are proprietary
- DOE / EM's Office of Packaging and Transportation
  - Placed many contracts for shipping radioactive waste by rail
  - Recommended $12,500 per loaded gondola ($3,000 return empty)

Off-Site Shipping Program Summary			Total Cost 337 months
Waste Form	Container	Railcars / month	
Grout Case II & Grout Case II w/ Sr-90 Removal	8.4 m3 soft side in steel box	26	$0.136 B
FBSR Case II, Granular Mineral Product	8.4 m3 soft side in steel box	8	$0.042 B

Cost detail better than Class 5. Key points – gondola car availability nor transport pricing impact results.

Estimate Range

by

Technology and Variant Case

Preliminary Cost Estimate: FBSR

Pre-Decisional

FBSR Case I

Technology Development	Pilot Plant TPC & OPEX	Total Project Cost (TPC)	IDF Expansion	OPEX/Life Cycle Cost	Shipment WCS	Major Equipment Replacement	D&D	Total Program Cost
$480M – $1,100M	$1,000M – $2,600M	$1,900M – $4,390M	$1M – $2.6M	$3,276M – $4,914M	N/A	$300M – $690M	$TBD	$8,500M – $15,000M

FBSR Case II

Technology Development	Pilot Plant TPC & OPEX	Total Project Cost (TPC)	IDF Expansion	OPEX/Life Cycle Cost	Shipment WCS	Major Equipment Replacement	D&D	Total Program Cost
$480M – $1,100M	$1,000M – $2,600M	$1,900M – $6,880M	N/A	$2,520M – $3,780M	$1,850M – $2,775M	$300M – $690M	$TBD	$9,500M – $19,200M

Notes: T&D cost impacted by waste characteristics, maturity, type of testing

OPEX / Life Cycle cost impacted by maturity

Transport and disposal significant but not dominant portion of cost

Preliminary Cost Estimate: Grout

Pre-Decisional

Grout Case I

Technology Development	Pilot Plant TPC & OPEX	Total Project Cost (TPC)	IDF Expansion	OPEX/Life Cycle Cost	Shipment WCS	Major Equipment Replacement	D&D	Total Program Cost
$90M – $210M	N/A	$500M – $1,150M	$1M – $2.6M	$1,120M – $1,680M	N/A	$250M – $1,160M	$TBD	$2,000M – $5,000M

Grout Case II

Technology Development	Pilot Plant TPC & OPEX	Total Project Cost (TPC)	IDF Expansion	OPEX/Life Cycle Cost	Shipment WCS	Major Equipment Replacement	D&D	Total Program Cost
$120M – $280M	N/A	$650M – $1,464M	$1M – $2.6M	$1,120M – $1,680M	$2,775M – $4,163M	$320M – $1,508M	$TBD	$5,000M – $10,000M

Notes: T&D cost impacted by waste characteristics, maturity, type of testing
OPEX / Life Cycle cost impacted by maturity
Transport and disposal significant but not dominant portion of cost
- Estimates reflect latest input with uncertainty on disposal.

Preliminary Cost Estimate: Vitrification

Pre-Decisional

Vit Case I

Technology Development	Pilot Plant TPC & OPEX	Total Project Cost (TPC)	IDF Expansion	OPEX/Life Cycle Cost	Shipment WCS	Major Equipment Replacement	D&D	Total Program Cost
$340M – $1,020M	$1,000M – $2,600M	$6,800M – $15,600M	$1M – $2.6M	$10,080M – $15,120M	N/A	$1400M – $2100M	$TBD	$21,300M – $40,000M

Vit Case II

Technology Development	Pilot Plant TPC & OPEX	Total Project Cost (TPC)	IDF Expansion	OPEX/Life Cycle Cost	Shipment WCS	Major Equipment Replacement	D&D	Total Program Cost
$680M – $1,560M	$1,000M – $2,600M	$6,800M – $15,600M	$1M – $2.6M	$8,540M – $12,810M	N/A	$770M – $1160M	$TBD	$19,300M – $37,000M

Notes: Significant overlap exists between HLW/PT capital projects and SLAW Vit

- Specific concern is multiple projects @ current funding cap (6-10 years)
- Alternative is schedule slip for SLAW Vitrification (as per current WTP PT/HLW)

OPEX / Life Cycle and TPC cost based on DFLAW actuals and estimates

- Closest analog of three technologies

Major equipment replacement examples – melters, bubblers

- Systematic replacement built into existing program

Cost Range Comparisons

Pre-Decisional

	Technology Development $(M)	Total Project Cost, TPC $(M)	OPEX / Life Cycle Cost $(M)	Total Program Cost $(M)
Vitrification	340-1560	6800-15,600	8500-15,100	19,000-40,000
FBSR	480-1100	1900-6900	2500-4900	8500-19000
Grout	90-280	500-2180	1100-1700	2000-10000

Notes: Analog based values consistent with aggregate SME rankings
Values shown reflect high – low range within individual technologies
Significant differential in DFLAW operations estimate vs IWTU or Saltstone
T&D cost impacted by duration, type of testing
Offsite disposal costs significant for variants, not between technologies

Timelines for Technology Options