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Final Report

Waste Treatment and Immobilization Plant
High-Level Waste Treatment

Analysis of Alternatives

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ACRONYMS

AACE	Association for the Advancement of Cost Engineering (International)
ACD	Amended Consent Decree
AHU	air handling unit
Al	aluminum
AoA	analysis of alternatives
ASME	American Society of Mechanical Engineers
BCWS	Budgeted Cost of Work Scheduled
BNI	Bechtel National Inc.
BOF	Balance of Facilities
BoM	Balance of Mission
BOP	Business Operating Procedure
C&I	control and instrumentation
CD	critical decision
CER	Cost Estimating Relationship
CESI	Cost Estimating and Scheduling Initiative
CFR	Code of Federal Regulations
CNP	Cs Nitric Acid Recovery Process
Cs	cesium
CTE	Critical Technology Element
CV	Critical Velocity
Cx	commissioning
CXP	Cs Ion Exchange Process
CY	calendar year
D&D	decontamination and decommissioning
DBE	Design Basis Event
DFHLW	direct feed high-level waste
DFLAW	direct-feed low activity waste
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
DST	double-shell tank
DWMP	Defense Waste Management Plan
ECMS	Enterprise Construction Management Services
Ecology	State of Washington Department of Ecology
EIS	Environmental Impact Statement
EM	Office of Environmental Management
EMF	Effluent Management Facility
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FCR	Facility Control Room
FEP	Feed Evaporation Process
FFV	Filter Feed Vessel
FMEF	Fuels Material Examination Facility
FRP	LAW Feed Receipt Process
FY	fiscal year
GAO	U.S. Government Accountability Office
gpm	gallon(s) per minute
HEMF	HLW Effluent Management Facility
HEPA	high-efficiency particulate air
HFP	HLW Feed Preparation
HFPEM	HLW Feed Preparation and Effluent Management Facility
HFPF	HLW Feed Preparation Facility
HFPV	HLW Feed Preparation Vessel
HFV	HLW Feed Vessel
HLP	HLW Lag Storage and Feed Blending Process
HLW	high-level waste
HLWV	high-level waste Vitrification Facility
HSF	Hanford Shipping Facility
HVAC	heating, ventilation and air conditioning
HWVP	Hanford Waste Vitrification Plant
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
IHS	Interim Hanford Storage (Facility)

ILAW	Immobilized LAW
IMUST	Inactive Miscellaneous Underground Storage Tank
IT	information technology
IX	ion exchange
kgal	Kilogallon(s)
LAW	low activity waste
LAWPS	LAW Pretreatment System (Facility)
LAWST	LAW Supplemental Treatment (Facility)
LCC	life-cycle cost
LCCE	life-cycle cost estimate
LERF	Liquid Effluent Retention Facility
LFE	LAW Feed Evaporator
LLW	low-level waste
M	mole(s) per liter
MAB	Melter Assembly Building
MAR	Material at Risk
MEB	Mechanical and Electrical Building
MFP	Melter Feed Preparation
Mgal	million gallons
MLLW	mixed low-level waste
MR	management reserve
MSA	Major System Acquisition
MSR	Modeling Scenario Request (Form)
MTG	metric ton(s) glass
MTS	Main Treatment System
MTT	Main Treatment Train
Na	sodium
NaNO2	sodium nitrite
NaOH	sodium hydroxide (caustic)
NNSA	National Nuclear Security Administration
NPH	Natural Phenomena Hazards
NQA	nuclear quality assurance
NRW	normalized relative weighting
O&M	operations and maintenance
OCT	On-Site Cask Transporter
OMB	Office of Management and Budget
ORP	Office of River Protection
OTC	On-Site Transportation Container
PA	Performance Assessment
PCS	Process Control System
PJM	Pulse Jet Mixer
PM	Office of Project Management
PSV	Primary Sludge Vessel
PT	Pretreatment (Facility)
PUREX	Plutonium and Uranium Extraction
PV	present value
PWD	Plant Wash and Disposal
RBA	Radiological Buffer Area
RCRA	Resource Conservation and Recovery Act
RL	Richland Operations Office
RLD	Radioactive Liquid Waste Disposal
RO	reverse osmosis
ROM	rough order of magnitude
RPP	River Protection Project
RPT	Repurposed PT Facility
SALDS	State-Approved Land Disposal Site
SC	safety class
SHSV	Standard High-Solids Vessel
SME	subject matter expert
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SS	safety significant
SSCs	structures, systems, and components
SST	single-shell tank
STS	Secondary Treatment System
STT	Secondary Treatment Train
TCP	Treated LAW Concentrate Storage Process
TFPT	Tank Farm Pretreatment (Facilities)
TI	technical issue

TLP	Treated Low-Activity Waste Evaporation Process
TOE	Total Operational Efficiency
TPA	Tri-Party Agreement (Hanford Federal Facility Agreement and Consent Order)
TPC	total project cost
TRA	Technology Readiness Assessment
TRL	Technical Readiness Level
TSCR	Tank-Side Cesium Removal (Facilities)
TWCSF	Tank Waste Characterization and Staging Facility
UFP	Ultrafiltration Process
UPS	uninterruptable power supply(ies)
U.S.	United States
USACE	U.S. Army Corps of Engineers
UV/OX	ultraviolet oxidation
VAC	volts of alternating current
WAC	Waste Acceptance Criteria
WBS	work breakdown structure
WFD	Waste Feed Delivery
WRF	Waste Retrieval Facility
WRPS	Washington River Protection Solutions
wt %	weight %
WTP	Waste Treatment and Immobilization Plant
WTS	Waste Transfer System
WTV	Waste Transfer Vault

REVISION SUMMARY

Revision No.	Date	Change Description	Pages Affected
0	January 12, 2023	Initial release	N/A

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EXECUTIVE SUMMARY

The Waste Treatment and Immobilization Plant (WTP) project is instrumental to the overall cleanup mission at the Hanford site. WTP aligns directly with the Department of Energy (DOE) Office of Environmental Management (EM)'s mission to complete the safe cleanup of environmental legacy from five decades of nuclear weapons development and nuclear energy research. In 2018, the U.S. Army Corps of Engineers delivered a report[f] to evaluate the probability of achieving critical project milestones. The report found the likelihood of meeting these milestones to be "very low" under the current funding profile. The Office of River Protection (ORP) required a comprehensive set of alternatives to evaluate other options for meeting the mission need.

The WTP high-level waste (HLW) analysis of alternatives (AoA) team used the process shown in Figure 1 to evaluate potential alternatives:

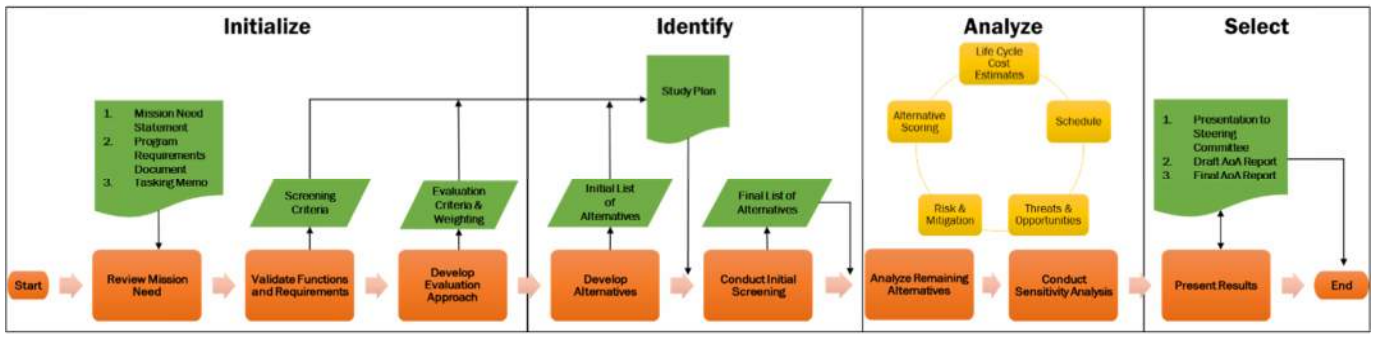

Figure 1: AoA Methodology

The initial phase of this AoA was conducted from May 2019 through August 2020, and the pre-final Revision C of this report was submitted on August 20, 2020. Minor non-content typographical and formatting edits were included in Revisions D and E, dated April 16, 2021 and May 12, 2022, respectively. Due to DOE's ongoing negotiations with the Washington State Department of Ecology, the final (Revision 0) release of this document and the two addenda developed to support negotiations were held until the issue date, January 12, 2023.

The team assembled to conduct the WTP HLW AoA included subject matter experts (SMEs) in project management, waste processing, process design, safety management, risk management, scheduling, and cost estimating.

The AoA Team developed three screening criteria to screen alternatives based on meeting the requirements of Title 40, Part 268 of the Code of Federal Regulations; the Hanford Tri-Party Agreement; and Department of Energy (DOE) Order 413.3B, Change 5. The screening criteria developed included:

- Criterion 1: Tank waste classified as HLW shall be immobilized by vitrification.
- Criterion 2: The HLW processing system shall not preclude processing of low-activity waste (LAW), either by Direct Feed LAW (DFLAW) or via the Pretreatment (PT) Facility, in parallel with HLW processing.
- Criterion 3: HLW processing alternatives shall use proven and established technologies.

If an alternative could not meet any one of the screening criteria, it was no longer considered viable and was not further evaluated. Following the development of these screening criteria, nine evaluation criteria were established to evaluate each alternative that passed screening. The evaluation criteria further describe the expected facility characteristics in support of the mission need. The evaluation criteria were weighted by relative importance to assist in differentiating how fully each alternative supports the WTP HLW mission need. Each viable alternative was scored against the evaluation criteria to produce a weighted score, as one metric to compare alternatives.

After the evaluation criteria were established, the AoA Team iteratively brainstormed 17 potentially viable alternatives. Table 1 lists these alternatives and their descriptions. It is important to note that these alternatives do not necessarily align to the Amended Consent Decree[e] (ACD) requirements.

Table 1: Potentially Viable Alternatives

#	Alternative Name	Alternative Description
1	HLW Characterization and Staging in New Tank Waste Characterization and Staging Facility (TWCSF) with HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario[1])	HLW characterization and staging provided by the new TWCSF; HLW feed from TWCSF is pretreated in PT Facility (Baseline Case); HLW effluents from PT Facility processes and from HLW Vitrification Facility are concentrated in PT Facility.
2	HLW Pretreatment and Effluent Management in New HLW Feed Preparation and Effluent Management (HFPEM) Facility	HLW is received, characterized, and pretreated in HLW Feed Preparation Tanks in HLW Feed Preparation Facility (HFPF); pretreated HLW Feed is staged in HLW Feed Staging Tank in HFPF; dilute decants from HLW Feed Preparation Tanks and effluents from HLW Vitrification Facility are concentrated in new HLW Effluent Management Facility (HEMF).
3	HLW Feed Characterization in Double Shell Tank (DST) System and Pretreatment in the New HFPF	HLW sampling, characterization, and staging occurs in DST system. HLW Feed Preparation Tanks in HFPF receives HLW feed from DST system and performs pretreatment functions (solid and liquid separation, leaching, washing, and concentration). Pretreated HLW feed is staged in HLW Feed Staging Tanks in HFPF; dilute decants from HLW Feed Preparation Tanks and effluents from HLW Vitrification Facility are concentrated in new HEMF.
4	HLW Feed Characterization and Pretreatment (including High-Temperature Leaching) in New HFPF.	Same as Alternative 3, except that caustic leaching in the HLW Feed Preparation Tanks in HFPF is performed at a higher temperature 60°C (140°F)
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	HLW slurry from DSTs is transferred to HLW Feed Preparation Tanks in PT Facility; HLW feed leaching, washing, and concentration functions are accomplished by settling/decant in HFPF Feed Preparation Tanks; pretreated HLW feed is staged in HLW Feed Staging Tank in PT Facility; dilute decants from HLW Feed Preparation Tanks and effluents from HLW Vitrification Facility are concentrated in PT Facility.
6	Use New Technologies to Immobilize HLW	Use alternative technologies, such as grouting or steam reforming. Would require technology development, research and development, laboratory testing, and technology readiness assessment, as required.
7	Immobilize HLW In-Situ (within DSTs)	Use alternative technologies to immobilize HLW within existing DSTs. Would require technology development, research and development, laboratory testing, and technology readiness assessment.
8	Pretreat and Treat West Area HLW in New West Area Facilities	HLW slurry from an SY Tank Farm DST is transferred to West Area HFPF; HLW feed leaching, washing, and concentration functions are accomplished by settling/decant in West Area HFPF Feed Preparation Tanks; pretreated HLW feed is staged in West Area HFPF Feed Tanks. Pretreated HLW feed is vitrified in new West Areas Vitrification Facility; HLW Facility effluents and dilute decants from Feed Preparation Tanks are concentrated in New West Area HEMF.
9	Pretreat HLW Feed in New HFPF and Repurpose PT Facility for LAW Pretreatment and Effluent Management	HLW slurry from DSTs is transferred to HLW Preparation Tanks in HFPF; HFPF pretreats and stages HLW feed - same as Alternative 2; dilute decants from Feed Preparation Tanks are collected in the Plant Wash and Disposal (PWD) system and concentrated in the Feed Evaporation Process (FEP) system, and concentrated decants are returned to DSTs; pretreated HLW feed is vitrified in HLW Facility; PWD system collects HLW Facility effluents and FEP evaporator concentrates effluents; supernate from DSTs is transferred to LAW Feed Receipt Vessels in PT Facility; PT Facility removes solids and cesium (Cs) and concentrates and stages LAW feed; effluents from LAW Facility are collected in Treated Low-Activity Waste Evaporation Process (TLP) system and concentrated in TLP evaporator; pretreated LAW feed is vitrified in LAW Facility.
10	Shipment of HLW Off Site for Treatment (e.g., Savannah River Site [SRS])	HLW would be transferred to compliant mediums for transfer to SRS for treatment and vitrification.
11	Repurpose Fuels Material Examination Facility (FMEF) to Provide HLW Pretreatment Capabilities	FMEF would be retrofitted to provide pretreatment capabilities. Pretreated HLW from repurposed FMEF would be transferred or transported to HLW Vitrification Facility for immobilization.

[1] The Baseline Scenario defined in Alternative 1 does not reflect the Code of Record (COR) established at Critical Decision 2 (2003) and Baseline Change Proposal 1 (2006) because the COR has been found to be technically infeasible. Alternative 1 reflects the current scope planned to provide a predictable and Waste Acceptance Criteria-compliant HLW waste feed and to address technical issues raised by the Defense Nuclear Facilities Safety Board. Refer to Appendix A for additional details.

#	Alternative Name	Alternative Description
12	Repurpose PT Facility for HLW Processing and Vitrification	HLW Vitrification Facility would be abandoned. PT facility pretreats and vitrifies HLW.
13	HLW Bulk Vitrification	HLW would be retrieved from DSTs and pretreated and vitrified at a near-tank mobile facility or in a centrally located facility. Bulk vitrification would require technology development, research and development, laboratory testing, and technology readiness assessment.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	Same as Alternative 2 with added capability to filter decants from HLW Feed Preparation Tanks in HFPF.
15	Direct Feed HLW (DFHLW) from DSTs and Effluent Management in New HEMF	Sludge is leached, washed, and concentrated in DST system and is transferred directly to Melter Feed Tanks in HLW Facility via new Jumper Pits; transfer line flush water and HLW Facility effluents are routed to Evaporator Feed Tanks in HEMF; HEMF concentrates flush water and effluents from HLW Vitrification Facility.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	Same as Alternative 15, except that HLW from DST system is concentrated in HLW Feed Concentration Tanks in HEMF Drain Tank Vault prior to delivery to the HLW Vitrification Facility.
17	DFHLW from DSTs without HLW Effluent Management	HLW feed is sampled, characterized, and pretreated (limited to solids washing) in a designated DFHLW Feed Pretreatment Tank in the DST system (AP-101). The pretreated HLW feed is then transferred to a designated DFHLW Feed Tank (AP-102) to be staged for delivery to the HLW Vitrification Facility via a new Waste Treatment Vault (WTV).

These 17 potentially viable alternatives were screened against the three screening criteria. Alternatives 6, 7, 10, 11, and 13 failed to pass initial screening and were not evaluated further. Alternative 6 (use alternative technologies to immobilize waste) failed to pass Screening Criterion 1, since the use of vitrification is required. Alternatives 7, 10, 11, and 13 failed Screening Criterion 3, since the technology required for those alternatives is not sufficiently mature. Alternatives 3, 4, 8, 9, and 12 passed initial screening, but were subsequently screened out with Steering Committee approval due to new information discovered during the alternative definition and evaluation process. Details on initial screening results and rationales for screening decisions can be found in Section 5 and Appendix D, respectively.

The AoA Team performed a comparative qualitative risk analysis for the alternatives that passed screening. After completing detailed scope descriptions, the AoA Team developed rough order of magnitude (ROM) cost estimates for the design and construction of new facilities, as well as the life-cycle cost (LCC) for each alternative. These are Class 5 estimates with uncertainty ranges of -50%/+100% and -30%/+50% for project/capital costs and operations costs, respectively, as described in the DOE Cost Estimating Guide[c].

The AoA team evaluated two funding cases, constrained and unconstrained, when evaluating the LCCs for each alternative. The constrained case assumed an annual funding limit of $2.5B (based on Steering Committee and ORP direction) with funds allocated to projects in accordance with current ORP priorities and a focus on completion of the HLW processing facilities as soon as possible within the available funding limit. This scenario led to Alternatives 1 and 5 to become non-viable because funding was insufficient for completion of the HLW treatment facilities needed for those alternatives.

The unconstrained case assumed that all necessary funding was available to the project to complete the HLW mission as soon as possible, including meeting the current ACD[e] milestone for starting operations of the HLW Vitrification Facility. The LCC estimates (LCCEs) were used to compare alternatives on a present value (PV) basis for the unconstrained funding scenario.

Under the constrained funding scenario, the full scope of the various capital facilities needed to support the HLW treatment mission cannot be constructed and operated due to insufficient funding being available. In particular, the LAW Supplemental Treatment (LAWST) capability cannot be constructed and operated as assumed for the base case (unconstrained) modeling. For this reason, the comparison of project capital costs amongst alternatives includes a different set of potential capital projects for the constrained funding scenario than are considered under unconstrained funding. Furthermore, it is not possible to estimate the LCC for each alternative under the constrained funding scenario

without additional process modeling due to the unavailability of the LAWST capability for each alternative which impacts operational life cycle duration and costs.

The point estimates developed for each alternative are Class 5 estimates and were developed for the sole purpose of comparing alternatives. At this point of project development, the cost ranges for a Class 5 estimate have an associated uncertainty of -50%/+100% for project/capital costs and -30%/+50% for operations costs, and are not intended for budgeting purposes. DOE projects historically finish with costs higher than the point estimate and toward the upper end of the cost range. Capital project cost ranges for the WTP HLW alternatives are shown in Table 2 and Table 3. LCC ranges for the WTP HLW alternatives under unconstrained funding are shown in Table 4 (PV) and Table 5 (escalated LCC) for the unconstrained funding scenario.

Table 2: Capital Cost Ranges - Constrained[2]

#	Alternative Name	Low ($B)	Point ($B)	High ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	N/A	N/A[3]	N/A
2	HLW Pretreatment in HFPF	6.4	12.8	25.6
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	N/A	N/A	N/A
14	New HFPF (with Filtration) and New HEMF	6.3	12.6	25.2
15	DFHLW and HLW Effluent Processing in New HEMF	5.8	11.5	23.0
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	5.9	11.8	23.6
17	DFHLW Single Melter HLW Without Evaporators or LAW Supplemental Treatment (LAWST)	4.5	8.9	17.8

Table 3: Capital Cost Ranges - Unconstrained[4]

#	Alternative Name	Low ($B)	Point ($B)	High ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	19.0	38.0	76.0
2	HLW Pretreatment in HFPF	20.5	41.0	82.0
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	19.7	39.3	78.6
14	New HFPF (with Filtration) and New HEMF	17.0	33.9	67.8
15	DFHLW and HLW Effluent Processing in New HEMF	17.6	35.2	70.4
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	17.8	35.6	71.2
17	DFHLW Single Melter HLW Without Evaporators or LAWST	4.5	9.0	18.0

[2] Includes facilities needed for HLW Treatment unique to each alternative; excludes ancillary/supporting projects common to all alternatives, including LAW Vitrification Facility, Balance of Facilities, and Analytical Laboratory / DFLAW Completion, Hanford Shipping Facility/Interim Hanford Storage (HSF/IHS), and needed Tank Farm Projects as well as LAWST and new Effluent Treatment Facility (ETF) which are not possible due to funding limitations

[3] Alternatives 1 and 5 fail to complete the HLW treatment mission due to insufficient annual funding. See Section 8 and Appendix E for additional details.

[4] Includes facilities needed for HLW Treatment unique to each alternative; excludes ancillary/supporting projects common to all alternatives, including LAW Vitrification Facility, Balance of Facilities, and Analytical Laboratory / DFLAW Completion, HSF/IHS, and needed Tank Farm Projects.

Table 4: PV of LCC Ranges – Unconstrained Funding

#	Alternative Name	Low ($B)	Point ($B)	High ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	98	151	246
2	HLW Pretreatment in HFPF	80	125	208
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	78	123	205
14	New HFPF (with Filtration) and New HEMF	76	119	196
15	DFHLW and HLW Effluent Processing in New HEMF	77	121	200
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	77	121	200
17	DFHLW Single Melter HLW Without Evaporators or LAWST	242	423	770

Table 5: Life Cycle Cost Ranges – Unconstrained Funding

#	Alternative Name	Low ($B)	Point ($B)	High ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	228	341	539
2	HLW Pretreatment in HFPF	139	215	350
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	142	217	352
14	New HFPF (with Filtration) and New HEMF	139	212	341
15	DFHLW and HLW Effluent Processing in New HEMF	140	214	346
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	139	213	344
17	DFHLW Single Melter HLW Without Evaporators or LAWST	2,835	5,099	9,484

There are several methods to compare alternatives. Table 6 (unconstrained funding) and Table 7 (constrained funding) provide a weighted score, which is based on evaluation criteria, capital costs, PV LCCs, durations to hot commissioning (Cx) and completion of HLW treatment, and risk ratings. It is important to note that the weighted score is based on nine evaluation criteria and not a composite score of the cost, schedule, and risk shown.

In the unconstrained case, the weighted score for Alternative 14 was highest by a relatively significant margin followed by a clustering of Alternatives 16, 15, and 2. Alternatives 5 and 1 also scored similarly, before a significant drop-off to the lowest ranked Alternative 17. TPC, LCCs, and overall risk profile amongst alternatives also are relatively similar. The exceptions are for Alternatives 1 (higher LCC by approximately $30B) and 17 (lowest TPC by approximately $25B, but highest LCC by $275B). Mission completion schedules are also relatively similar for Alternatives 2, 5, 14, 15, and 16. Alternative 1 trails by approximately 20 years, and Alternative 17 by over 100 years.

In the constrained case, as mentioned previously, Alternatives 1 and 5 become non-viable due to annual funding constraints. Alternative 17 rises to the highest rank by a wide margin, due to a lower cost, schedule, and risk profile. It is important to note, however, that the constrained case results are based on the point estimate values for new facilities. If the high-end cost ranges are realized, all alternatives except for Alternative 17 would become non-viable due to projected funding constraints. Even so, Alternative 17 would be challenging to accomplish due to limited funding.

Table 6: AoA Results - Unconstrained Funding

#	Weighted Score	Start Date HLW Treatment Operations	Total Project Cost ($B)	Project / Technical Risk	Operational Risk	Programmatic Risk	Life Cycle Cost (PV, $B)	Complete HLW Treatment	Increased Operational Flexibility	# IHLW Canisters Produced	# ILAW Canisters Produced	Volume of Secondary Liquid Effluent Produced
1	64.0	12/31/2033	38.0	Moderate	Moderate	Moderate	151	08/2084	Somewhat Meets	9,500	93,900	17 Mgal
2	70.0	12/31/2033	41.0	Low	Moderate	Moderate	125	07/2061	Fully Meets	8,200	101,400	34 Mgal
5	66.0	12/31/2033	39.3	Moderate	Moderate	Moderate	123	09/2064	Fully Meets	9,500	97,800	30 Mgal
14	79.0	12/31/2033	33.9	Low	Moderate	Moderate	119	09/2064	Fully Meets	9,500	97,800	30 Mgal
15	71.0	12/31/2033	35.2	Moderate	Moderate	Moderate	121	05/2064	Generally Meets	8,100	103,600	32 Mgal
16	72.0	12/31/2033	35.6	Moderate	Moderate	Moderate	121	10/2062	Generally Meets	8,100	102,000	31 Mgal
17	58.0	12/31/2033	9.0	Low	Moderate	Moderate	423	2168+	Doesn't Meet	14,900+	67,000+	8 Mgal

Table 7: AoA Results - Constrained Funding

#	Weighted Score	Start Date HLW Treatment Operations	Total Project Cost ($B)	Project / Technical Risk	Programmatic Risk
2	41.7	FY 2036	12.8	Moderate	High
14	41.7	FY 2036	12.6	Moderate	High
15	50.0	FY 2035	11.5	Moderate	High
16	50.0	FY 2035	11.8	Moderate	High
17	91.7	FY 2034	8.9	Low	Moderate

Sensitivity analyses were conducted to determine the influence of evaluation criteria priority on overall alternative ranking. The AoA Team brainstormed eight scenarios for the unconstrained case, and four scenarios for the unconstrained case. Details on these scenarios, including descriptions, are further described in section 9.4. The results are summarized in Table 8 and Table 9.

Table 8: Sensitivity Analysis Results, Unconstrained Funding

	Baseline		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
ALT #	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK
1	64.0	6	63.9	6	63.5	6	73.7	3↑	55.0	6
2	70.0	4	66.7	3↑	75.0	4	78.9	2↑	62.5	4
5	66.0	5	66.7	3↑	72.9	5	73.7	3↑	57.5	5
14	79.0	1	75.0	1	84.4	1	82.9	1	73.8	1
15	71.0	3	66.7	3	78.1	3	72.4	6↓	63.8	3
16	72.0	2	69.4	2	79.2	2	73.7	3↓	65.0	2
17	58.0	7	50.0	7	39.6	7	55.3	7	47.5	7
	Baseline		**Scenario 5**		**Scenario 6**		**Scenario 7**		**Scenario 8**	
ALT #	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK
1	64.0	6	65.2	5↑	53.3	5↑	63.0	6	60.0	4↑
2	70.0	4	67.4	4	61.7	4	70.7	4	65.0	3↑
5	66.0	5	63.0	7↓	53.3	7↓	66.3	5	70.0	1↑
14	79.0	1	77.2	1	75.0	1	80.4	1	70.0	1
15	71.0	3	70.7	3	66.7	2↑	71.7	3	55.0	6↓
16	72.0	2	71.7	2	66.7	2	72.8	2	60.0	4↓
17	58.0	7	63.0	6↑	50.0	6↑	58.7	7	40.0	7

Rank indicates the alternatives' order based on scoring with a rank of 1 corresponding to the highest score.

Arrows indicate increase (↑) or decrease (↓) in rank relative to baseline rank.

Table 9: Sensitivity Results, Constrained Funding

	Baseline		Scenario 9		Scenario 10		Scenario 11		Scenario 12	
ALT #	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK
2	41.7	4	44.4	4	36.1	4	44.4	4	58.3	4
14	41.7	4	44.4	4	36.1	4	44.4	4	66.7	2↑
15	50.0	2	63.9	2	55.6	2	55.6	2	66.7	2
16	50.0	2	63.9	2	55.6	2	55.6	2	66.7	2
17	91.7	1	94.4	1	94.4	1	86.1	1	91.7	1

Rank indicates the alternatives' order based on scoring with a rank of 1 corresponding to the highest score.

Arrows indicate increase (↑) or decrease (↓) in rank relative to baseline rank.

In both the unconstrained and constrained case sensitivity analyses, the AoA Team did not find evidence of inherent bias through weighting and scoring. In most cases, the top and bottom ranked alternatives remained in those relative positions. In instances where relative rankings did change, the differences between total scores were generally not significant in comparison to other alternatives.

1 Scope

The U.S. Department of Energy (DOE) Office of River Protection (ORP) tasked Enterprise Construction Management Services (ECMS) under the awarded Call FNA0000043 to develop an independent analysis of alternatives (AoA) for the Waste Treatment and Immobilization Plant (WTP) high-level waste (HLW) Treatment mission.

Following the process described in DOE Order 413.3B[a] and the National Nuclear Security Administration (NNSA) Business Operating Procedure (BOP) 03.07[b], the AoA Team of subject matter experts (SMEs) worked closely with ORP personnel and the Washington State Department of Ecology (Ecology) to develop and evaluate the potential alternatives. This report describes the systematic process by which a broad range of alternatives were evaluated. . This report includes the alternative high-level functions/requirements; alternative descriptions with their associated risks and opportunities, assumptions and constraints, evaluation criteria, and life-cycle cost estimates (LCCEs); and the results of the alternatives evaluation.

1.1 Approach

The approach used by the AoA Team for conducting the AoA included the following eight primary steps:

1. Identify high-level functional requirements to meet the mission need (Section 2.1).
2. Establish the criteria to be used to screen the alternatives.
3. Develop evaluation criteria and assign weighting factors for each based on their relative importance.
4. Conduct brainstorming sessions to identify a list of potential alternatives.
5. Review and screen out alternatives that do not meet the mission and program requirements (Section 3.1).
6. Rate each alternative according to its ability to meet evaluation criteria (Section 7) using multiple attribute decision analysis.
7. Conduct sensitivity analysis.
8. Present AoA results to management.

Figure 2 summarizes the overall process, which included several visits to the Hanford site to kick off the AoA and conduct fact gathering and working sessions. Multiple stakeholder group discussions and weekly conference calls were also held and recorded with meeting notes.

The approach highlighted above follows the GAO 22-Step Best Practices referenced in NNSA BOP-03.07[b]. The use of a thorough and systematic AoA process, based on a set of criteria established, reviewed, and approved by major stakeholders, supports the DOE selection of a preferred alternative.

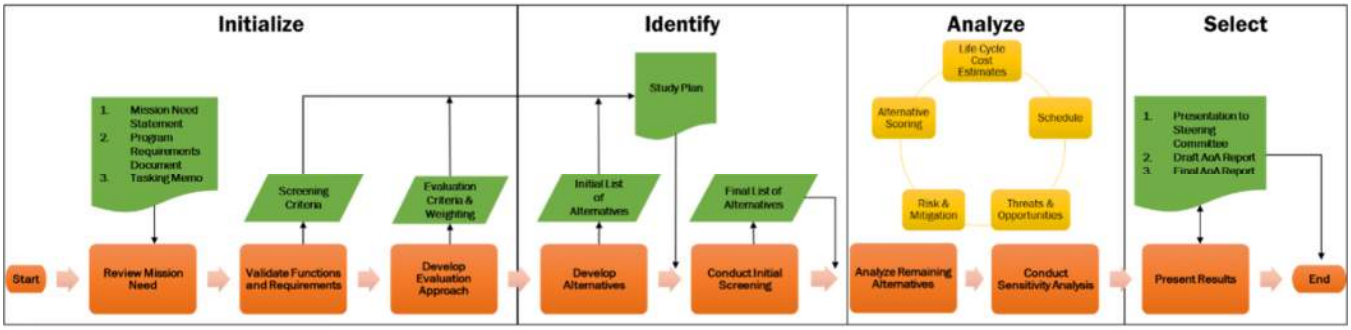

Figure 2: Overall AoA Process Diagram

The process started with a review of existing project documentation. The AoA team reviewed this information to ensure that the functions and requirements were clearly stated and could be used for the initial screening of alternatives. The results of the requirements validation were presented to the Steering Committee for review and approval.

The AoA Team developed the specific evaluation approach for the AoA, informed by the mission need and requirements and potential alternatives. The specific approach included developing initial screening criteria to determine if the alternatives were viable. The validated data, along with other mission need and requirements information, was used to establish these initial screening criteria. The screening criteria are aligned with the project requirements. Evaluation of the alternatives is bound by established screening criteria.

After developing the screening criteria, the AoA Team developed the initial evaluation criteria. The evaluation criteria are traceable to the requirements and, to the extent possible, are based on measurable outcomes, including performance criteria, safety, or environmental impact. Each criterion is defined to ensure that all members of the team understand how it will be measured. As described in the approved Study Plan, these criteria include cost, schedule, risk, and secondary waste generation, as well as other factors.

Following the identification of the evaluation criteria, the AoA Team assigned weighting factors to each criterion to reflect the relative importance to the requirements. The weighting factors are non-linear: the most important criterion is weighted 5; the next most important criterion is weighted 3. This adds emphasis to the importance of the highest criterion.

After the evaluation criteria, initial risk, and other evaluation materials were established, the next step was to develop a broad list of potential alternatives to satisfy the mission need and to meet requirements. This activity included brainstorming by the AoA Team to identify the possible alternatives. At this point in the process, the alternatives were defined at a high level, with enough detail to perform initial screening but without detailed analysis of risks and costs.

The next step was to perform an initial screening of the alternatives using the screening criteria identified in Step 2. If any of the alternatives did not meet the screening criteria, either the alternative was adjusted to add in the necessary capabilities or capacity, or the alternative was screened out from further consideration and documented as a non-viable alternative. No further analysis was conducted for alternatives that were screened out. The rationale for the screening decisions was documented, and is described further in section 5 and Appendix D.

Risk identification and evaluation included both threats and opportunities, hereby referred to as risks. For each alternative, the AoA Team rated every threat and opportunity using five-by-five matrices of likelihood versus consequence (impact or benefit).

LCCEs were developed for all viable alternatives. Cost estimates were prepared to conform to Class 5 as defined in the DOE cost estimating guide[c]. Notional project execution schedules were developed for each alternative and were used to demonstrate projected funding outlays through design, construction, startup, and turnover activities. Costs for operation and maintenance, system rehabilitation/replacement, initial repositioning of material, and end-of-life decommissioning were estimated over the intended useful life of the facility, and these time-phased costs were discounted in accordance with Office of Management and Budget guidelines to generate present value (PV) calculations that were used to compare the alternatives.

The AoA Team scored each alternative against the evaluation criteria. The rationale for scoring each alternative against each criterion is documented in this report.

The AoA Team performed a series of sensitivity analyses to confirm the validity of the final rank order of the alternatives. Specific focus areas included criteria importance weighting levels as well as cost factors and assumptions. The AoA Team performed multiple scenarios of the evaluation criteria weighting, including emphasizing or deemphasizing criteria by adjusting weighting, removing criteria that were found to not be differentiators between alternatives, and evaluating only TPC, project/technical and programmatic risks, and start of HLW treatment operations for viable alternatives under the constrained funding case.

The AoA Team developed this report and briefed the Steering Committee on the preliminary evaluation results, including the results of the sensitivity analyses. The analysis resulting from the Steering Committee meeting was updated. The AoA Team documented the analysis methodology, data, assumptions, and results, including sensitivity analyses and the results from the final Steering Committee briefing in this report.

2 Project Background

2.1 Introduction and Mission Need

The 586-square-mile Hanford Site is located along the Columbia River in southeastern Washington State. Beginning in the 1940s with the Manhattan Project, the Hanford Site played a pivotal role in the nation's defense with the construction and operation of nine nuclear reactors and five large plutonium-processing complexes. Today, the Hanford Site includes numerous former nuclear material production areas, active and closed research facilities, waste storage and disposal sites, and large areas of natural habitat and buffer zones. Under DOE direction, the Hanford Site workforce is engaged in the cleanup of contaminated facilities, groundwater, and soils resulting from national defense activities.

Hanford Site cleanup is overseen at DOE Headquarters by the Office of Environmental Management (EM) and is directed and implemented locally by two DOE field offices: the Richland Operations Office (RL) and ORP. ORP was established in response to Section 3139 of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 to manage the River Protection Project (RPP). This Act was extended through September 30, 2024, in the National Defense Authorization Act for Fiscal Year 2019, passed on January 3, 2018. The RPP includes the safe storage, retrieval, and treatment of tank wastes currently stored in the 200 Area tank farms; construction of a WTP to process and immobilize the tank waste and associated operations, maintenance, engineering, and construction activities.

The HLW mission need dates back to The Atomic Energy Act of 1954 and the DOE Organization Act of 1977, both which directed DOE and its predecessors to manage defense-related nuclear wastes. Consistent with that responsibility, and in accordance with Public Law 97-90, in June of 1983, the President submitted the Defense Waste Management Plan (DWMP) to Congress. The fundamental goal of the plan was to present interim storage practices for defense wastes and to provide for permanent disposal. To achieve this goal, the DWMP established, as an objective, that the HLW be immobilized and prepared for shipment to a geologic repository.

In 1987, DOE published a Justification for the New Start of the Hanford Waste Vitrification Plant (HWVP). The HWVP was established to achieve permanent disposal of Hanford defense wastes with safe, environmentally acceptable, and cost-effective disposal methods that meet applicable regulations. The objective of the HWVP was to immobilize pretreated waste in borosilicate glass, cast the glass into stainless steel canisters, and store the canisters at Hanford until they are shipped to a Federal geologic repository. The HWVP subsequently became known as WTP.

In 1989, DOE, U.S. Environmental Protection Agency (EPA), and State of Washington Department of Ecology (Ecology) entered into the Hanford Federal Facility Agreement and Consent Order, commonly referred to as the Tri-Party Agreement[xx], or TPA. Additionally, the Department of Ecology and DOE entered into a Consent Decree which includes milestones for tank retrievals as well as the construction and commissioning of facilities and the hot commissioning of the WTP.

The WTP Project is pivotal to the cleanup mission at Hanford, providing most hazardous and radioactive tank waste treatment and immobilization functions. The WTP is currently comprised of the following primary facilities:

- Low-Activity Waste (LAW) Vitrification Facility
- Analytical Laboratory
- HLW Vitrification Facility
- Pretreatment (PT) Facility.

The remaining WTP structures and facilities make up a facility grouping referred to as the Balance of Facilities (BOF), which includes an Effluent Management Facility (EMF) to support direct-feed LAW (DFLAW) processing.

The change in budget[d] associated with DFLAW modifications, including revised estimates for the LAW Facility, BOF, and Analytical Laboratory, results in an incremental WTP Project Performance Baseline of $16.813 billion. However, this Total Project Cost (TPC) does not include the updated re-baseline cost for completion of HLW and PT facilities, since the design of these two facilities was stopped in 2012 and resolution of the Defense Nuclear Facilities Safety Board (DNFSB) technical issues (TIs) were not addressed prior to stopping design. The revised incremental schedule

milestone[5] date to complete cold commissioning, an Operational Readiness Review, and receive approval to initiate hot commissioning of the LAW Facility is August 31, 2023, which is also being defined as Critical Decision (CD) 4a for the DFLAW project. This CD-4a date also defines the interim WTP Project CD-4 date to approve start of operations. The final WTP Project CD-4 milestone will be established to support integrated operations of all WTP facilities as part of a future incremental Performance Baseline update. The 2016 update to the plan[d] and the Performance Baseline only reflects incorporation of the DFLAW strategy and does not yet reflect Performance Baseline updates for completing the design, construction, and commissioning of the PT and HLW facilities.

DOE's integration of the WTP and Tank Farms projects is critical to ensuring successful startup, commissioning, and facility transition of the WTP. Primary goals of this integration are to create a single tank waste treatment system and to ensure efficient and consistent waste feed during the processing and immobilization of tank waste.

Project priority is currently given to DFLAW, while positioning the project to start HLW treatment and vitrification as design issues are resolved and funding is provided.

In late calendar year 2017, DOE started considering an option to continue preservation and maintenance of the PT and HLW facilities for a period of 3 to 5 years while DOE focused its efforts on implementing DFLAW operations. In March 2017, ORP asked the U.S. Army Corps of Engineers (USACE) to perform an initial parametric analysis of certain options and funding scenarios to evaluate the likelihood of achieving PT and HLW milestones[e]. The USACE report[f] showed the probability of achieving the PT and HLW milestones would be very low under the current funding profile. This report also estimated that the WTP TPC could be as high as $30 billion.

3 Requirements and Assumptions

3.1 Requirements

The AoA Team received information from ORP to identify and establish requirements and assumptions. Selected mission and program requirements statements were extracted from the documents to establish the high-level screening criteria that were required to be met to satisfy the mission need. These screening criteria were used during the initial screening of potential alternatives to determine whether an alternative is viable or non-viable. If an alternative was unable to meet one of these criteria it was deemed non-viable and not evaluated further. Screening criteria for the WTP HLW are detailed in Table 10.

Table 10: Alternative Screening Criteria

Criterion #	Screening Criteria Description	Source / Basis
1	Tank waste classified as HLW shall be immobilized by vitrification.	EPA treatment standard for HLW is defined as vitrification per 40 Code of Federal Regulations (CFR) 268.
2	The HLW processing system shall not preclude processing of LAW (either by DFLAW or via the PT Facility) in parallel with HLW processing.	TPA[xx] milestone M-062-00, Complete pretreatment processing and vitrification of Hanford High-level (HLW) and Low activity (LAW) Tank Wastes.
3	HLW processing alternatives shall use proven and established technologies.	DOE Order 413.3B Change 5 requires that critical technologies for Major System Acquisition (MSA) projects achieve Technical Readiness Level TRL-4 prior to CD-1 (Approve Alternative Selection and Cost Range). CD-1 marks the completion of the Project Definition phase and Conceptual Design. DOE Order 413.3B also requires that all critical technologies achieve TRL-7 prior to CD-2 (Approve Performance Baseline). Given the difficulty that DOE has had in resolving the TIs associated with the new tank mixing technologies for the WTP PT Facility, the AoA Team will not evaluate HLW processing alternatives that use critical technologies that have not been demonstrated for HLW processing.

[5] Schedule milestones indicate an important date in the life of the project/mission. This is not to be confused with an ACD milestone, which may have legally binding implications

Alternatives were screened against each criterion. If an alternative did not meet one or more of the screening criteria, the alternative was determined to be nonviable and was not evaluated any further.

3.2 Assumptions, Constraints, and Facts

Several key assumptions and one constraint are associated with the scope and content of the WTP HLW requirements. The AoA Team reviewed the assumptions and constraints in relevant documents (e.g., RPP Mission Analysis, RPP System Plan, WTP Program Requirements Document, WTP Project Execution Plan, etc.) and identified key assumptions and constraints below to support the WTP HLW AoA. More specific assumptions associated with the cost estimate for each alternative are included in the estimate assumptions in Appendix E.

- The immobilized HLW (IHLW) product must meet the requirements of the Waste Acceptance System Requirements Document and the Waste Acceptance Product Specification[j] for vitrified high-level waste forms.
- HLW feed processing alternatives must include the facilities and capabilities to process all tank waste that is classified as HLW and produce an HLW feed stream that will meet the HLW Vitrification specification.
- The HLW feed processing system will deliver waste in compositions, quantities, and rates sufficient to support HLW vitrification.
- Volume of HLW that will be provided to the DSTs used for feed staging and delivery to the treatment facilities is the same as described for the baseline in the RPP System Plan[cc].
- The cost estimates for HLW processing alternatives that require use of some, or all, of the planned WTP PT Facility or the HLW Vitrification Facility process capabilities will include the cost of facility modifications that are required to close the relevant DNFSB technical issues.
  - The activities that are needed to close the technical issues associated with the WTP, identified in the DNFSB Technical Report[g] issued October 12, 2017, are described in DOE's report on issues T-1 through T-8.
- The alternative cost and schedule estimates and risk analyses for each HLW processing alternative will include all elements directly related to HLW processing, as well as additional elements that differ from the baseline case.
  - The baseline case is consistent with "Scenario 1" as described in Revision 8 of the RPP System Plan.
  - The cost and schedule estimates for all HLW processing alternatives will include differences in construction and operating costs and schedules for the Hanford Site projects (including infrastructure) that support treatment.
  - Examples of differences in Tank Farm costs could include such factors as: changes in the schedule for tank waste retrieval, waste transfers, and processing operations; modifications to the DSTs selected for feed blending, characterization, and staging of HLW; and changes in waste transfer line configuration from the DST staging tanks to the HLW feed processing facility or to the HLW Vitrification Facility.
- The alternative cost and schedule estimates and risk analyses will include the activities necessary for permitting new HLW processing facilities that are not included in the baseline.
  - Permits are required for facilities that treat Resource Conservation and Recovery Act (RCRA) wastes.
  - Permits include Air Operating Permits and RCRA Permits based on requirements for treatment, storage, and disposal of hazardous wastes.
  - Permitting activities include preparation of permit applications, regulator review and approval of the permits, and certifications of readiness to operate.
- All HLW will be immobilized in a canister acceptable for shipment and disposal at an offsite geological repository.
- All IHLW will be shipped to an offsite geological repository, which will be available to receive shipments of IHLW no later than mid-2030s based on DOE planning assumptions.
  - Section A.1.5.3 (titled Interim Hanford Storage [IHS]) of Appendix A of the Rev 8 System Plan[cc] describes the required capabilities and capacity of the IHS.
  - The IHS is sized to store all IHLW produced until 2034.
- Cost estimates for the HLW processing alternatives will not include costs beyond IHLW placement at the IHS.
- New projects required for HLW feed processing will be managed in accordance with DOE Orders, Policies, and Directives.

- The HLW processing alternative evaluations will rely in part on the data outputs from the TOPSim flowsheet modeling[k] to be performed under direction of ORP.
  - The flowsheet modeling outputs for the HLW processing alternatives will provide the same data outputs as those described in the scenario analyses in the RPP System Plan[cc].
  - Unless otherwise specified, the assumptions used in the flowsheet modeling as described in RPP System Plan[cc] Appendix A (titled Model Starting Assumptions) are assumed to remain valid for the flowsheet modeling for the HLW processing alternatives.
- The cost and schedule estimates and risk analyses for the HLW processing alternatives will be based on both unconstrained and constrained annual funding levels for the WTP. Constrained case will consider an annual ORP operating budget of $2.5B (based on Steering Committee and ORP direction).

4 Alternatives

The AoA Team developed the initial set of alternatives during a series of meetings at the Hanford Site. The team iteratively brainstormed 17 potentially viable alternatives, which are summarized in Table 11. Additional details on alternatives that passed screening (Section 5) can be found in Appendices A and B.

Table 11: Potentially Viable Alternatives

#	Alternative Name	Alternative Description
1	HLW Characterization and Staging in New Tank Waste Characterization and Staging Facility (TWCSF) with HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)	HLW characterization and staging provided by new TWCSF; HLW feed from TWCSF is pretreated in PT Facility (Baseline Case); HLW effluents from PT Facility processes and from HLW Vitrification Facility are concentrated in PT Facility
2	HLW Pretreatment and Effluent Management in New HLW Feed Preparation and Effluent Management (HFPEM) Facility	HLW is received, characterization, and pretreated in HLW Feed Preparation Tanks in HLW Feed Preparation Facility (HFPF); pretreated HLW Feed is staged in HLW Feed Staging Tank in HFPF; dilute decants from HLW Feed Preparation Tanks and effluents from HLW Vitrification Facility are concentrated in new HLW Effluent Management Facility (HEMF).
3	HLW Feed Characterization in DST System and Pretreatment in New HFPF	HLW sampling, characterization, and staging occurs in DST system. HLW Feed Preparation Tanks in HFPF receives HLW feed from DST system and performs pretreatment functions (solid and liquid separation, leaching, washing, and concentration). Pretreated HLW feed is staged in HLW Feed Staging Tanks in HFPF; dilute decants from HLW Feed Preparation Tanks and effluents from HLW Vitrification Facility are concentrated in new HEMF
4	HLW Feed Characterization and Pretreatment (including High-Temperature Leaching) in New HFPF.	Same as Alternative 3, except that caustic leaching in the HLW Feed Preparation Tanks in HFPF is performed at a higher temperature 60°C (140°F).
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	HLW slurry from DSTs is transferred to HLW Feed Preparation Tanks in PT Facility; HLW feed leaching, washing, and concentration functions are accomplished by settling/decant in HFPF Feed Preparation Tanks; pretreated HLW feed is staged in HLW Feed Staging Tank in PT Facility; dilute decants from HLW Feed Preparation Tanks and effluents from HLW Vitrification Facility are concentrated in PT Facility.
6	Use New Technologies to Immobilize HLW	Use alternative technologies, such as grouting or steam reforming. Would require technology development, research and development, laboratory testing, and technology readiness assessment, as required.
7	Immobilize HLW In-Situ (within DSTs)	Use alternative technologies to immobilize HLW within existing DSTs. Would require technology development, research and development, laboratory testing, and technology readiness assessment.
8	Pretreat and Treat West Area HLW in New West Area Facilities	HLW slurry from SY Tank Farm DST is transferred to West Area HFPF; HLW feed leaching, washing, and concentration functions are accomplished by settling/decant in West Area HFPF Feed Preparation Tanks; pretreated HLW feed is staged in West Area HFPF Feed Tanks. Pretreated HLW feed is vitrified in new West Areas Vitrification Facility; HLW Facility effluents and dilute decants from Feed Preparation Tanks are concentrated in New West Area HEMF.

#	Alternative Name	Alternative Description
9	Pretreat HLW Feed in New HFPF and Repurpose PT Facility for LAW Pretreatment and Effluent Management	HLW slurry from DSTs is transferred to HLW Preparation Tanks in HFPF; HFPF pretreats and stages HLW feed - same as Alternative 2; dilute decants from Feed Preparation Tanks are collected in Plant and Wash Disposal (PWD) system and concentrated in Feed Evaporation Process (FEP) system, and concentrated decants are returned to DSTs; pretreated HLW feed is vitrified in HLW Facility; PWD system collects HLW Facility effluents and FEP evaporator concentrates effluents; supernate from DSTs is transferred to LAW Feed Receipt Vessels in PT Facility; PT Facility removes solids and cesium and concentrates and stages LAW feed; effluents from LAW Facility are collected in Treated Low-Activity Waste Evaporation Process (TLP) system and concentrated in TLP evaporator; pretreated LAW feed is vitrified in LAW Facility.
10	Shipment of HLW Off Site for Treatment (e.g., Savannah River Site [SRS])	HLW would be transferred to compliant mediums for transfer to SRS for treatment and vitrification.
11	Repurpose Fuels Material Examination Facility (FMEF) to Provide HLW Pretreatment Capabilities	FMEF would be retrofitted to provide pretreatment capabilities. Pretreated HLW from repurposed FMEF would be transferred or transported to HLW Vitrification Facility for immobilization.
12	Repurpose PT Facility for HLW Processing and Vitrification	HLW Vitrification Facility would be abandoned. PT Facility pretreats and vitrifies HLW.
13	HLW Bulk Vitrification	HLW would be retrieved from DSTs and pretreated and vitrified at a near-tank mobile facility or in a centrally located facility. Bulk vitrification would require technology development, research and development, laboratory testing, and technology readiness assessment.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	Same as Alternative 3 with added capability to filter decants from HLW Feed Preparation Tanks in HFPF.
15	Direct Feed HLW (DFHLW) from DSTs and Effluent Management in New HEMF	Sludge is leached, washed, and concentrated in DST system and is transferred directly to Melter Feed Tanks in HLW Facility via new Jumper Pits; transfer line flush water and HLW Facility effluents are routed to Evaporator Feed Tanks in HEMF; HEMF concentrates flush water and effluents from HLW Vitrification Facility.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	Same as Alternative 15, except that HLW from DST system is concentrated in HLW Feed Concentration Tanks in HEMF Drain Tank Vault prior to delivery to the HLW Vitrification Facility.
17	DFHLW from DSTs without HLW Effluent Management	HLW feed is sampled, characterized, and pretreated (limited to solids washing) in a designated DFHLW Feed Pretreatment Tank in the DST system (AP-101). The pretreated HLW feed is then transferred to a designated DFHLW Feed Tank (AP-102) to be staged for delivery to the HLW Vitrification Facility via a new Waste Treatment Vault (WTV).

5 Screening of Alternatives

The AoA Team performed an initial screening of the 17 alternatives against the three screening criteria. The screening resulted in either a rating of "Yes" (meaning that the alternative fully met a criterion) or a rating of "No" (meaning that the alternative did not fully meet a criterion). Table 12 summarizes the initial results of the alternatives screening. If an alternative has a single "No" score, the summary shows a "No." Appendix D further describes the screening criteria, process performed, screening rationale.

Table 12: Initial Screening Results

Criterion #	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Tank waste classified as HLW shall be immobilized by vitrification.	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	The HLW processing system shall not preclude processing of LAW (either by Direct Feed LAW (DFLAW) or via the PT Facility) in parallel with HLW processing.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	HLW processing alternatives shall use proven and established technologies.	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	Y
	Summary Conclusion	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	N	Y	Y	Y	Y

Alternatives 6, 7, 10, 11, and 13 failed to pass initial screening, and were not evaluated further. Alternative 6 (use alternative technologies to immobilize waste) failed to pass Screening Criterion 1, which requires vitrification. Alternatives 7, 10, 11, and 13 failed Screening Criterion 3, since the technology required for those alternatives is not sufficiently mature.

After initial screening during alternative definition and evaluation, Alternatives 3, 4, 8, 9, and 12 were further screened in coordination with, and approval by, the Steering Committee. Appendix D has further details on these alternatives' descriptions and rationale for subsequent screening. Brief rationales are below:

Alternative 3

Alternative 3 is functionally equivalent to Alternative 2 aside from characterizing HLW feed in the DST system. Since assigning the HLW characterization function to the DST system did not provide any discernable cost or schedule benefit, Alternative 3 was determined to be indistinguishable from Alternative 2 from a technical standpoint. The Steering Committee agreed, and further evaluation of Alternative 3 was discontinued.

Alternative 4

Alternative 4 was developed to improve the efficiency of the HLW melters by using a more robust (i.e., higher temperature) leaching process for the HLW feed. Further evaluation by Washington River Protection Solutions (WRPS) determined that increasing the leaching temperature from 60°C (140°F) (temperature used for HLW leaching in Alternatives 1 and 2) to 82°C (180°F) as proposed for Alternative 4 had minimal effect on melter efficiency. Additionally, the PT Facility Standard High-Solids Vessel (SHSV) Concept Design Alternative Study[o] determined that leaching temperatures should be limited to 60°C (140°F) to reduce the hydrogen generation rate, risk of stress corrosion cracking, and thermal stresses on the vessels and equipment. Considering the risks involved in high temperature leaching and the fact that using this process did not appreciably improve HLW melter performance, Alternative 4 was eliminated.

Alternative 8

The "in-can melter" and "transportable vitrification system" technologies were tested at pilot-scale on surrogate materials selected to be representative of waste remediation and decontamination and decommissioning (D&D) solid and liquid wastes. The pilot-scale testing did not achieve all test objectives. Also, since the pilot-scale tests only used surrogates for

mixed waste and low-activity D&D waste, the results were not considered to be directly relevant to HLW in the Hanford Tank Farms.

Based on the lack of any relevant technology demonstration test data, the ECMS and Government AoA Teams determined that Alternative 8 did not meet Screening Criterion 3 which requires that "the HLW processing alternatives use proven and established technologies." Since none of the vitrification technologies were tested with surrogates that were representative of HLW from the Hanford Tank Farms, the technologies cannot be considered "proven and established."

Alternative 9

The Alternative 9 evaluation process relies on the results of the process modeling performed by WRPS. To complete the AoA evaluation per the Study Plan schedule, the Alternative 9 modeling results were needed in January 2020. WRPS could not complete modeling of all HLW processing alternatives being considered in this timeframe. The ECMS and Government AoA Teams reviewed the alternatives under consideration in the late 2019 timeframe to reassess their viability based on technical or cost considerations.

During this review, Alternative 9 was determined to be non-viable from a cost perspective since it would require completing the PT Facility and construction of a new HFPF in parallel. Given the cost constraints on the ORP budget, completion of both projects would significantly delay the start of HLW treatment. Alternative 9 evaluation was therefore discontinued at that time.

Alternative 12

Based on the limited PT Facility space available to house the new HLW pretreatment vessels and the HLW melters and the limited maintenance access to the Hot Cell, the AoA Team concluded that this alternative was not viable due to the space/fit issues. Additionally, since construction of the HLW Vitrification Facility was considered 43% complete by ORP, the cost to complete the remaining construction was judged to be less than the cost to install HLW melters in the PT Facility.

6 Alternative Summary Descriptions

The AoA Team developed detailed scope descriptions for each alternative, which are described in more detail in Appendix A. Brief scope descriptions for each viable alternative are also included below.

Alternative 1: HLW Characterization and Staging in New TWCSF with HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)

In Alternative 1, HLW sludge from the DST system is sampled, characterized, and staged in a new TWCSF. The PT Facility pretreats the HLW feed received from the TWCSF (note that this represents a modification to the baseline and assumes the PT Facility is modified to address the DNFSB TIs[o]). The pretreated slurry from the PT Facility is sent to the HLW Vitrification Facility to be vitrified.

Alternative 2: HLW Pretreatment and Effluent Management in New HFPEM Facility

In Alternative 2, HLW sludge is staged in the DST system, and a HLW slurry is subsequently transferred to a new HFPEM Facility where it is sampled, characterized, and pretreated in HLW Feed Preparation Vessels (HFPVs). The pretreated HLW feed is staged in an HLW Feed Vessel (HFV) located in an HLW Feed Preparation (HFP) Vault. The HFPEM Facility design (including preconceptual drawings) and the associated support structures, systems, and components (SSCs) are described in more detail in Appendix B.

Alternative 5: HLW Pretreatment and Effluent Management in Repurposed PT Facility

In Alternative 5, the PT Facility is repurposed for HLW pretreatment and effluent management functions as described in Appendix B. New HFPVs, Filter Feed Vessels (FFVs), and HFVs will be installed in PT Facility Planning Areas 3 and 4 in cells previously designated as "Dark Cells." The cells will be modified to provide access through removeable roof covers to allow removal/replacement of tank equipment by external cranes. To limit the size of the pretreatment process vessels that would need to be installed in the Repurposed PT Facility, Alternative 5 relies on the DST system to characterize the HLW feed and adds the capability to filter the decanted liquids removed during the pretreatment process. These flowsheet changes allow shorter pretreatment cycle times which in turn allow for a reduction in the pretreatment tank sizes.

Alternative 14: HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility

In Alternative 14, HLW sludge is staged and characterized in the DST system. The HLW feed is transferred to a new HFPEM Facility (described in Appendix B) to be pretreated and staged for delivery to the HLW Vitrification Facility. The HLW pretreatment functions and capacities are like those for Alternative 5. As in Alternative 5, adding the capability to filter decants allows a reduction in the settling time which results in a significant reduction in the HLW feed pretreatment cycle time. By sampling and characterizing the HLW feed in the DST system and reducing the pretreatment cycle time, the capacity of the HLW pretreatment tanks was reduced from that which was required for Alternative 2.

Alternative 15: DFHLW from DSTs and Effluent Management in New HEMF

In Alternative 15, HLW feed is staged, characterized and pretreated in the DST system. The pretreated HLW slurry is transferred directly to HLW Vitrification Facility. This HLW feed delivery approach is referred to as DFHLW.

Long-term DFHLW operations place a higher demand on the 242-A Evaporator since the supernate decanted from the HLW Feed Preparation DSTs must be accommodated within the DST system. To partially mitigate the adverse effect on the 242-A Evaporator duty cycle and on the space margin within the DST system, Alternative 15 includes a new HEMF to concentrate the HLW liquid effluents from the HLW Vitrification Facility.

Alternative 16: DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF

In Alternative 16, the HLW feed staging, characterization, and pretreatment operations are performed in the DST system in the same manner as Alternative 15. After pretreatment in the DST system, the pretreated slurry is transferred to a Settling Vessel in an HLW Slurry Vault in the HEMF. The pretreated slurry is concentrated in this vessel by settling and decant operations. After concentrating the pretreated slurry to 15 weight percent (wt %), the slurry is sent to an HLW Feed Vessel where it is staged for delivery to the HLW Vitrification Facility.

The HEMF for Alternative 16 provides the same capabilities for collecting liquid effluents and flush water from waste transfer lines as Alternative 15. These liquids are collected in an Effluent Collection Vessel in the HEMF Waste Transfer Pit. For Alternative 16, the HLW evaporator in the HEMF Process Building concentrates the decanted supernate from the Slurry Settling Vessel and the secondary liquid waste in the Effluent Collection Vessel. The HLW evaporator process operations for Alternative 16 are the same as for Alternative 15.

Alternative 17: DFHLW from DSTs without HLW Effluent Management

Alternative 17 provides HLW pretreatment and treatment capabilities with the lowest possible capital investment. HLW feed is sampled, characterized, and pretreated (limited to solids washing) in a designated DFHLW Feed Pretreatment Tank in the DST system (AP-101). The pretreated HLW feed is then transferred to a designated DFHLW Feed Tank (AP-102) to be staged for delivery to the HLW Vitrification Facility via a new WTV. The WTV pre-conceptual design is described in Appendix B. The slurry in AP-102 is transferred to an HFV in the WTV. The WTV is located near the HLW Vitrification Facility to facilitate waste transfer line connections. The HFV transfers the slurry to the HLW Vitrification Facility in a recirculating loop. An Effluent Collection Vessel in the WTV receives liquid effluents and waste transfer line

flush water drainage from the HLW Vitrification Facility. The Effluent Collection Vessel contents are transferred to the DST system (AP-103).

Since Alternative 17 does not provide new HLW effluent management capabilities, the 242-A evaporator is used to concentrate the effluents received from the Effluent Collection Vessel. The chemical and water additions used for solids washing in the DST system also will need to be concentrated in the 242-A evaporator to make space available in the DST system to continue to prepare HLW (and LAW) feed, receive the HLW Vitrification Facility liquid effluents, and receive waste from single-shell tank (SST) retrievals.

HLW processing continues using the DFHLW approach through completion of the HLW and LAW processing mission. No additional HLW processing capabilities are added after starting processing using the DFHLW approach for Alternative 17.

The new WTV Facility and Tank Farm upgrades that will be required for Alternative 17 provide features that will facilitate the later addition of new facilities and capabilities. Spare transfer line nozzles, valving, and jumpers will be provided in the WTV Facility to facilitate routing to and from future pretreatment or effluent management facilities.

The HLW Vitrification Facility will operate with one melter in service. Except for the limitation on HLW feed availability, the HLW Vitrification Facility is assumed to operate in the same manner as assumed for all other alternatives.

LAW pretreatment is limited to filtration and cesium removal by the Tank-Side Cesium Removal (TSCR) and/or Tank Farm Pretreatment (TFPT) facilities. Since the LAW Feed Evaporator (LFE) is not provided, the dilute pretreated LAW feed is sent to the LAW Vitrification Facility.

7 Evaluation Criteria

7.1 Evaluation Process

The AoA Team facilitated group discussions to develop the evaluation criteria to be used in determining the effectiveness of each alternative in meeting the mission need. The criteria that were developed are statements that reflect the desired attributes of the program and directly support the requirements. Table 13 describes the evaluation criteria developed collaboratively by the team.

Table 13: Evaluation Criteria Descriptions

#	Evaluation Criteria	Description
EC-1	Alternative allows for earlier completion of high-level waste (HLW) Vitrification Facility hot Cx	Parametric methodology will be used to estimate time required to design, permit, construct, and commission new HLW processing facilities. As appropriate, current baseline Waste Treatment and Immobilization Plant (WTP) schedules will be used to determine time required to complete construction, facility modifications, and commissioning of WTP facilities needed for HLW processing. Critical path analysis will determine earliest date for starting hot operations of the HLW Vitrification Facility.
EC-2	Lower HLW project Total Project Cost (TPC) range	Parametric methodology will be used to estimate capital cost to design, permit, construct, and commission all new HLW processing and support facilities required for each alternative. As appropriate, current baseline WTP capital cost estimates may be used to inform these parametric estimates. Appropriate TPC ranges will be provided for each alternative, reflective of alternative-specific risks and uncertainties. Since the same ranges will be applied to all alternatives, the point estimates will be used to evaluate this criterion.
EC-3	Lower operational, technical, and programmatic risk	The level of operational, technical, and programmatic risks will be determined as part of the analysis of alternatives (AoA) risk analysis process.
EC-4	Lower HLW processing Life Cycle Cost (LCC) (Present Value [PV] range)	Total LCC for each alternative will be estimated, including, permitting, construction, operating, and decontamination and decommissioning (D&D) phases. As appropriate, current baseline LCC data and System Plan 8 estimates, together with facility operating schedules (see notes for criteria #1 and #2), will be used to estimate operating costs for all facilities needed for HLW processing. PV of LCC will be calculated using current Office of Management and Budget (OMB) discount rate and the calculated PV will be presented as a range, incorporating appropriate risk and uncertainty determinations.

#	Evaluation Criteria	Description
EC-5	Alternative allows for earlier completion of HLW treatment	AoA Team will specify HLW processing operations and sequence of operations for each alternative. Washington River Protection Solutions (WRPS) modeling (Office of River Protection [ORP] scope) will determine tank retrieval sequencing and HLW and low-activity waste (LAW) processing rates and durations for each alternative. These durations, together with the schedule date for starting hot operations of the HLW Vitrification Facility (see notes for criteria #1), will determine the date for completion of HLW (and LAW) treatment.
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	WRPS flowsheet modeling will determine the double-shell tank (DST) volumes and free space over time. Modeling results will also provide data on the number of required evaporator runs, waste transfers, and availability of other Tank Farm facilities and infrastructure that may be needed to recover from tanks leaks or other single point failures (e.g., 242-A Evaporator and waste transfer lines).
EC-7	Fewer IHLW canisters produced	WRPS flowsheet modeling will provide data on the number of IHLW canisters produced over time.
EC-8	Lower volume of Immobilized high-level waste (ILAW) generated by HLW processing	WRPS flowsheet modeling will provide data on the volume of secondary LAW that is produced by HLW processing operations over time.
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	WRPS flowsheet modeling will provide data on the volume of secondary low-level waste (LLW) that is produced by HLW processing operations over time.

The AoA Team assigned a level of importance (highest importance, very important, medium importance, or lowest importance) for individual criteria. Each level of importance corresponds to a weighting factor to support the evaluation of alternatives. Table 14 shows the weighting factors used. This weighting scale adds greater emphasis to the highest importance criteria. Each weighting factor is used to establish relative weights and normalized relative weights (NRWs).

Table 14: Evaluation Criteria Importance and Weighting Factors

Evaluation Criteria Importance	Weighting Factor
Highest importance (borders on a requirement)	5
Very important (highly desirable)	3
Medium importance (desirable)	2
Lowest importance	1

After discussing the weighting factors that would be used, the Team discussed the relative importance of each criterion. Through discussion and Steering Committee input, the team was able to come to consensus on the importance rankings. The full list of criteria, their importance rankings, and rationale for those rankings are shown in Table 15.

Table 15: Evaluation Criteria Rationale

#	Evaluation Criteria	Importance	Rationale for Ranking
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot Cx	Highest Importance	The Consent Decree has facility and process start schedules that are mandated through a Federal Court. Maximizing the probability of meeting the Consent Decree milestone for hot operations is of highest importance to show progress to stakeholders and gain acceptance of path forward.
EC-2	Lower HLW project TPC range	Highest Importance	TPC has been the key reason the project could not proceed because it is cost/funding prohibitive. The reduction of cost to support HLW design and construction completion is of highest importance.
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	Minimizing current and future risk is of highest importance based on experience and maximizing the probability of meeting Consent Decree milestones for HLW. Minimizing risk increases stakeholder support and ensures sustained funding and the ability to accomplish the mission in a timely manner.

#	Evaluation Criteria	Importance	Rationale for Ranking
EC-4	Lower HLW processing LCC (PV range)	Very Important	Operating costs are an important part of selecting an alternative that is affordable and can be implemented within funding constraints. Costly options cannot be funded or executed but are slightly less important than near-term design and construction costs (TPC).
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	Reducing the HLW completion time reduces the environmental liability. While related to LCCs, completion of HLW treatment is somewhat less important than the LCC.
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	It is important to consider the reliability and availability of the HLW feed stream and its impact on HLW treatment operations; however, the current focus should be the initial capability to provide feed to WTP. Operations will need flexibility to complete the mission. Important to have consistency for delivering waste because it impacts the treatment process.
EC-7	Fewer IHLW canisters produced	Lowest Importance	Reasonable waste loading is preferred; however, a few more HLW canisters will not substantially impact the mission. The number of canisters produced was conservatively estimated for the IHLW storage capability. Minimizing canister count through glass loading is important but less important than cost, schedule, and risk.
EC-8	Lower volume of ILAW generated by HLW processing	Lowest Importance	Processing of HLW needs to consider impacts to the LAW mission and capacity. Retrievals are required and DST space is limited; understanding the relationship minimizes inefficiencies. While important, can be optimized through system design.
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	Generation and processing of secondary waste is important. The current system has a potential capacity issue, and additional capacity for the secondary waste processing facilities is challenging. However, solutions may exist for secondary waste. While important, secondary waste generation and processing can be optimized through system design.

To calculate a weighted score for each criterion, the AoA Team normalized the weighting based on the total number of criteria. To illustrate this calculation, the first step is to establish a relative weight by taking the weight (5, 3, 2, or 1) associated with the importance level and dividing it by the total number of attributes.

The next step is to normalize these relative weights by standardizing these weights to a scale of 100. This was accomplished by dividing the numerical weight value by the total number of criteria to come up with a relative weight. Then the relative weight for each attribute was multiplied by 100 and divided by the total sum of all relative weights.

Calculating the normalized relative weight provides a consistent basis from which all subsequent alternative scores were compared by converting them to a 0-to-100 grading scale, with 0 being the lowest possible score and 100 being the highest possible score.

Changing the criteria after identifying alternatives and subsequent scoring presents challenges to maintaining the integrity of the AoA process in not predefining a desired outcome. Thus, it is necessary to gain concurrence on the evaluation criteria in advance of alternative development. This was done via approval of the Study Plan.

Sensitivity analyses were also used to determine the impact of the importance ratings on the overall evaluation. This process is described in more detail in Section 9.3.

7.2 Evaluation Weightings

The evaluation criteria that were developed by the AoA Team, along with importance factors and resulting relative weightings, are shown in Table 16 and Table 17 for the unconstrained and constrained cases, respectively.

Table 16: Evaluation Criteria – Unconstrained Case

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot Cx	Highest Importance	5	0.556	20.0
EC-2	Lower HLW project TPC range	Highest Importance	5	0.556	20.0
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.556	20.0
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Very Important	3	0.333	12.0
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	2	0.222	8.0
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	2	0.222	8.0
EC-7	Fewer IHLW canisters produced	Lowest Importance	1	0.111	4.0
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Lowest Importance	1	0.111	4.0
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.111	4.0

Table 17: Evaluation Criteria – Constrained Case

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot Cx	Highest Importance	5	0.333	33.3
EC-2	Lower HLW project TPC range	Highest Importance	5	0.333	33.3
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.333	33.3

8 Cost and Schedule Estimates

Capital Cost estimates and LCCEs were developed for each of the viable WTP HLW alternatives that passed the screening. The LCCs include all upfront construction costs, operations, maintenance, periodic upgrades, and end-of-life D&D, including appropriate escalation allowances. The capital cost estimates and LCCEs are only intended to support the WTP HLW AoA for the purpose of comparing each alternative's LCC and are not to be considered budget quality estimates.

The LCCEs used to evaluate the HLW alternatives are based on and derived from the WRPS modeling results and resultant cost and schedule estimates generated by WRPS. The AoA Team used those results, added appropriate work breakdown structure elements not included in the WRPS models (in particular, the completion of the design, procurement, construction, and commissioning activities for all elements of the WTP project), and made adjustments, where appropriate, which are described in Appendix E. The bases and assumptions used for the WRPS modeling efforts are described in a separate report[k].

The AoA Team bases and assumptions used for the LCCEs and the calculations of PV for each alternative are described in Appendix E. Appendix H also discusses how these estimates were developed in accordance with the best practices for developing and managing capital program costs found in the U.S. Government Accountability Office (GAO) Cost Estimating and Assessment Guide[h].

The estimated costs for each of the viable WTP HLW alternatives were developed in accordance with the alternative-specific summary level project development and operational schedules depicted in Appendix C. The project schedules for each alternative vary based on the scope required and may be accelerated or extended depending on the final acquisition strategy chosen for the project.

8.1 Cost Estimates – Unconstrained Funding

The AoA evaluated two funding cases, unconstrained and constrained. When evaluating the LCCs for each alternative, the unconstrained case assumed that all necessary funding was available to the project to complete the HLW mission. The constrained case assumed annual funding for ORP would increase to $2.5 billion per year (based on Steering Committee and ORP direction), beginning in FY 2024 after DFLAW operations are started. The WTP HLW AoA unconstrained cost estimate results are summarized in Table 18. Table 19 provides a further breakdown of the capital projects for each alternative, showing the estimated cost to complete the WTP facilities needed for the alternative separate from the various other alternative-specific projects that are included for each alternative.

Note that the TPC values shown in both Table 18 and

#	Alternative Name	WTP Completion ($B)	Other Alternative Specific Capital Projects ($B)	Total TPC ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	20.0	18.0	38.0
2	HLW Pretreatment in HLW Feed Preparation Facility (HFPF)	9.6	31.4	41.0
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	17.7	21.6	39.3
14	New HFPF (with Filtration) and New HEMF	9.6	24.3	33.9
15	Direct Feed HLW (DFHLW) and HLW Effluent Processing in New HLW EMF	9.6	25.6	35.2
16	HLW Pretreatment in DSTs and in Feed Prep Tanks in New HEMF	9.6	26.0	35.6
17	DFHLW Single Melter HLW Without Evaporators or LAWST	8.8	0.2	9.0

include only those facilities unique or different for each Alternative and exclude those ancillary and supporting elements common to all alternatives to facilitate the alternative evaluations, as described in Section 6. However, those other project costs are included in the LCC, as are the operating costs and end-of-life D&D costs for all alternatives. Under unconstrained funding (Table 18), the TPC includes both a LAWST Facility and new ETF.

Table 18: LCC Summary – Unconstrained Funding

#	Alternative Name	TPC ($B)	LCC ($B)	PV ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	38.0	341	151
2	HLW Pretreatment in HFPF	41.0	215	125
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	39.3	217	123
14	New HFPF (with Filtration) and New HEMF	33.9	212	119
15	DFHLW and HLW Effluent Processing in New HEMF	35.2	214	121
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	35.6	213	121
17	DFHLW Single Melter HLW Without Evaporators or LAW Supplemental Treatment (LAWST) Facility	9.0	5,099	423

Table 19: TPC Summary – Unconstrained Funding

#	Alternative Name	WTP Completion ($B)	Other Alternative Specific Capital Projects ($B)[6]	Total TPC ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	20.0	18.0	38.0
2	HLW Pretreatment in HLW Feed Preparation Facility (HFPF)	9.6	31.4	41.0
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	17.7	21.6	39.3
14	New HFPF (with Filtration) and New HEMF	9.6	24.3	33.9
15	Direct Feed HLW (DFHLW) and HLW Effluent Processing in New HLW EMF	9.6	25.6	35.2
16	HLW Pretreatment in DSTs and in Feed Prep Tanks in New HEMF	9.6	26.0	35.6
17	DFHLW Single Melter HLW Without Evaporators or LAWST	8.8	0.2	9.0

8.2 Constrained Funding Analysis

The WRPS modeling effort and resultant schedule and cost estimate assumes unconstrained funding, as do the additions made by the AoA Team for completion of the WTP project. It is assumed DOE will meet the Amended Consent Decree milestones and begin HLW processing operations in FY 2034 for all alternatives under this scenario. Thus, all facilities needed to support the HLW mission, as identified for each HLW alternative being evaluated, must also be completed to support the HLW processing schedule. Additionally, the WRPS modeling assumes that a LAWST Facility is also operational at that same time and sized such that LAW and HLW processing are completed on the same overall mission schedule duration for each alternative.

The resultant annual funding requirements needed over the next 30 years to support this unconstrained funding schedule scenario and associated LCCE for each alternative are shown in Figure 3.

[6] Includes, as appropriate to alternative, TWCSF, HFPEM, HEMF, WTV, LFE, additional ETF, and LAWST Facilities.

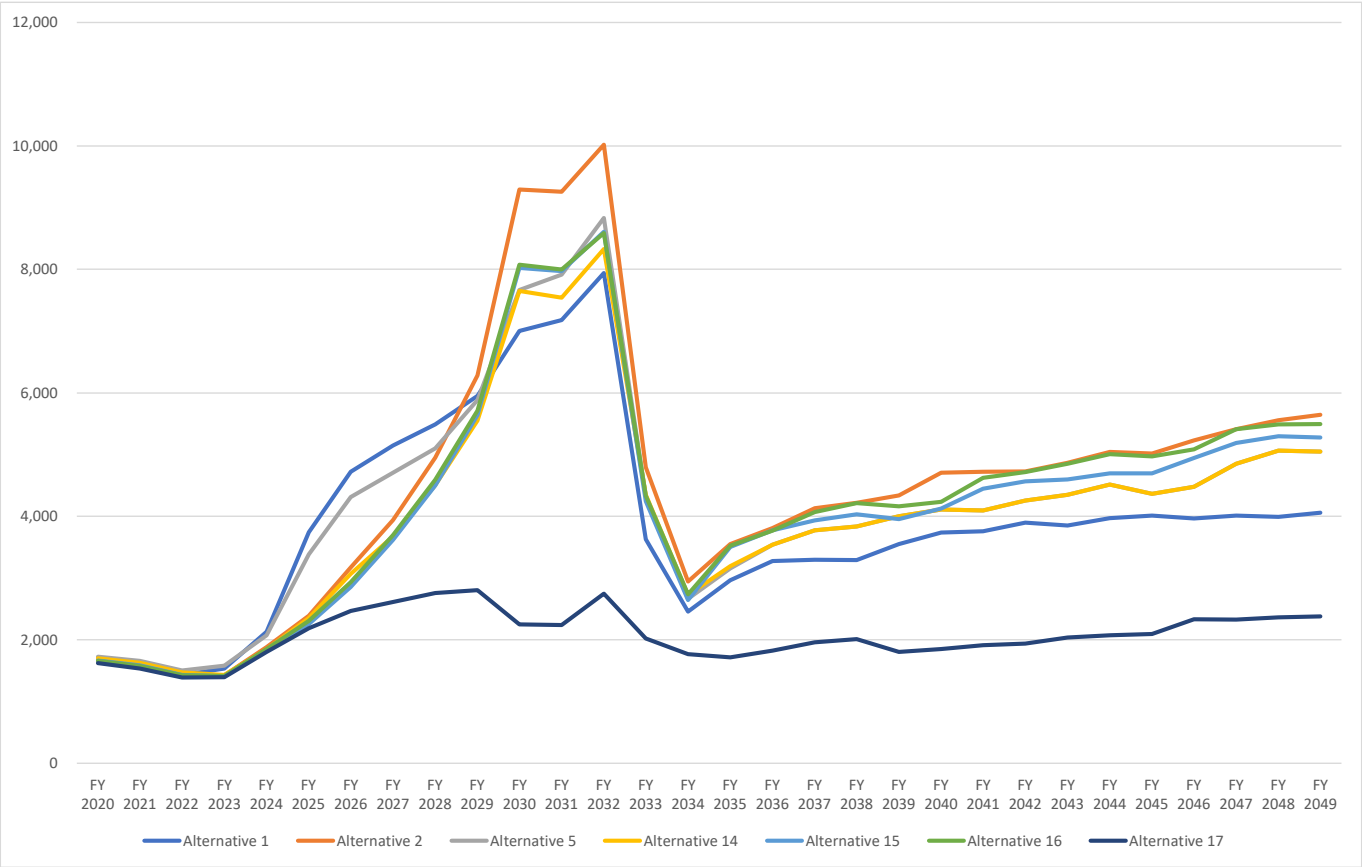

Figure 3: Annual Funding ($M) - Unconstrained Case

As can be seen in Figure 3, the annual requirements for all alternatives require far more than the current ORP funding level of approximately $1.5 billion per year. To support evaluation of the alternatives under a more realistic funding scenario, the AoA Team was directed to analyze the impact of an annual funding cap of $2.5B for all ORP activities and projects. It was assumed this level of funding could begin in FY 2024 after DFLAW operations commence, and that this level remains constant indefinitely thereafter.

The constrained funding analysis was done from a spreadsheet perspective. As a result, the analysis only identifies expenditures in FY increments and does not provide specific dates (day or month) for accomplishing the key milestones discussed below.

The analysis focused on completion of the HLW Vitrification Facility and supporting facilities needed to begin HLW operations. The supporting facilities include those Tank Farm upgrades and infrastructure projects common to all alternatives, such as Waste Retrieval Facilities, Cross-Site Waste Transfer System, 242-A Evaporator, and other Tank Farm upgrades. In addition, the pretreatment and feed staging facilities unique to each alternative, and an LFE when applicable, are prioritized over the expected duration of the HLW Vitrification Facility construction.

To accommodate the constrained funding assumption, construction and operation of a LAWST Facility and a new ETF were assumed to be deferred for all alternatives (except Alternative 17 that does not include a LAWST Facility). Because construction of the LAWST Facility is deferred for those alternatives, the LAW pretreatment rate is limited to the capacity of the LAW Vitrification Facility. Based on this, the TSCR capacity and cost profile (capital and operating costs) for each alternative were adjusted to be the same as those elements within the WRPS cost model for Alternative 17.

The results of the analysis are summarized in Table 20, and the assumptions and results for each alternative are discussed in Appendix E.

Table 20: Constrained Funding Analysis Results Comparison ($2.5B Annual Cap)

Alternative	Start of HLW Operations[7]	HSF/IHS Completion[8]	Year Annual Costs Begin to Exceed Cap[9]	Unused Funding ($B)[10]	% of LAWST Capital Cost[11]
1	Facility Not Completed	Facility Not Completed	FY 2054	N/A	0%
2	FY 2036	FY 2040	FY 2041	$0.7	2%
5	Facility Not Completed	Facility Not Completed	FY 2044	N/A	0%
14	FY 2036	FY 2040	FY 2043	$1.5	5%
15	FY 2035	FY 2037	FY 2042	$2.8	8%
16	FY 2035	FY 2039	FY 2041	$2.1	6%
17	FY 2034	FY 2033	FY 2052	$10.5	N/A

Under this constrained funding scenario, it will not be possible to build and operate a LAWST Facility as assumed for the WRPS process model due to the funding limitations that will exist, thus it is not possible to predict the duration of the LAW and HLW treatment mission, or to estimate the alternative life-cycle costs, without additional process modeling efforts. For alternative evaluation purposes, the TPC evaluation also excludes the LAWST Facility and new ETF, since there would not be adequate funding available for those projects. The resultant TPC values for each alternative are shown in Table 21. This includes only those facilities needed for HLW processing operations that are unique for each alternative (TWCSF, HFPEM Facility, HEMF, WTV Facility, LFE Facility, HLW Vitrification Facility).

Table 21: Alternative TPC Summary for $2.5B Annual Cap

Alternative	TWCSF/HFPEM/ HEMF/WTV ($B)	LFE ($B)	HLW/PT Completion ($B)	TPC of Projects Needed ($B)
1	1.4	N/A	Not Completed	N/A
2	2.2	0.6	10.0	12.8
5	N/A	N/A	Not Completed	N/A
14	2.1	0.5	10.0	12.6
15	1.2	0.6	9.7	11.5
16	1.5	0.6	9.7	11.8
17	0.2	N/A	8.7	8.9

The constrained funding analysis summarized above and described in more detail in Appendix E has concluded that Alternatives 1 and 5 are not viable under the prescribed scenario since the available funding is insufficient to enable completion of the HLW Vitrification and PT Facilities. Furthermore, it should be noted that this analysis is based on the AoA point estimates for both project and operations costs. If the high end of the uncertainty range for those costs is realized, this analysis indicates that perhaps only Alternative 17 can be considered possible for implementation under a $2.5B annual funding cap, and even Alternative 17 could be very challenging to implement.

[7] HLW operations are assumed to start in the year following completion of HLW construction and commissioning.
[8] This is the year Hanford Shipping Facility (HSF) and Interim Hanford Storage (IHS) Facility can be completed based on available funding. If this is later than the year when HLW operations start, there may be possible to do some type of phased construction (i.e., completing construction of a single storage vault in the IHS) to accommodate the HLW canisters being produced immediately after starting HLW treatment operations. However, given the limited IHLW interim storage capability within the HLW Vitrification Facility, a delay in completing the IHS would result in delaying the start of full capacity HLW treatment operations.
[9] Annual costs do not include any costs to construct and operate either a LAWST Facility or a new ETF.
[10] This is the total of unused funding through the year before annual costs begin to exceed the annual cap.
[11] This percentage represents a comparison of Unused Funding to the estimated capital cost for the LAWST Facility assumed/used for the WRPS modeling, escalated to the year when the Unused Funding total occurs (at 4%/year). Note that funding would also need to be used to construct the additional ETF needed for each alternative as well, and costs for LAWST will continue to escalate over the period needed to construct that facility.

8.3 Cost Ranges

The estimates used for the HLW alternative LCCEs are all considered Association for the Advancement of Cost Engineering (AACE) International Class 5 estimates. Class 5 estimates have an expected accuracy low range of -20%/-50% to +30%/+100%. Due to the varying level of information available, the AoA Team used different low- and high-end ranges for the capital projects and operational activities.

For the purposes of the AoA, it is assumed that the operational activities have a somewhat narrower uncertainty range since those activities are generally staff-based and level of effort in terms of the annual expenditures expected. Of course, there is still a great deal of uncertainty as to overall duration that is dependent on a wide set of factors, including Total Operational Efficiency (TOE) achieved/experienced for the vitrification facilities over their operational life. Because the WRPS modeling is based on an assumed 40% TOE, the overall duration is not considered overly optimistic. For these reasons, the operational period elements of the LCC for each alternative are assumed to have an uncertainty range of from -30% to +50%.

The project related costs, consisting of both expense funded projects and the various capital projects needed for each alternative, are expected to have much broader ranges of uncertainty, consistent with DOE experience. These estimates are based on pre-conceptual design information and are primarily parametric-based estimate. Thus, a range of from -50% to +100% has been assumed for the estimated costs of these elements of the LCC for each alternative.

Table 20 presents the PV of the LCC for each alternative in terms of a range. Table 21 shows the as-spent (escalated) range of the LCCE for each alternative. Note that these ranges are for the unconstrained funding scenario because LCCEs cannot be developed for the constrained funding scenario at this time.

Table 22: PV of LCC Ranges – Unconstrained Funding

#	Alternative Name	Low ($B)	Point ($B)	High ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	98	151	246
2	HLW Pretreatment in HFPF	80	125	208
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	78	123	205
14	New HFPF (with Filtration) and New HEMF	76	119	196
15	DFHLW and HLW Effluent Processing in New HEMF	77	121	200
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	77	121	200
17	DFHLW Single Melter HLW Without Evaporators or LAWST	242	423	770

Table 23: Life Cycle Cost Ranges – Unconstrained Funding

#	Alternative Name	Low ($B)	Point ($B)	High ($B)
1	HLW Pretreatment in PT Facility (Baseline Case)	228	341	539
2	HLW Pretreatment in HFPF	139	215	350
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	142	217	352
14	New HFPF (with Filtration) and New HEMF	139	212	341
15	DFHLW and HLW Effluent Processing in New HEMF	140	214	346
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	139	213	344
17	DFHLW Single Melter HLW Without Evaporators or LAWST	2,835	5,099	9,484

8.4 Schedule Analysis

Critical path schedules for each alternative were developed as part of the WRPS modeling efforts and modified by the AoA Team to incorporate the completion of the HLW Vitrification Facility (and PT Facility when included for an alternative), assuming unconstrained funding. The schedules are presented as summary timelines in Appendix C. The assumptions and bases for the WRPS schedules can be found in a separate report[k]. The schedules for completion of the HLW Vitrification and PT Facilities are derived from the schedules that support the USACE parametric estimates for completion of those facilities, as described in the cost estimate basis discussion found in Appendix E.

A fundamental assumption of the unconstrained analysis for this AoA is that the HLW processing can be started to meet the current Amended Consent Decree[e] milestone of December 2033. Therefore, this is the starting point for both the WRPS modeling of the HLW processing operations and the LCCEs used for the AoA evaluations.

Schedule timelines for the constrained funding scenario can also be found in Appendix C. These timelines are derived from the constrained funding analysis described in Appendix E.

High-level milestones for each alternative, under the unconstrained and constrained funding scenarios, are shown in Table 24 and Table 25, respectively.

Table 24: High Level Schedule Milestone Dates – Unconstrained Funding

#	Alternative Name	HLW Treatment Start	SST Retrievals Complete	DST Retrievals Complete	Tank Waste Treatment Completed
1	HLW Pretreatment in PT Facility (Baseline Case)	Dec-2033	Jun-2073	Jun 2083	Aug 2084
2	HLW Pretreatment in HFPF	Dec-2033	Apr 2056	Feb 2061	Jul 2061
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	Dec-2033	Apr 2056	Sep 2064	Sep 2064
14	New HFPF (with Filtration) and New HEMF	Dec-2033	Apr 2056	Sep 2064	Sep 2064
15	DFHLW and HLW Effluent Processing in New HLW EMF	Dec-2033	May 2059	Mar 2064	Mar 2064
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	Dec-2033	Jan 2059	Jul 2062	Oct 2062
17	DFHLW Single Melter HLW Without Evaporators or LAWST*[12]	Dec-2033	Aug 2159	>2168	>2168

Table 25: High Level Schedule Milestone Dates - Constrained Funding

#	Alternative Name	HLW Treatment Facilities Completed	Start HLW Treatment Operations	IHS/HSF Completed
1	HLW Pretreatment in PT Facility (Baseline Case)	Facilities Not Completed		
2	HLW Pretreatment in HFPF	FY 2035	FY 2036	FY 2040
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	Facilities Not Completed		
14	New HFPF (with Filtration) and New HEMF	FY 2035	FY 2036	FY 2040
15	DFHLW and HLW Effluent Processing in New HEMF	FY 2034	FY 2035	FY 2037
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	FY 2034	FY 2035	FY 2039
17	DFHLW Single Melter HLW Without Evaporators or LAWST[12]	FY 2034	FY 2034	FY 2033

[12] Durations and end dates for Alternative 17 are uncertain due to known limitations of WRPS modeling for very long mission duration necessary for this alternative.

9 Alternatives Evaluation

The AoA Team performed an initial risk assessment, developed LCCs, and scored each alternative against the agreed-to evaluation criteria defined in Section 6. This step integrates the analyses and results in a rank order of alternatives.

9.1 Risk Assessment

The WTP HLW AoA qualitative risk assessment included the following:

- Defining the qualitative risk assessment framework to be used to evaluate threats and opportunities
- Reviewing existing risk documentation to identify potentially applicable threats and opportunities
- Brainstorming additional threats and opportunities
- Evaluating threats and opportunities identified in accordance with the established framework
- Documenting the qualitative risk assessment evaluation results.

The WTP HLW AoA qualitative risk assessment process followed the guidelines provided by the DOE Risk Management Guide[i].

First, the AoA Team established the qualitative risk assessment framework to be used to evaluate threats and opportunities, including threat and opportunity matrices for determining risk levels based on probability of occurrence and the consequence of occurrence. The matrices for determining risk level are provided in Figure 4 and Figure 5. These matrices were derived from the Qualitative Risk Analysis Matrix in the DOE Risk Management Guide. Risk levels are documented as: "Very Low," "Low," "Moderate," "High," and "Very High."

		Consequences of Occurrence				
		Negligible	**Marginal**	**Significant**	**Critical**	**Crisis**
Cost		Minimal or no consequence. No impact to project cost	Small increase in meeting objectives. Marginally increases costs.	Significant degradation in meeting objectives. Significantly increases cost; fee is at risk	Goals and objectives are not achievable. Additional funding may be required; loss of fee and/or fines and penalties imposed.	Project stopped. Funding withdrawal, withdrawal of scope, or severe contractor cost performance issues
Schedule		Minimal or no consequence. No impact to project schedule.	Small increase in meeting objectives. Marginally impacts schedule.	Significant degradation in meeting objectives; significant impacts to schedule	Goals and objectives are not achievable. Additional time may need to be allocated. Missed incentives and/or regulatory milestones.	Project stopped. Withdrawal of scope or severe contractor schedule performance issues.
Probability	**Very High > 90%**	Low	Moderate	High	Very High	Very High
	High 75% - 90%	Very Low	Moderate	Moderate	High	Very High
	Moderate 26% - 74%	Very Low	Low	Moderate	Moderate	High
	Low 10% - 25%	Very Low	Very Low	Low	Moderate	Moderate
	Very Low < 10%	Very Low	Very Low	Very Low	Low	Moderate

Figure 4: Threat Assessment Matrix

		Consequences of Occurrence				
		Negligible	Marginal	Significant	Efficient	Optimal
Cost		Minimal or no consequence. No impact to project cost.	Small decrease in meeting objectives. Marginally decreases costs.	Significant improvement in meeting objectives. Significantly decreases cost.	10-20% positive cost impact.	Greater than 20% positive cost impact.
Schedule		Minimal or no consequence. No impact to project schedule.	Small decrease in meeting objectives. Marginally impacts schedule.	Significant improvement in meeting objectives. Significantly impacts schedule.	10-20% positive schedule impact.	Greater than 20% positive schedule impact.
Probability	Very High > 90%	Low	Moderate	High	Very High	Very High
	High 75% - 90%	Very Low	Moderate	Moderate	High	Very High
	Moderate 26% - 74%	Very Low	Low	Moderate	Moderate	High
	Low 10% - 25%	Very Low	Very Low	Low	Moderate	Moderate
	Very Low < 10%	Very Low	Very Low	Very Low	Low	Moderate

Figure 5: Opportunity Assessment Matrix

Threats and opportunities were evaluated using the probability and consequence assessment matrices above. The resulting risk level was determined based on the probability of occurrence and the consequence of occurrence. Numerical values were assigned to the resulting risk level. The risk levels were given a numeric value as follows:

- Very High Threat (Very Low Opportunity) = 5
- High Threat (Low Opportunity) = 4
- Moderate Threat (Opportunity) = 3
- Low Threat (High Opportunity) = 2
- Very Low Threat (Very High Opportunity) = 1

The numeric values for individual threats and opportunities for a particular alternative were then added and divided by the combined number of threats and opportunities evaluated to arrive at a composite numerical value. The overall risk rating for each alternative was based on the composite numerical value using the scale summarized in Table 26.

Table 26: Risk Scores and Associated Ratings

Risk Score	Risk Rating
4.20 – 5.00	Very High
3.40 – 4.19	High
2.60 – 3.39	Moderate
1.80 – 2.59	Low
1.00 – 1.79	Very Low

The WTP HLW AoA qualitative risk assessment methodology and matrices used to evaluate threats and opportunities are documented in the WTP HLW AoA Study Plan.

The AoA Team reviewed existing risk documentation to identify previously identified threats and opportunities to determine if they were applicable to HLW processing. Documentation reviewed included the DFLAW Risk Register, the RPP Risk Register, the USACE Parametric Estimate Risk Register[f], and several other engineering studies and technical reports. A preliminary set of threats and opportunities were developed and reviewed by team members. The preliminary threats and opportunities were grouped into three evaluation categories – project/technical risks, operations risks, and programmatic risks – which are described in Table 27.

Table 27: Risk Type Descriptions

Risk Type	Risk Description
Technical / Project Risk	Risk related to technology issues and limitations, and/or technical constraints that render previous solution assumptions invalid (such as major technological failures, changes due to direction from Agency senior management, and interpretation of regulatory and statutory requirements)
Programmatic Risk	Risk related to external events outside the control of the program/project (such as national repository opening later than anticipated, Congressional funding reductions, DOE funding reductions, and regulatory and statutory changes)
Operational Risk	Risk resulting from inadequate or failed systems, structures or components impeding the ability to conduct operations (such as cross site transfer lines and 242-A Evaporator)

Additional project/technical, operations, and programmatic threats and opportunities were developed during brainstorming sessions with team members and subsequently reviewed, discussed, and included (as appropriate) in the final list of threats and opportunities to be evaluated as part of the WTP HLW AoA qualitative risk assessment.

Next, the final list of threats and opportunities were evaluated. The probability of occurrence and consequence of occurrence values were determined during risk evaluation sessions conducted February 11 – 13, 2020, and February 25 – 27, 2020, involving the ECMS Team members, DOE ORP representatives, Ecology, and supporting SMEs. Rating guidelines (the Threat Assessment Matrix and Opportunity Assessment Matrix) were provided to all participants in advance of the risk evaluation sessions. Each threat and opportunity were discussed until a consensus was reached regarding the probability and consequence values. Potential mitigation strategies were identified for those threats rated Moderate, High, and Very High.

Lastly, the AoA Team documented the qualitative risk assessment results in this report. The AoA Team performed a qualitative risk assessment under unconstrained and constrained funding assumptions (see Appendix E) for viable HLW processing alternatives. The AoA Team identified and evaluated a total of 46 potential risks, 41 threats, and five opportunities across three major categories: project/technical, operations, and programmatic. Threats and opportunities were evaluated within the context of the alternative descriptions and process flowsheets and using modeling and cost estimating results. Each threat and opportunity were evaluated for viable alternatives. As described previously, under the $2.5 billion annual constrained funding, design, construction, startup, and commissioning cannot be completed for Alternatives 1 and 5. Consequently, the risk assessment under constrained funding was not conducted for either alternative, and both were designated as “not applicable” under constrained funding.

Table 28 shows the composite risk ratings (including corresponding risk scores in parentheses that accounts for both threats and opportunities) for each alternative under unconstrained and constrained funding assumptions. The risk ratings and scores represent “pre-mitigation” values.

Table 28: Composite Risk Ratings

#	Alternative Name	Project / Technical Risk Rating		Operations Risk Rating		Programmatic Risk Rating	
		Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained	Constrained
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)	Moderate (2.82)	Not Applicable	Moderate (2.88)	Not Applicable	Moderate (2.92)	Not Applicable
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	Low (2.47)	Moderate (2.65)	Moderate (2.69)	Moderate (3.13)	Moderate (3.15)	High (3.46)
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	Moderate (2.94)	Not Applicable	Moderate (2.81)	Not Applicable	Moderate (3.08)	Not Applicable
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	Low (2.47)	Moderate (2.65)	Moderate (2.81)	Moderate (3.25)	Moderate (3.15)	High (3.46)
15	DFHLW from DSTs and Effluent Management in New HEMF	Moderate (2.65)	Moderate (2.82)	Moderate (3.06)	High (3.50)	Moderate (3.23)	High (3.54)
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	Moderate (2.65)	Moderate (2.82)	Moderate (3.06)	High (3.50)	Moderate (3.23)	High (3.54)
17	DFHLW from DSTs without HLW Effluent Management	Low (2.29)	Low (2.35)	Moderate (3.06)	Moderate (3.13)	Moderate (3.15)	Moderate (3.15)

The following sections summarize the risk assessment results for the unconstrained funding and constrained funding scenarios. Appendix F contains detailed tables for project/technical, operations, and programmatic threats and opportunities, including the rationale for probability and consequence selections and mitigation strategies and post mitigation evaluations for threats originally rated as moderate, high, or very high.

9.1.1 RISK ASSESSMENT – UNCONSTRAINED FUNDING

Table 29 provides a summary risk rating for project/technical, operations, and programmatic threats and opportunities for each alternative based on unconstrained funding.

Table 29: Composite Risk Ratings - Unconstrained Funding

	Alternative Name	Project / Technical Risk Rating	Operations Risk Rating	Programmatic Risk Rating
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)	Moderate	Moderate	Moderate
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	Low	Moderate	Moderate
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	Moderate	Moderate	Moderate
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	Low	Moderate	Moderate
15	DFHLW from DSTs and Effluent Management in New HEMF	Moderate	Moderate	Moderate
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	Moderate	Moderate	Moderate
17	DFHLW from DSTs without HLW Effluent Management	Low	Moderate	Moderate

The individual threats with risk levels that varied significantly among the alternatives for the unconstrained funding case are listed below.

Project/Technical Threats

- **Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning.
  - **Alternatives 1, 2, 14, 15, 16 (Moderate); Alternative 5 (High); and Alternative 17 (Very High)**
- **Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs.
  - **Alternative 17 (High); Alternatives 1, 2, 5, 14, 15, 16 (Very High)**
- **Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available are insufficient, resulting in delayed project schedules and increased project costs.
  - **Alternative 17 (Low); Alternatives 1, 2, 5, 14, 15, 16 (High)**

Operations Threats

- **Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules.
  - **Alternatives 2, 5, 14 (Moderate); Alternatives 15, 16 (High); Alternatives 1, 17 (Very High)**
- **Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.
  - **Alternatives 1, 2 (Moderate); Alternatives 5, 14 (High); Alternatives 15, 16, 17 (Very High)**
- **Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.
  - **Alternatives 1, 2, 5, 14 (Moderate); Alternatives 15, 16, 17 (Very High)**
- **Threat #9**. HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations) which result in extended mission duration and increased costs.
  - **Alternative 17 (Very Low); Alternatives 2, 5, 14, 15, 16 (Moderate); Alternative 1 (High)**
- **Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission.
  - **Alternatives 2, 5, 14, 15, 16 (Moderate); Alternative 1 (High); Alternative 17 (Very High)**

Programmatic Threats

- **Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs.
  - **Alternatives 1, 5 (Moderate); Alternatives 2, 14, 17 (High); Alternatives 15, 16 (Very High)**
- **Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs.
  - **Alternative 17 (Moderate); Alternatives 1, 2, 5, 14, 15, 16 (Very High)**

- **Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current Amended Consent Decree (ACD) and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes.
  - **Alternative 1 (Moderate); Alternatives 2, 5, 14 (High); Alternatives 15, 16, 17 (Very High)**

The following summarizes the top threats (rated High and Very High) associated with each alternative based on unconstrained funding.

Alternative 1 (3 – Very High Threats; 4 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels resulting in schedule delays and increased project costs. (Very High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Project/Technical Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available is insufficient, resulting in delayed project schedules and increased project costs. (High)
- **Operations Threat #9**. HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations), which results in extended mission duration and increased costs. (High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 2 (2 – Very High Threats; 4 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Project/Technical Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available is insufficient, resulting in delayed project schedules and increased project costs. (High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 5 (2 – Very High Threats; 6 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (High)
- **Project/Technical Threat #8**. The facility modifications that are required to segregate the LAW and HLW pretreatment functions within the PT Facility or "repurpose" its use (i.e., to serve a purpose that was not intended nor described in the facility technical baseline) are more complex than planned, resulting in additional facility design changes and delays in hot operations and the overall HLW (and LAW) treatment schedule. (High)
- **Project/Technical Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available is insufficient, resulting in delayed project schedules and increased project costs. (High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 14 (2 – Very High Threats; 5 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Project/Technical Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available is insufficient, resulting in delayed project schedules and increased project costs. (High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 15 (6 – Very High Threats; 3 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (Very High)
- **Project/Technical Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available is insufficient, resulting in delayed project schedules and increased project costs. (High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 16 (6 – Very High Threats; 3 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (Very High)

- **Project/Technical Threat #13**. The number of qualified design, construction, startup, and commissioning personnel available is insufficient, resulting in delayed project schedules and increased project costs. (High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 17 (6 – Very High Threats; 7 – High Threats)

- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (Very High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (Very High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP 105, 106, 107 and 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (Very High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (Very High)
- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (High)
- **Operations Threat #10.** A leak or other failure in a DST (AP-105, -106, -107 or -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Operations Threat #13.** The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs. (High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (High)
- **Programmatic Threat #4.** Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls, leading to delays in operations and in increased lifecycle costs. (High)

- **Programmatic Threat #5.** Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved nuclear quality assurance [NQA-1] program, vendor competency and quality of work, long lead procurements) adversely impact procurement costs and schedules, mission duration and lifecycle costs. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

The risk level results for project/technical, operations, and programmatic threats and opportunities evaluated in the unconstrained funding case are summarized in Table 30, Table 31, and Table 32, respectively.

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Table 30: Qualitative Risk Assessment Summary – Project/Technical Threats and Opportunities – Unconstrained Funding

Alt #	Tech and science maturity T1	Changes in reqmt's T2	Changes code of record T3	Changes in safety basis T4	System interface complex T5	Safety incident delays T6	DNFSB issue Delays T7	PT re-purpose delays T8	Site specific cond T9	Control of p/C changes T10	Equip. aging & obsol T11	Contr perf issues T12	Suffic qualif person T13	TF upgrade delays T14	ETF upgrade delays T15	Use of existing equip Op1	Excess BOF Capacity OP2
1	Moderate	Moderate	Moderate	Very Low	Low	Very Low	Low	Very Low	Moderate	Moderate	Moderate	Very High	High	Low	Low	Very Low	Very Low
2	Very Low	Moderate	Low	Very Low	Moderate	Very Low	Very Low	Very Low	Moderate	Moderate	Low	Very High	High	Low	Moderate	Low	Moderate
5	Low	High	Moderate	Very Low	Moderate	Very Low	Low	High	Very Low	Moderate	Moderate	Very High	High	Low	Low	Very Low	Very Low
14	Very Low	Moderate	Low	Very Low	Moderate	Very Low	Very Low	Very Low	Moderate	Moderate	Low	Very High	High	Low	Moderate	Low	Moderate
15	Very Low	Moderate	Low	Moderate	Moderate	Very Low	Very Low	Very Low	Moderate	Low	Low	Very High	High	Moderate	Moderate	Very Low	Moderate
16	Very Low	Moderate	Low	Moderate	Moderate	Very Low	Very Low	Very Low	Moderate	Low	Low	Very High	High	Moderate	Moderate	Very Low	Moderate
17	Very Low	Very High	Low	Moderate	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Low	High	Low	Low	Low	Very Low	Very Low

Table 31: Qualitative Risk Assessment Summary – Operations Threats and Opportunities – Unconstrained Funding

Alt #	242-A avail & reliab. T1	Cross site transfer start up T2	Cross site transfer avail T3	TF waste feed del infrastr T4	222-s LAB avail T5	WTP lab function T6	DST leak/ failure T7	DST repurp degrad T8	Sustain through rates T9	DST leak/ failure (ap 105-AP 108) T10	BOF Facilities capabil T11	Mission design life T12	Site infrastr avail T13	Labor to support LAW/HLW T14	Waste load improv Op1	Higher oper effic. Op2
1	Very High	Moderate	Low	Low	Low	Very Low	Moderate	Moderate	High	Moderate	Low	High	Moderate	Low	Low	Moderate
2	Moderate	Moderate	Moderate	Low	Moderate	Very Low	Moderate	Moderate	Moderate	Moderate	Very Low	Moderate	Moderate	Low	Low	Moderate
5	Moderate	Moderate	Moderate	Moderate	Low	Very Low	High	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Low	Low	Moderate
14	Moderate	Moderate	Moderate	Moderate	Moderate	Very Low	High	Moderate	Moderate	Moderate	Very Low	Moderate	Moderate	Low	Low	Moderate
15	High	Moderate	Moderate	Moderate	Moderate	Very Low	Very High	Very High	Moderate	Moderate	Very Low	Moderate	Moderate	Low	Low	Moderate
16	High	Moderate	Moderate	Moderate	Moderate	Very Low	Very High	Very High	Moderate	Moderate	Very Low	Moderate	Moderate	Low	Low	Moderate
17	Very High	Very Low	Very Low	Moderate	Low	Very Low	Very High	Very High	Very Low	High	Very Low	Very High	High	Very Low	Very Low	Very Low

Table 32: Qualitative Risk Assessment Summary – Programmatic Threats and Opportunities – Unconstrained Funding

Alt #	Permitting approval delays T1	DFLAW delay impacts T2	Safety event during const T3	Safety event during ops T4	Supply chain mgt challenge T5	Funding shortfall delays T6	Deviation from ACD & Reg fram T7	Natl geo repos delay T8	Changes in IHLW WAC & packaging T9	New DOE dir/policy or ext regs T10	New external stake T11	Solid waste with no treat/disp T12	Change in waste class. Op1
1	Moderate	Moderate	Low	Moderate	Moderate	Very High	Moderate	Moderate	Low	Low	Low	High	Moderate
2	High	Moderate	Low	Moderate	Moderate	Very High	High	Moderate	Low	Low	Moderate	High	Moderate
5	Moderate	Moderate	Low	Moderate	Moderate	Very High	High	Moderate	Low	Low	Moderate	High	Moderate
14	High	Moderate	Low	Moderate	Moderate	Very High	High	Moderate	Low	Low	Moderate	High	Moderate
15	Very High	Moderate	Low	Moderate	Moderate	Very High	Very High	Moderate	Low	Low	Low	High	Moderate
16	Very High	Moderate	Low	Moderate	Moderate	Very High	Very High	Moderate	Low	Low	Low	High	Moderate
17	High	Moderate	Low	High	High	Moderate	Very High	Low	Moderate	Moderate	Low	High	High

Lastly, Figure 6 summarizes the number of identified threats by associated levels (Very High, High, Medium, Low, or Very low) for each alternative based on the constrained funding case.

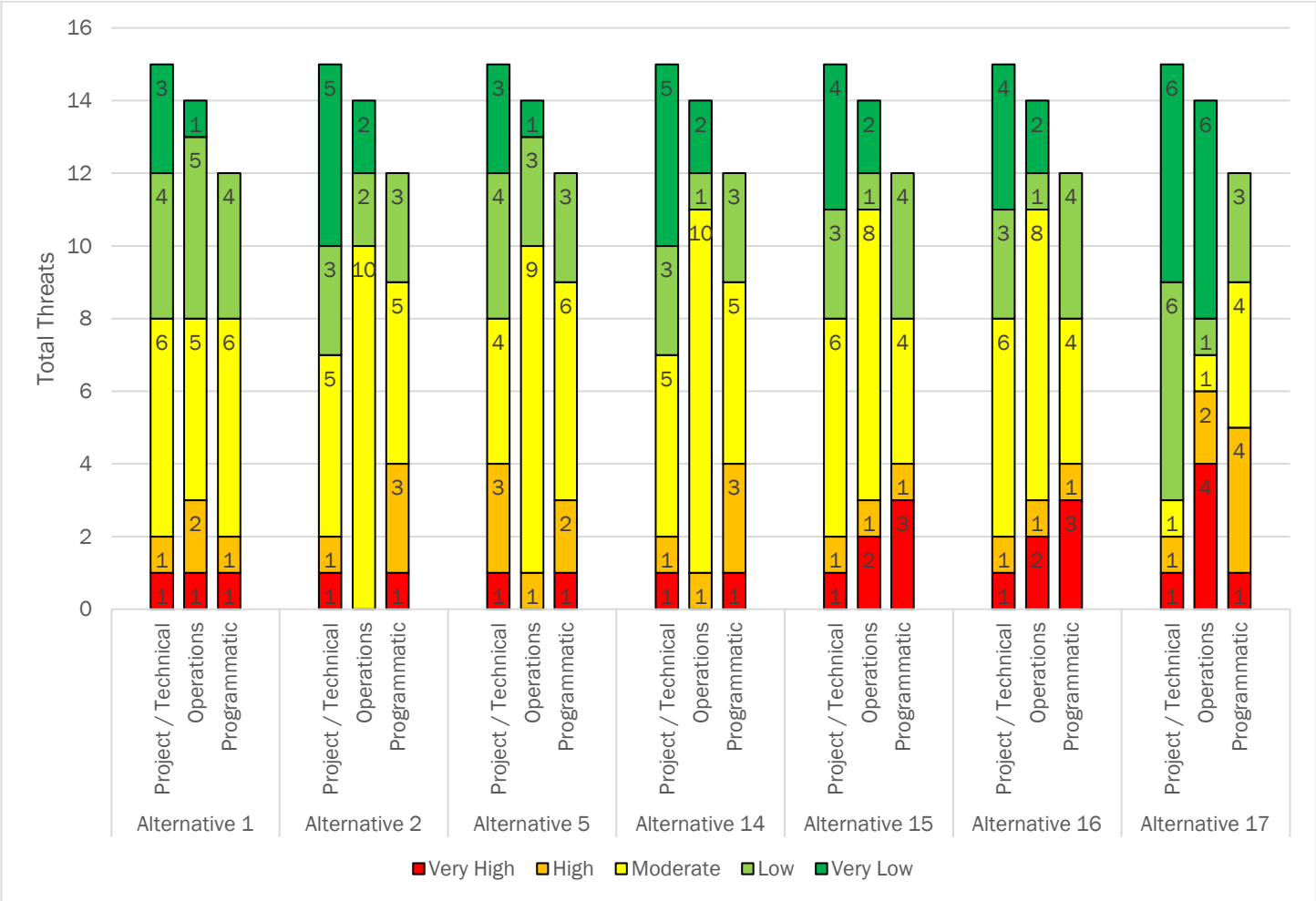

Figure 6: Alternative Threat Level Summary - Unconstrained Funding

9.1.2 RISK ASSESSMENT – CONSTRAINED FUNDING

Table 33 provides a summary risk rating for project/technical, operations, and programmatic threats and opportunities for each alternative based on constrained funding.

Table 33: Composite Risk Ratings - Constrained Funding

	Alternative Name	Project / Technical Risk Rating	Operations Risk Rating	Programmatic Risk Rating
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)	Not Applicable	Not Applicable	Not Applicable
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	Moderate	Moderate	High
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	Not Applicable	Not Applicable	Not Applicable
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	Moderate	Moderate	High
15	DFHLW from DSTs and Effluent Management in New HEMF	Moderate	High	High
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	Moderate	High	High
17	DFHLW from DSTs without HLW Effluent Management	Low	Moderate	Moderate

The individual threats with risk levels that varied significantly among the alternatives for the constrained funding case are listed below.

Project/Technical Threats

- **Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning.
  - **Alternatives 2, 14, 15, 16 (High); Alternative 17 (Very High)**
- **Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels resulting in schedule delays and increased project costs.
  - **Alternative 17 (High); Alternatives 2, 14, 15, 16 (Very High)**
- **Project/Technical Threat #15**. Delays to upgrades for the ETF to treat all HLW secondary liquid effluents result in schedule delays and increased costs.
  - **Alternative 17 (Very Low); Alternatives 2, 14, 15, 16 (Very High)**

Operations Threats

- **Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules.
  - **Alternatives 2, 14 (High); Alternatives 15, 16, 17 (Very High)**
- **Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.
  - **Alternative 2 (Moderate); Alternative 14 (High); Alternatives 15, 16, 17 (Very High)**
- **Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.
  - **Alternatives 2, 14 (Moderate); Alternatives 15, 16, 17 (Very High)**

Programmatic Threats

- **Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs.
  - **Alternatives 2, 14, 17 (High); Alternatives 15, 16 (Very High)**
- **Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities resulting in extended HLW treatment mission duration and increased costs.
  - **Alternative 17 (Moderate); Alternatives 2, 14, 15, 16 (Very High)**
- **Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes.
  - **Alternatives 2, 14 (High); Alternatives 15, 16, 17 (Very High)**

The following summarizes the top threats (rated High and Very High) associated with each alternative based on constrained funding.

Alternative 2 (4 – Very High Threats, 10 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels resulting in schedule delays and increased project costs. (Very High)
- **Project/Technical Threat #15**. Delays to upgrades for the ETF to treat all HLW secondary liquid effluents result in schedule delays and increased costs. (Very High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (High)
- **Operations Threat #9**. HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations), which results in extended mission duration and increased costs. (High)
- **Operations Threat #10.** A leak or other failure in a DST (AP-105, -106, -107 or -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Operations Threat #13.** The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs. (High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules, and subsequent processing schedules and associated costs. (High)
- **Programmatic Threat #4.** Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls, leading to delays in operations and in increased lifecycle costs. (High)
- **Programmatic Threat #5.** Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved NQA-1 program, vendor competency and quality of work, long lead procurements) adversely impact procurement costs and schedules, mission duration and lifecycle costs. (High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path) which results in increased lifecycle costs. (High)

Alternative 14 (4 – Very High Threats, 11 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Project/Technical Threat #15**. Delays to upgrades for the ETF to treat all HLW secondary liquid effluents result in schedule delays and increased costs. (Very High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP 105, 106, 107 and 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Operations Threat #9**. HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations), which results in extended mission duration and increased costs. (High)
- **Operations Threat #10.** A leak or other failure in a DST (AP-105, -106, -107 or -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Operations Threat #13.** The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs. (High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules, and subsequent processing schedules and associated costs. (High)
- **Programmatic Threat #4.** Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls, leading to delays in operations and in increased lifecycle costs. (High)
- **Programmatic Threat #5.** Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved NQA-1 program, vendor competency and quality of work, long lead procurements) adversely impact procurement costs and schedules, mission duration and lifecycle costs. (High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 15 (9 – Very High Threats, 7 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (Very High)
- **Project/Technical Threat #15**. Delays to upgrades for the ETF to treat all HLW secondary liquid effluents result in schedule delays and increased costs. (Very High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (Very High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (Very High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities, resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (Very High)
- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (High)
- **Operations Threat #9**. HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations), which results in extended mission duration and increased costs. (High)
- **Operations Threat #10.** A leak or other failure in a DST (AP-105, -106, -107 or -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Operations Threat #13.** The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs. (High)
- **Programmatic Threat #4.** Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls, leading to delays in operations and in increased lifecycle costs. (High)

- **Programmatic Threat #5.** Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved NQA-1 program, vendor competency and quality of work, long lead procurements) adversely impact procurement costs and schedules, mission duration and lifecycle costs. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 16 (9 – Very High Threats, 7 – High Threats)

- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels resulting in schedule delays and increased project costs. (Very High)
- **Project/Technical Threat #15**. Delays to upgrades for the ETF to treat all HLW secondary liquid effluents result in schedule delays and increased costs. (Very High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (Very High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (Very High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (Very High)
- **Programmatic Threat #6**. Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities resulting in extended HLW treatment mission duration and increased costs. (Very High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (Very High)
- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan.) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (High)
- **Operations Threat #9**. HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations), which results in extended mission duration and increased costs. (High)
- **Operations Threat #10.** A leak or other failure in a DST (AP-105, -106, -107 or -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)

- **Operations Threat #13.** The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs. (High)
- **Programmatic Threat #4.** Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls, leading to delays in operations and in increased lifecycle costs. (High)
- **Programmatic Threat #5.** Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved NQA-1 program, vendor competency and quality of work, long lead procurements) adversely impact procurement costs and schedules, mission duration and lifecycle costs. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path), which results in increased lifecycle costs. (High)

Alternative 17 (6 – Very High Threats, 7 – High Threats)

- **Project/Technical Threat #2**. Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects. This impacts the schedule and cost for completing treatment facility/system design, construction, startup and commissioning. (Very High)
- **Operations Threat #1**. The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules. (Very High)
- **Operations Threat #7**. A leak or other failure in a DST (excluding AP-105, -106, -107 and -108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #8**. HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges), resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (Very High)
- **Operations Threat #12.** The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated, resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission. (Very High)
- **Programmatic Threat #7.** The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current ACD and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes. (Very High)
- **Project/Technical Threat #12**. Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels, resulting in schedule delays and increased project costs. (High)
- **Operations Threat #10.** A leak or other failure in a DST (AP 105, AP 106, AP 107 or AP 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs. (High)
- **Operations Threat #13.** The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs. (High)
- **Programmatic Threat #1.** Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules and subsequent processing schedules and associated costs. (High)

- **Programmatic Threat #4.** Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls, leading to delays in operations and in increased lifecycle costs. (High)
- **Programmatic Threat #5.** Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved NQA-1 program, vendor competency and quality of work, long lead procurements) adversely impact procurement costs and schedules, mission duration and lifecycle costs. (High)
- **Programmatic Threat #12**. High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path) which results in increased lifecycle costs. (High)

The risk level results for project/technical, operations, and programmatic threats and opportunities evaluated in the constrained funding case are summarized in Table 34, Table 35, and Table 36, respectively.

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Table 34: Qualitative Risk Assessment Summary – Project/Technical Threats and Opportunities – Constrained Funding

Alt #	Tech and science maturity T1	Changes in reqmt's T2	Changes code of record T3	Changes in safety basis T4	System interface complex T5	Safety incident delays T6	DNFSB issue Delays T7	Pt re-purpose delays T8	Site specific cond T9	Control of p/C changes T10	Equip. aging & obsol T11	Contr perf issues T12	Suffic qualif person T13	TF upgrade delays T14	ETF upgrade delays T15	Use of existing equip Op1	Excess BOF Capacity OP2
2	Very Low	High	Moderate	Very Low	Moderate	Very Low	Very Low	Very Low	Moderate	Moderate	Low	Very High	Moderate	Low	Very High	Low	Moderate
14	Very Low	High	Moderate	Very Low	Moderate	Very Low	Very Low	Very Low	Moderate	Moderate	Low	Very High	Moderate	Low	Very High	Low	Moderate
15	Very Low	High	Moderate	Moderate	Moderate	Very Low	Very Low	Very Low	Moderate	Low	Low	Very High	Moderate	Moderate	Very High	Very Low	Moderate
16	Very Low	High	Moderate	Moderate	Moderate	Very Low	Very Low	Very Low	Moderate	Low	Low	Very High	Moderate	Moderate	Very High	Very Low	Moderate
17	Very Low	Very High	Moderate	Moderate	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Low	High	Low	Low	Very Low	Very Low	Very Low

Table 35: Qualitative Risk Assessment Summary – Operations Threats and Opportunities – Constrained Funding

Alt #	242-A avail & reliab. T1	Cross site transfer start up T2	Cross site transfer avail T3	TF waste feed del infrastr T4	222-s LAB avail T5	WTP lab function T6	DST leak/ failure T7	DST repurp degrad T8	Sustain through rates T9	DST leak/ failure (ap 105-AP 108) T10	BOF Facilities capabil T11	Mission design life T12	Site infrastr avail T13	Labor to support law/hlw T14	Waste load improv Op1	Higher oper effic. Op2
2	High	Moderate	Moderate	Low	Moderate	Very Low	Moderate	Moderate	High	High	Low	Very High	High	Very Low	Low	Low
14	High	Moderate	Moderate	Moderate	Moderate	Very Low	High	Moderate	High	High	Low	Very High	High	Very Low	Low	Low
15	Very High	Moderate	Moderate	Moderate	Moderate	Very Low	Very High	Very High	High	High	Low	Very High	High	Very Low	Low	Low
16	Very High	Moderate	Moderate	Moderate	Moderate	Very Low	Very High	Very High	High	High	Low	Very High	High	Very Low	Low	Low
17	Very High	Very Low	Very Low	Moderate	Low	Very Low	Very High	Very High	Very Low	High	Low	Very High	High	Very Low	Very Low	Very Low

Table 36: Qualitative Risk Assessment Summary – Programmatic Threats and Opportunities – Constrained Funding

Alt #	Permitting approval delays T1	DFLAW delay impacts T2	Safety event during const T3	Safety event during ops T4	Supply chain mgt challenge T5	Funding shortfall delays T6	Deviation from ACD & Reg fram T7	Natl geo repos delay T8	Changes in IHLW WAC & packaging T9	New DOE dir/policy or ext regs T10	New external stake T11	Solid waste with no treat/disp T12	Change in waste class. Op1
2	High	Moderate	Low	High	High	Very High	High	Moderate	Moderate	Moderate	Moderate	High	Moderate
14	High	Moderate	Low	High	High	Very High	High	Moderate	Moderate	Moderate	Moderate	High	Moderate
15	Very High	Moderate	Low	High	High	Very High	Very High	Moderate	Moderate	Moderate	Low	High	Moderate
16	Very High	Moderate	Low	High	High	Very High	Very High	Moderate	Moderate	Moderate	Low	High	Moderate
17	High	Moderate	Low	High	High	Moderate	Very High	Low	Moderate	Moderate	Low	High	High

Lastly, Figure 7 summarizes the number of identified threats by associated levels (Very High, High, Medium, Low, or Very low) for each alternative based on the constrained funding scenario.

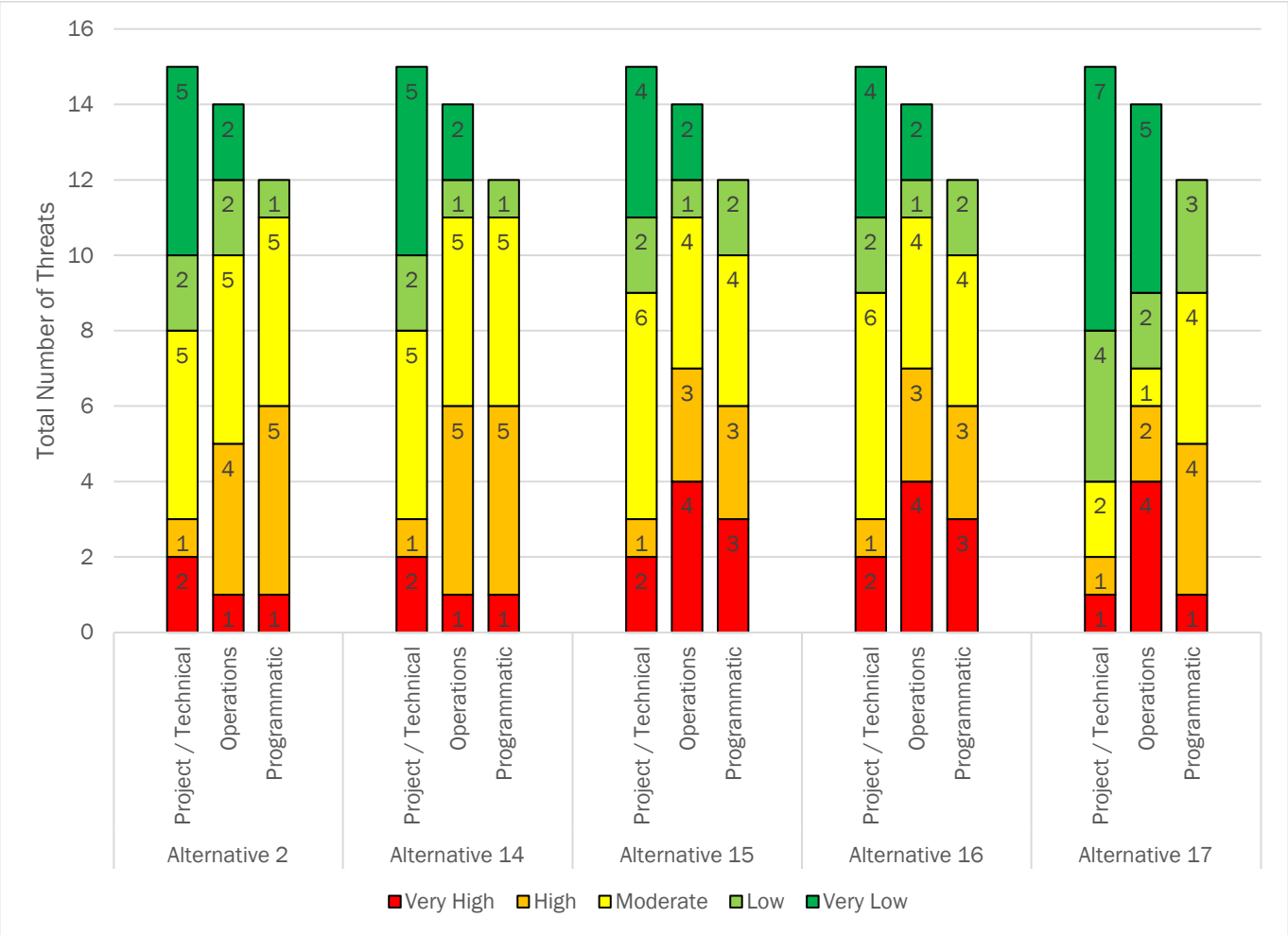

Figure 7: Alternative Threat Level Summary - Constrained Funding

9.1.3 SUMMARY

The WTP HLW AoA qualitative risk assessment shows the impact of unconstrained funding from the standpoint of "buying down" risk. Overall, risk levels either remained the same or were reduced with unconstrained funding. However, for all alternatives except Alternative 17, under the constrained funding case, deferral of design, construction and operation of a LAW supplemental treatment facility and a new ETF results in a significant reduction in the LAW treatment rate, which substantially increases the mission duration. Consequently, threats with probabilities and consequences that are linked to mission duration have risk levels that are higher for the constrained funding case. The threats with higher risk levels in the constrained funding case include, but are not limited to, 242-A evaporator availability, DST leaks/failures, facilities design life, site infrastructure availability, and supply chain management.

9.2 Performance Against Evaluation Criteria

The AoA team evaluated the alternatives using the weighted analysis matrix described in Section 7 and rated how completely each alternative met each evaluation criterion. The scoring system used is summarized in Table 37. Unlike the importance scoring, the criteria scoring is linear to prevent the difference in scores from being exaggerated.

Table 37: Evaluation Criteria Scoring

Criteria Evaluation	Score
Fully meets the criterion	1.00
Generally meets the criterion	0.75
Somewhat meets the criterion	0.50
Barely meets the criterion	0.25
Does not meet the criterion	0.00

The scoring and associated rationale for individual scores are summarized in Appendix G. To provide a consistent basis from which all alternative scores could be compared, the weighted scores were converted to a 0-to-100 grading scale (see description of calculating the normalized relative weighting in Section 7, above), with 0 being the lowest possible score and 100 being the highest possible score.

Individual criteria scores for each alternative are determined by multiplying the normalized relative weight for the evaluation criterion by the scores for each alternative. The scores for all evaluation criteria for each alternative are summed to determine a total weighted score. Table 38 and Table 39 summarize the weighted scores for each alternative in the unconstrained and constrained cases, respectively.

Table 38: Evaluation Results – Weighted Scores – Unconstrained Funding

#	Evaluation Criteria	NRW	Alt 1	Alt 2	Alt 5	Alt 14	Alt 15	Alt 16	Alt 17
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
EC-2	Lower HLW project TPC range	20.0	5.0	5.0	5.0	10.0	10.0	10.0	20.0
EC-3	Lower operational, technical, and programmatic risk	20.0	15.0	15.0	10.0	15.0	10.0	10.0	10.0
EC-4	Lower HLW processing LCC (PV range)	12.0	6.0	9.0	9.0	12.0	12.0	12.0	0.0
EC-5	Alternative allows for earlier completion of HLW treatment	8.0	6.0	8.0	8.0	8.0	8.0	8.0	0.0
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	8.0	4.0	8.0	8.0	8.0	6.0	6.0	0.0
EC-7	Fewer IHLW canisters produced	4.0	3.0	4.0	3.0	3.0	4.0	4.0	0.0
EC-8	Lower volume of ILAW generated by HLW processing	4.0	3.0	1.0	2.0	2.0	1.0	1.0	4.0
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	4.0	2.0	0.0	1.0	1.0	0.0	1.0	4.0
	Totals	100	64.0	70.0	66.0	79.0	71.0	72.0	58.0

Under the $2.5 billion annual constrained funding, design, construction, startup, and commissioning cannot be completed for all of the facilities needed for HLW processing for Alternatives 1 and 5. Although sufficient funds are available to complete the facilities needed to start HLW processing for Alternatives 2, 14, 15, and 16 under the constrained funding case, the remaining funds are not sufficient to construct the facilities needed to support the processing rates assumed in the unconstrained funding case. In addition, no process or cost modeling was conducted to support the constrained funding case for Alternatives 2, 14, 15, and 16. As a result, there is no measurable, quantifiable data to support evaluation criteria 4 through 9 (EC-4 – EC-9) for these alternatives. However, under the constrained

funding scenario all alternatives will likely result in mission durations extending well beyond the 2100 timeframe with process and cost modeling results that would more closely parallel those for Alternative 17 under unconstrained funding.

Table 39: Evaluation Results – Weighted Scores – Constrained Funding

#	Evaluation Criteria	NRW	Alt 2	Alt 14	Alt 15	Alt 16	Alt 17
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	33.3	16.7	16.7	25.0	25.0	33.3
EC-2	Lower HLW project TPC range	33.3	8.3	8.3	16.7	16.7	33.3
EC-3	Lower operational, technical, and programmatic risk	33.3	16.7	16.7	8.3	8.3	25.0
	Totals	100	41.7	41.7	50.0	50.0	91.7

9.3 Cost Sensitivity

GAO Best Practices for Cost Estimating advise conducting sensitivity analysis to determine which key assumptions and estimating input values are key cost drivers and which cost elements are affected most by changes to those assumptions or input values. While there are a myriad of assumptions and estimate inputs that can impact LCCEs for the alternatives being evaluated for this AoA, most of those, if changed, would not have an impact on the alternative LCCEs from a comparative or relational (i.e., ranking) perspective. The fact these uncertainties do exist is the major reason for the broad LCCE ranges described previously.

However, the following are key inputs and assumptions that could, theoretically impact the comparative LCCE for the various alternatives:

- Changes to the assumed TOE for the LAW and HLW processing operations (assumed to be 40% for the WRPS modeling effort) which can impact mission duration
- Changes to tank retrieval rates and tank farm operational efficiencies which can impact mission duration as well as estimated costs to accomplish those activities
- Changes in future cost escalation rates that can impact comparative alternative LCCEs that have disparate cost profiles over time (both in terms of magnitude of costs and timing of those costs)

Unfortunately, for this AoA, it is not possible to assess the impact on alternative LCCEs for changes in the first two elements cited above without additional modeling efforts that are not possible within the context of this AoA. However, the AoA Team believes that it is not likely that changes to these assumptions would have an impact on relative/comparative ranking of the LCCEs for those alternatives being evaluated.

To evaluate the potential impact of future cost escalation that may vary from the rates assumed for the AoA LCCEs, the AoA Team calculated the PV of the LCCE for each alternative using the Office of Management and Budget (OMB) real discount rate, applied to unescalated annual costs over the full mission life cycle. This analysis provides PV comparisons that eliminate any influence of escalation rate on the comparative values. The results of this analysis, and comparison to the PV calculations using the OMB nominal discount rate, are shown in Table 40.

Table 40: Comparison of LCC PV Calculations - Unconstrained Funding

#	Alternative Name	Nominal Rate PV ($B)	Ratio to Lowest	Real Rate PV ($B)	Ratio to Lowest
1	HLW Pretreatment in PT Facility (Baseline Case)	151	1.27	126	1.24
2	HLW Pretreatment in HFPF	125	1.05	106	1.05
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	123	1.04	105	1.04
14	New HFPF (with Filtration) and New HEMF	119	1.00	101	1.00
15	DFHLW and HLW Effluent Processing in New HEMF	121	1.02	103	1.02
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	121	1.02	103	1.02
17	DFHLW Single Melter HLW Without Evaporators or LAWST	423	3.56	174	1.72

The alternative approach to calculating the PV of the LCC for each alternative does not impact the ranking of the alternatives from a PV perspective. This approach does, however, significantly lower the PV for Alternative 17 and brings it closer to the PV for the other alternatives. This is the result of the very long mission life for Alternative 17 combined with the relatively high future year expenditures included in the LCCE for replacement facilities and other ongoing upgrade projects over the full mission life for which the relatively high project cost escalation rate of 4%/year was used in the LCCE calculations.

9.4 Sensitivity Analysis

Sensitivity Analyses are performed to test and document the sensitivity effectiveness estimates for each alternative. To perform the sensitivity analyses, the relative importance of the Evaluation Criteria are modified to determine which of the criteria are driving the performance (composite evaluation score) of the alternatives. In some cases, select evaluation criteria are eliminated to determine the performance of the alternatives independent of the selected criteria. Baseline evaluation criteria importance factors and resulting relative weightings are detailed in Table 16 and Table 17 for the unconstrained and constrained cases, respectively. This section details the variations from the baseline cases that were made to perform the sensitivity analysis for the unconstrained and the constrained funding cases.

9.4.1 SENSITIVITY SCENARIOS FOR UNCONSTRAINED FUNDING CASE WHERE IMPORTANCE RATINGS ARE CHANGED

This section describes the sensitivity scenarios that are based on varying the weighting (Importance Ratings) of the evaluation criteria for the Unconstrained Funding Case.

Scenario 1 weights all evaluation criteria equally to address the potential for unintentional bias in assignment of relative Importance ratings. The resultant importance ratings, weights, and normalized relative weights are described in Table 41.

Table 41: Scenario 1 Equal Weighting (Normalized to 100 Point Scale)

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Highest Importance	5	0.556	11.11
EC-2	Lower HLW project TPC range	Highest Importance	5	0.556	11.11
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.556	11.11
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Highest Importance	5	0.556	11.11
EC-5	Alternative allows for earlier completion of HLW treatment	Highest Importance	5	0.556	11.11
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Highest Importance	5	0.556	11.11
EC-7	Fewer IHLW canisters produced	Highest Importance	5	0.556	11.11

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Highest Importance	5	0.556	11.11
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Highest Importance	5	0.556	11.11

Scenario 2 emphasizes earlier completion of the HLW treatment mission. ECs 4 &-5 are elevated to Highest Importance, as there is high correlation between mission duration and LCC. The Importance Rating for ECs 1-3 are dropped to Very Important, and the Importance Ratings for all other evaluation criteria remain as per baseline. The resultant importance ratings, weights, and normalized relative weights are shown in Table 42

Table 42: Scenario 2 Earlier Completion of HLW Treatment is Emphasized

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Very Important	3	0.333	12.50
EC-2	Lower HLW project TPC range	Very Important	3	0.333	12.50
EC-3	Lower operational, technical, and programmatic risk	Very Important	3	0.333	12.50
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Highest Importance	5	0.556	20.83
EC-5	Alternative allows for earlier completion of HLW treatment	Highest Importance	5	0.556	20.83
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	2	0.222	8.33
EC-7	Fewer IHLW canisters produced	Lowest Importance	1	0.111	4.17
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Lowest Importance	1	0.111	4.17
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.111	4.17

The TPC and LCC cost criteria are deemphasized in Scenario 3. The Importance Ratings of ECs 2 and 4 are dropped to Lowest Importance, and all other ratings remain the same as shown in Table 43.

Table 43: Scenario 3 Cost is Deemphasized

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Highest Importance	5	0.556	26.32
EC-2	Lower HLW project TPC range	Lowest Importance	1	0.111	5.26
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.556	26.32
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Lowest Importance	1	0.111	5.26
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	2	0.222	10.53
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	2	0.222	10.53
EC-7	Fewer IHLW canisters produced	Lowest Importance	1	0.111	5.26
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Lowest Importance	1	0.111	5.26
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.111	5.26

9.4.2 SENSITIVITY SCENARIOS FOR UNCONSTRAINED FUNDING CASE WHERE SELECT EVALUATION CRITERIA ARE REMOVED

This section describes the sensitivity scenarios that are based on removing evaluation criteria for which all alternatives are rated the same in the baseline analysis, or which have been determined during the analysis to be less important than was assumed when the Study Plan was developed.

In Scenario 4, EC-1 (Early Completion of HLW Vitrification Facility Hot Commissioning) is eliminated since in the unconstrained funding case, hot commissioning of the HLW Vitrification Facility is assumed to be completed on 12/31/2033 (based on the ACD) for all alternatives. The changes in the importance and weighting of the evaluation criteria for Scenario 4 are shown in Table 44.

Table 44: Scenario 4 Remove Evaluation Criterion 1

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-2	Lower HLW project TPC range	Highest Importance	5	0.625	25.00
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.625	25.00
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Very Important	3	0.375	15.00
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	2	0.250	10.00
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	2	0.250	10.00
EC-7	Fewer IHLW canisters produced	Lowest Importance	1	0.125	5.00
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Lowest Importance	1	0.125	5.00
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.125	5.00

In Scenario 5, EC-6 (Increased Flexibility in the Tank Farm System) is eliminated since determining operational flexibility within the Tank Farm system requires qualitative analysis of multiple model outputs and cannot be evaluated directly. The changes in the importance and weighting for Scenario 5 are shown in Table 45.

Table 45: Scenario 5 Remove Evaluation Criterion 6

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Highest Importance	5	0.625	21.74
EC-2	Lower HLW project TPC range	Highest Importance	5	0.625	21.74
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.625	21.74
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Very Important	3	0.375	13.04
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	2	0.250	8.70
EC-7	Fewer IHLW canisters produced	Lowest Importance	1	0.125	4.35
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Lowest Importance	1	0.125	4.35
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.125	4.35

Table 46 describes Scenario 6, in which only the differentiable criteria related to cost, schedule, and risk are considered.

Table 46: Scenario 6 Analyze Only Cost, Schedule, and Risk

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-2	Lower HLW project TPC range	Highest Importance	5	1.250	33.33
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	1.250	33.33
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Very Important	3	0.750	20.00
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	2	0.500	13.33

In Scenario 7, Evaluation Criteria 7 (Fewer IHLW Canisters) and 8 (Lower Volume of ILAW) are eliminated. The cost and schedule impacts of variability in the number of IHLW canisters and ILAW containers produced are captured in the capital and operating cost estimates for the LAW and HLW Vitrification facilities. The cost to provide interim storage for IHLW canisters in the IHS is relatively small compared to the pretreatment and treatment facilities. Additionally, the cost to transport or dispose of the IHLW canisters is not considered in this AoA. Finally, the volume of ILAW for all alternatives represents only a small fraction of the capacity of the IDF. The volume of ILAW produced therefore does not appreciably drive the IDF cost. The change in the importance and weighting of the evaluation criteria for Scenario 7 are shown in Table 47.

Table 47: Scenario 7 Remove Evaluation Criteria 7 & 8

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Highest Importance	5	0.714	21.74
EC-2	Lower HLW project TPC range	Highest Importance	5	0.714	21.74
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	0.714	21.74
EC-4	Lower HLW processing life-cycle cost (LCC) (PV range)	Very Important	3	0.429	13.04
EC-5	Alternative allows for earlier completion of HLW treatment	Medium Importance	2	0.285	8.70
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	2	0.285	8.70
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.143	4.35

In Scenario 8, only the technical performance of the alternatives is evaluated. The evaluation criteria related to cost, schedule, and risk were eliminated. The changes in the importance and weighting of the evaluation criteria for Scenario 8 are shown in Table 48.

Table 48: Scenario 8 Remove Evaluation Criteria Related to Cost, Schedule, and Risk

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	Medium Importance	2	0.500	40.00
EC-7	Fewer IHLW canisters produced	Lowest Importance	1	0.250	20.00
EC-8	Lower volume of immobilized LAW (ILAW) generated by HLW processing	Lowest Importance	1	0.250	20.00
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	Lowest Importance	1	0.250	20.00

9.4.3 SENSITIVITY RESULTS FOR THE UNCONSTRAINED FUNDING CASE

Table 49 summarizes the results of all of the sensitivity analyses for the unconstrained funding case.

Table 49: Sensitivity Results, Unconstrained Funding

	Baseline		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
ALT #	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK
1	64.0	6	63.9	6	63.5	6	73.7	3↑	55.0	6
2	70.0	4	66.7	3↑	75.0	4	78.9	2↑	62.5	4
5	66.0	5	66.7	3↑	72.9	5	73.7	3↑	57.5	5
14	79.0	1	75.0	1	84.4	1	82.9	1	73.8	1
15	71.0	3	66.7	3	78.1	3	72.4	6↓	63.8	3
16	72.0	2	69.4	2	79.2	2	73.7	3↓	65.0	2
17	58.0	7	50.0	7	39.6	7	55.3	7	47.5	7
	Baseline		**Scenario 5**		**Scenario 6**		**Scenario 7**		**Scenario 8**	
ALT #	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK
1	64.0	6	65.2	5↑	53.3	5↑	63.0	6	60.0	4↑
2	70.0	4	67.4	4	61.7	4	70.7	4	65.0	3↑
5	66.0	5	63.0	7↓	53.3	7↓	66.3	5	70.0	1↑
14	79.0	1	77.2	1	75.0	1	80.4	1	70.0	1
15	71.0	3	70.7	3	66.7	2↑	71.7	3	55.0	6↓
16	72.0	2	71.7	2	66.7	2	72.8	2	60.0	4↓
17	58.0	7	63.0	7	50.0	6↑	58.7	7	40.0	7

Rank indicates the alternatives' order based on scoring with a rank of 1 corresponding to the highest score.

Arrows indicate increase (↑) or decrease (↓) in rank relative to baseline rank.

In Scenarios 2, 4, and 7, there was no change to rank order. Scenario 2 emphasized earlier completion of HLW treatment, which lowered scores for the longer mission durations of Alternatives 1 and 17. Scenario 4 removed Evaluation Criterion 1 because it was not a differentiator between the alternatives. Unsurprisingly, the alternatives scores changed but their relative rankings did not. Scenario 7 removed evaluation criteria related to the volumes of ILAW and IHLW produced and had no effect on the rank order of the alternatives.

In Scenario 1, all evaluation criteria are weighted equally. Without the influence of weighting, Alternatives 2 and 5 rise in ranking to 3 to tie Alternative 15. Other rankings remained the same

In Scenario 3, cost (both TPC and LCC) is deemphasized. Alternative 14 remains the highest score. This is primarily because of better scores for risk (EC-3) and operational flexibility. Alternative 2 is the next best with a ranking score of 2, also based primarily on better risk scores.

The removal of Evaluation Criterion 6 (Increased flexibility within the tank farm system) in Scenario 5 caused Alternative 5 to drop to the lowest ranking, tied with Alternative 17. Alternative 5 was rated *Fully Meets* and Alternative 17 was rated *Doesn't Meet* for EC-6 in the baseline case. It therefore makes sense that removing EC-6 results in Alternative 17 scoring the same as Alternative 5 for Scenario 5.

Limiting evaluation criteria to differentiable cost, schedule, and risk in Scenario 6 caused Alternative 5 to drop to the lowest rank. Alternatives 1, 15, and 17 each rose by one rank under this scenario. Alternative 14 remained the highest rank.

Scenario 8 considered only criteria that were based on technical model outputs without consideration for cost, schedule, or risk. Because Alternatives 5 and 14 are identical from a model flowsheet perspective, their scores were identical.

It is noteworthy that, in the unconstrained funding case, Alternative 14 is ranked the highest for all scenarios and Alternative 17 is nearly always ranked the lowest.

9.4.4 SENSITIVITY SCENARIOS FOR THE CONSTRAINED FUNDING CASE

In the constrained funding case, hot commissioning of the HLW Vitrification Facility cannot be completed in the timeframe specified in the ACD (12/31/2033) for some alternatives. Since the process modeling performed by WRPS was based on the unconstrained funding case and assumed completion of the HLW Vitrification Facility, a LAWST Facility and the start of HLW treatment on 12/31/2033, the process modeling results are not applicable to the constrained funding case since there are inadequate funds available to construct and operate a LAWST Facility under that scenario. As a result, the alternatives for the constrained funding case cannot be evaluated against many of the evaluation criteria that are dependent on the timing of tank waste processing operations. These criteria include EC-4 through EC-9. Additionally, the operational risks that were evaluated as part of EC-3 in the unconstrained funding case cannot be evaluated in the constrained funding case.

Scenario 9 increases the relative importance of early completion of the HLW Vitrification Facility by leaving EC-1 at Highest Importance, and dropping ECs 2 and 3 to Medium Importance. In scenario 10, the relative importance of TPC is increased by leaving EC-2 at Highest Importance, and dropping ECs 1 and 3 to Medium Importance. In scenario 11, the relative importance of technical and programmatic risk is increased by leaving EC-3 at Highest Importance and dropping ECs 1 and 2 to Medium Importance. Scenario 12 compares the scoring results for the constrained funding case against the unconstrained funding case using only the three evaluation criteria that are considered in the constrained funding case - TPC, project/technical and programmatic risks, and start of HLW treatment operations – each rated Highest Importance. Evaluation of EC-3 was modified to only consider risks through CD-4 and the start of HLW treatment operations, meaning that the operational risks were not evaluated.

The changes in the importance and weighting of the evaluation criteria for Scenarios 9 – 12 are shown in Table 50, Table 51, Table 52, and Table 53.

Table 50: Scenario 9 Emphasize Earlier Completion of HLW Vitrification Facility Hot Commissioning

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Highest Importance	5	1.667	55.56
EC-2	Lower HLW project TPC range	Medium Importance	2	0.667	22.22
EC-3	Lower operational, technical, and programmatic risk	Medium Importance	2	0.667	22.22

Table 51: Scenario 10 Emphasize Lower HLW Project TPC

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Medium Importance	2	0.667	22.22
EC-2	Lower HLW project TPC range	Highest Importance	5	1.667	55.56
EC-3	Lower operational, technical, and programmatic risk	Medium Importance	2	0.667	22.22

Table 52: Scenario 11 Emphasize Lower Technical and Programmatic Risk

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Medium Importance	2	0.667	22.22
EC-2	Lower HLW project TPC range	Medium Importance	2	0.667	22.22
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	1.667	55.56

Table 53: Scenario 12 Comparison of Constrained and Unconstrained TPC, Non-Operational Risk, and HLW Treatment Start

#	Evaluation Criteria	Importance	Weight	Relative Weight	Normalized Relative Weight
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	Highest Importance	5	1.667	33.33
EC-2	Lower HLW project TPC range	Highest Importance	5	1.667	33.33
EC-3	Lower operational, technical, and programmatic risk	Highest Importance	5	1.667	33.33

9.4.5 SENSITIVITY RESULTS FOR THE CONSTRAINED FUNDING CASE

The sensitivity analysis results for the constrained funding case are shown in Table 54. The relative rank order remains unchanged except when comparing the constrained and unconstrained funding cases. Alternative 17 consistently scores significantly higher by virtue of its lower TPC and composite risk score, as well as earlier completion of hot commissioning of the HLW Vitrification Facility.

Table 54: Sensitivity Results, Constrained Funding

	Baseline		Scenario 9		Scenario 10		Scenario 11		Scenario 12	
ALT #	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK
2	41.7	4	44.4	4	36.1	4	44.4	4	58.3	4
14	41.7	4	44.4	4	36.1	4	44.4	4	66.7	2↑
15	50.0	2	63.9	2	55.6	2	55.6	2	66.7	2
16	50.0	2	63.9	2	55.6	2	55.6	2	66.7	2
17	91.7	1	94.4	1	94.4	1	86.1	1	91.7	1

Rank indicates the alternatives' order based on scoring with a rank of 1 corresponding to the highest score.

Arrows indicate increase (↑) or decrease (↓) in rank relative to baseline rank.

10 Conclusions

Overall AoA results of the WTP HLW AoA are summarized in Table 55 and Table 56.

In the unconstrained case, Alternative 14 scores the highest. Alternative 14 has the second lowest TPC, a lower relative risk profile, the lowest LCC, and completes HLW treatment at relatively the same time as other alternatives. The next grouping of alternative scores, which are lower than Alternative 14 by at least seven points, are Alternatives 16, 15, and 2, by rank order. Alternatives 1 and 5 are the next grouping lower by at least six points. Alternative 17 scores the lowest.

In the constrained case, the scoring landscape is much different. Because Alternative 17 is able to start HLW treatment earlier, has the lowest TPC, and has the lowest risk profile, it scores the highest by a wide margin. It is important to note, however, that the constrained case results are based on the point estimate values for new facilities. If the high-end cost ranges are realized, all alternatives except for Alternative 17 would become non-viable due to funding constraints. Even so, Alternative 17 would be challenging to accomplish due to limited funding.

Table 55: AoA Results - Unconstrained Funding

#	Weighted Score	Start Date HLW Treatment Operations	Total Project Cost ($B)	Project / Technical Risk	Operational Risk	Programmatic Risk	Life Cycle Cost (PV, $B)	Complete HLW Treatment	Increased Operational Flexibility	# IHLW Canisters Produced	# ILAW Canisters Produced	Peak Annual Volume of Secondary Liquid Effluent Produced
1	64.0	12/31/2033	38.0	Moderate	Moderate	Moderate	151	08/2084	Somewhat Meets	9,500	93,900	17 Mgal
2	70.0	12/31/2033	41.0	Low	Moderate	Moderate	125	07/2061	Fully Meets	8,200	101,400	34 Mgal
5	61.0	12/31/2033	39.3	Moderate	Moderate	Moderate	123	09/2064	Fully Meets	9,500	97,800	30 Mgal
14	79.0	12/31/2033	33.9	Low	Moderate	Moderate	119	09/2064	Fully Meets	9,500	97,800	30 Mgal
15	71.0	12/31/2033	35.2	Moderate	Moderate	Moderate	121	05/2064	Generally Meets	8,100	103,600	32 Mgal
16	72.0	12/31/2033	35.6	Moderate	Moderate	Moderate	121	10/2062	Generally Meets	8,100	102,000	31 Mgal
17	58.0	12/31/2033	9.0	Low	Moderate	Moderate	423	2168+	Doesn't Meet	14,900+	67,000+	8 Mgal

Table 56: AoA Results - Constrained Funding

#	Weighted Score	Start Date HLW Treatment Operations	Total Project Cost ($B)	Project / Technical Risk	Programmatic Risk
2	41.7	FY 2036	12.8	Moderate	High
14	41.7	FY 2036	12.6	Moderate	High
15	50.0	FY 2035	11.5	Moderate	High
16	50.0	FY 2035	11.8	Moderate	High
17	91.7	FY 2034	8.9	Low	Moderate

11 Analysis of Alternatives Team

The following sections identify the overall AoA Team, including the Government team, the SME team, and other contributors to the analysis.

11.1 Analysis Team

The AoA Team was comprised of experienced SMEs and government staff members charged with executing the AoA. The AoA Team was supported by a panel of SMEs who provided technical information to the team conducting the AoA. There were also other government staff members participating in the AoA process as stakeholders, independent reviewers, and technical advisors. The ECMS Team was led by Matt Champagney and supported by several experienced SMEs as shown in Table 57.

Table 57: ECMS Team

Name	Organization	Role
Matt Champagney	Parsons	AoA Team Lead
Scott Kubaryk	Parsons	AoA Coordinator
Chris Davis	JGMS	Risk & Evaluation Lead
Chris Gruber	JGMS	Life Cycle Cost Estimating
Melanie McAnally	Parsons	Schedule
Tracy Cangelosi	Parsons	Evaluation Support
Jack Kasper	JGMS	Technical SME
Jon Tanke	JGMS	Technical SME, ORP Coordination
Brad Knutson	Parsons	Technical SME
Brad Hartl	Parsons	Architectural Support
Stan George	Parsons	Architectural Support

The government staff was responsible for approving the evaluation factors and screening criteria, providing scoring and risk rating input, and governing the process to ensure independence and compliance with all the applicable guides, directives, best practices, and memoranda. The government team included the following individuals listed in Table 58. EM and ORP have established a Steering Committee to provide direction and guidance to the AoA team. The Steering Committee (Table 59) reviewed and approved the Study Plan and AoA Report.

Table 58: Government Team

Name	Organization	Role
Kaylin Burnett	ORP	Federal AoA Lead
Wahed Abdul	ORP	Federal Project Director
Anne McCartney	ORP	Federal Analysis Support

Table 59: Steering Committee

Name	Organization	Role
Thomas Fletcher	ORP	Committee Chair
Paul Bosco	DOE-PM	Member Representative DOE-PM
Robert Raines	NNSA	Member Representative NNSA APM
Steven Ho	CEPE	Member Representative CEPE
Randall Hendrickson	CFO	Member Representative CFO
James Owendoff	CFO	Member Representative CFO

Additional personnel participated in meetings to provide subject matter expertise in operational or site information but were not part of the scoring or voting process. The list of federal and non-federal SMEs who supported the AoA is presented in Table 60.

Table 60: Supporting SMEs

Name	Organization	Role
Albert Kruger	ORP	Vitrification SME
Alec Schubick	WRPS	Modeling SME
Ben Harp	ORP	AoA Support
Chris Musick	Bechtel	Subject Matter Expert
Craig Whiteley	ORP/Consultant	AoA Support
Dan McDonald	Department of Ecology	Regulatory Perspective
Gary Younger	ORP	AoA Support
Isabelle Wheeler	ORP	AoA Support
Ivan Papp	ORP	Vitrification SME
Jeanne Bernards	WRPS	Life Cycle Cost SME
Jeff Trent	Contractor Support to ORP	Subject Matter Expert
Jeremy Johnson	ORP	AoA Support
John Julyk	Bechtel	Subject Matter Expert
John Vienna	PNNL	Subject Matter Expert
Linda Bergmann	WRPS	Modeling SME
Mat Irwin	ORP	AoA Support
Michaella Swinhart	ORP	AoA Support
Mike Johnson	ORP/Northwind Solutions	AoA Support
Naseeha Cardwell	ORP	AoA Support
Nathan Denney	ORP	AoA Support
Richard Valle	WRPS	Existing Facilities SME
Sean Reaksecker	WRPS	Modeling SME
Steve Beehler	Contractor Support to ORP	Subject Matter Expert
Stuart Arm	PNNL	Subject Matter Expert
Vic Callahan	ORP	AoA Support
Wahed Abdul	ORP	AoA Support

APPENDIX A: ALTERNATIVE SCOPE DESCRIPTIONS AND PROCESS FLOWSHEETS

1 Summary

This appendix describes the high-level waste (HLW) processing alternatives that were fully evaluated by the Waste Treatment and Immobilization Plant (WTP) HLW Analysis of Alternatives (AoA) Team. The alternatives that were chosen to be fully evaluated are those that met all three screening criteria, remained technically feasible as they were defined in more detail, and were not removed from consideration by the AoA Steering Committee. The alternative descriptions provided herein identify the waste processing functions and associated facilities assumed to be required for the HLW processing alternative that were selected for evaluation by the HLW AoA Team. The alternative selection/screening process is further described in Appendix D.

For purposes of defining the HLW processing alternatives, the term "waste processing" is assumed to include all functions necessary to retrieve, treat, and dispose[13] of waste currently stored in the Hanford Site Single-Shell Tanks (SSTs), Double-Shell Tanks (DSTs), and Inactive Miscellaneous Underground Storage Tanks (IMUSTs) as described in the River Protection Project (RPP) Mission Analysis Report[gg]. Tank waste that is currently characterized as transuranic waste is assumed to be processed independent of the HLW and Low-Activity Waste (LAW) processing operations and is not considered within the AoA scope. Tank waste that is not classified as transuranic waste is classified as either LAW or HLW.

During HLW feed preparation and pretreatment, low-solids liquids are removed from the HLW feed stream and are returned to the DST system for processing as LAW. Additionally, during LAW feed preparation and pretreatment, high-activity liquids and solids are removed from the LAW feed stream and returned to the DST system for processing as HLW. HLW and LAW processing operations are therefore closely coupled and are performed in parallel. Completion of HLW processing necessarily requires completion of LAW processing. The reverse also is true – completion of LAW processing also requires completion of HLW processing. To understand the interdependencies between HLW and LAW processing, the LAW processing functions and facilities also are described in this document, albeit in more general terms.

The focus of this document is on the HLW processing functions and facilities. The lower-level (i.e., more detailed) processing functions and processing facilities are described in the following sections of this appendix. The facility descriptions in Appendix B describe the preconceptual design features and facility layout drawings for the new and repurposed facilities that would be required for HLW processing for each alternative.

The higher-level HLW processing functions include all major waste processing steps (functions) beginning with retrieval of sludge from the tanks and concluding with interim storage of immobilized HLW (IHLW). These high-level HLW processing functions include:

- Interim storage of waste in existing tanks (DSTs, SSTs, and IMUSTs)
- Mobilization and retrieval of waste from existing tanks
- Characterization (sampling, sample analysis, and evaluation of sample results for compliance with the WTP Waste Acceptance Criteria [WAC])[j]
- Segregation (solid/liquid separation), mixing, blending, and staging slurry for waste feed delivery (WFD)

[13] Dispose in the context of this AoA is clarified as follows: For HLW, 'dispose' functions include storing IHLW canisters onsite on an interim basis at the IHS Facility until they are shipped to an offsite geological repository from the HSF for final disposal; storing spent HLW melters at or near the IHS Facility (final disposal pathway is TBD); and packaging and storing of TSCR and TFPT Facility spent IX columns on concrete pads to be constructed in the 200 East Area near the AP Tank Farm (final disposal pathway is TBD). Excluded from the AoA scope is shipping of IHLW canisters from the HSF and receiving and placing (disposing) of IHLW canisters at an offsite geological repository. For LAW, 'dispose' functions include storing ILAW containers and spent LAW melters at the IDF (a 200 Area landfill); disposing treated LAW liquid effluents at the SALDS (a near-surface LLW repository); and disposing of evaporator solids at the ERDF or IDF.

- Pretreatment
- Treatment (i.e., vitrification in HLW Vitrification Facility)
- Interim storage of IHLW canisters and spent HLW melters
- Concentration of secondary low-activity liquid effluents by evaporation

The LAW processing functions are the same as the HLW processing functions, with the following exceptions:

- LAW fraction (supernate) is segregated from the HLW fraction (slurry) in the DST system.
- LAW treatment occurs in the LAW Vitrification Facility and in the LAW Supplemental Treatment (LAWST) Facility.
- Immobilized LAW (ILAW) containers and spent melters are disposed of on site.

The processing functions and facilities needed for retrieval of the DSTs, SSTs, and IMUSTs are the same for all HLW processing alternatives and were outside of the scope of the HLW AoA. The processing functions and facilities described in this appendix were therefore limited to the following processing functions and facilities:

- Interim storage of sludge and supernate within the DSTs
- Sludge mobilization in the source DSTs
- HLW feed staging in designated DSTs
- HLW feed characterization (facilities vary by alternative)
- HLW feed pretreatment (facilities vary by alternative)
- Concentration of pretreated HLW feed in HLW Effluent Management Facility (HEMF) (Alternative 16 only)
- Concentration of HLW liquid effluents (facilities vary by alternative)
- Vitrification of pretreated slurry in HLW Vitrification Facility
- Interim storage of IHLW canisters in Interim Hanford Storage (IHS) Facility
- Interim storage of spent HLW melters on storage pad(s) adjacent to the IHS Facility
- Staging secondary liquid effluents (process condensate and leachate) in Liquid Effluent Retention Facility (LERF) and treatment in Effluent Treatment Facility (ETF)

The requirements for immobilizing HLW are codified in Title 40 Code of Federal Regulations (CFR) 268.42. Treatment standards are expressed as specified technologies. The technology specified in this code for immobilization of HLW is vitrification. Since the HLW Vitrification Facility is being constructed for this purpose, all HLW processing alternatives assume use of this facility for HLW vitrification.

LAW treatment operations are planned to begin once hot commissioning of the LAW Vit Facility has been completed. The LAW processing operations that occur prior to starting HLW treatment is referred to as Direct Feed LAW (DFLAW). It is assumed that the LAW Vit Facility provides the only LAW treatment capability during DFLAW.

It is further assumed that HLW treatment operations will start immediately after completion of hot commissioning of the HLW Vit Facility. Subsequent HLW and LAW processing operations after the start of HLW treatment are referred to as balance of mission (BoM), During the BoM phase the LAW pretreatment and treatment processing rates will are assumed to increase to keep pace with HLW processing. LAWST is assumed to provide the additional LAW treatment capability during BoM. Since the LAWST treatment technology has not been selected, and since a project has not been established to design and construct a new facility to provide the LAWST capability, the LAWST capability and facility is only described in general terms in Appendices A and B.

The HLW process alternatives that are described in Appendices A and B are those that were determined to satisfy the preestablished screening criteria for the AoA. The alternatives that were selected for further evaluation are listed in Table 61.

Table 61: WTP HLW AoA Alternatives

#	Alternative Name
1	HLW Characterization and Staging in New Tank Waste Characterization and Staging Facility (TWCSF) and HLW (and LAW) Pretreatment in Pretreatment (PT) Facility (Baseline Case)
2	HLW Pretreatment and Effluent Management in New HLW Feed Preparation and Effluent Management (HFPEM) Facility
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility
15	Direct Feed HLW (DFHLW) from DSTs and Effluent Management in New HEMF
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF
17	DFHLW from DDSTs without HLW Effluent Management

Except for Alternative 17, each alternative provided similar processing functions, but assigned the functions to different existing, planned, new, or repurposed facilities. Alternative 17 was constrained to limit capital cost to the minimum amount necessary to start HLW processing and does not include the same LAW pretreatment and treatment and LAW and HLW effluent management capabilities provided by the other alternatives. Table 62 identifies the lower-level HLW processing functions and the assignment of these functions to the facilities assumed for each alternative.

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Table 62: Comparison of Processing Functions by Facility

Alt No	HLW Process Function / Alternative Title	Mixing	Characterization[14]	Initial Solids & Liquids Separation[15]	Caustic Leaching	Solids Washing	Feed Concentration	Filtration	Staging for Delivery to HLWV	Effluent Management	Vitrification
1	HLW Characterization and Staging in New TWCSF with HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)	E-DST & TWCSF	TWCSF	PT	PT	PT	PT	PT	PT	PT	HLWV
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	E-DST & HFPEM	HFPEM	HFPEM	HFPEM	HFPEM	HFPEM	N/A	HFPEM	HFPEM	HLWV
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	E-DST & RPT	E-DST	RPT	RPT	RPT	RPT	RPT	RPT	RPT	HLWV
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	E-DST & HFPEM	E-DST	HFPEM↓	HFPEM↓	HFPEM↓	HFPEM↓	HFPEM↓	HFPEM↓	HFPEM↓	HLWV
15	DFHLW from DSTs and Effluent Management in New HEMF	E-DST	E-DST	E-DST	E-DST	E-DST	N/A	N/A	E-DST	HEMF↓	HLWV
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	E-DST	E-DST	E-DST	E-DST	E-DST	HEMF	N/A	E-DST	HEMF↓	HLWV
17	DFHLW from DSTs without HLW Effluent Management[16]	E-DST	E-DST	E-DST	N/A	E-DST	WTV	N/A	WTV	N/A	HLWV

DFHLW - Direct Feed HLW
DST - Double Shell Tank
E - East Area
WTV – Waste Transfer Vault

HLWV - WTP HLW Vitrification Facility
PT - Pretreatment (Facility)
RPT - Repurposed PT Facility
TWCSF - Tank Waste Characterization and Staging Facility

[14] Characterization in this context refers to obtaining and transferring HLW slurry feed samples for analysis in the 222-S Laboratory to accomplish qualification to ensure slurry meets the requirements WTP WAC[i] before transfer.
[15] 'Initial Solids/Liquid Separation' in this context refers to initial settling/decant operations recognizing that additional settling/decant operations are required to support caustic leaching, solids washing, and feed concentration.
[16] Under Alternative 17, slurry is concentrated by settling and decanting in an HLW feed concentration tank to be installed in a Waste Transfer Vault. The concentrated slurry is transferred to the HLW Vitrification Facility where only one melter is used to vitrify the HLW feed.

Process flowsheets were developed to depict the movement of the HLW, LAW, and other waste streams between the processing facilities for each alternative. These process flowsheets also identify which processing facilities are existing, repurposed, planned, or proposed. For the purposes of the WTP HLW AoA, these terms are defined as follows:

- Existing Facility – Facility that is operational, constructed, or under construction, and is intended to be used to perform the mission for which it was designed.
- Repurposed Existing Facility – Facility that meets the definition of an existing facility but is being modified to serve a purpose that was not intended and is not described in the *Facility Technical Baseline*[cc].
- Planned New Facility – Facility that is described in the *River Protection Project System Plan 8*[cc] and has an approved mission need (i.e., critical decision [CD-0] ["Approve Mission Need"] was approved) per DOE Order (O) 413.3B, *Program and Project Management for the Acquisition of Capital Assets*), but is not authorized to start full construction (i.e., CD-3 not approved).
- Proposed New Facility – Facility that is not specifically described in *System Plan 8*[cc] that is proposed by the Enterprise Construction Management Services (ECMS) AoA Team to provide waste processing capabilities that do not currently exist.

Waste processing in all alternatives requires use of some existing facilities, including DST facilities (referred to as the "DST system") and the HLW Vitrification Facility. These existing facilities will require significant modifications and upgrades to perform the required functions for HLW characterization, pretreatment, and treatment (waste immobilization). The design assumptions used to identify the scope of the facility modifications and upgrades are summarized in this document and described in more detail in Appendix B.

Each facility depicted in the process flowsheets is identified by a number. These numbers correlate to a section number in the following alternative descriptions. The alternative descriptions identify the tank waste processing functions and provide a brief description of the facilities that provide these functions.

Appendix B identifies the design assumptions and the preconceptual facility layout and configuration that the AoA Team used for the alternative evaluation process, including the cost estimates. To assist in development of the cost estimates, preconceptual drawings also were developed for the new HLW processing facilities. These preconceptual drawings also were prepared to show where the new pretreatment vessels and equipment would be located within the repurposed Pretreatment (PT) Facility for Alternative 5. The preconceptual drawings developed to support the AoA are included in Appendix B.

The detailed descriptions of the processing functions in this appendix and the descriptions of the processing facilities in Appendix B, are pre-decisional in nature. This information was developed for the purposes of alternative definition and evaluation and for development of cost and schedule estimates. Once a decision is made on which alternative to pursue, additional design development and nuclear safety analysis will be required before starting conceptual design for new facility or redesign for existing or repurposed facilities.

The AoA Team developed process flowsheets for each alternative. These flowsheets were used by Washington River Protection Solutions (WRPS) to perform process and cost modeling analyses to support the AoA Team. The inputs and assumptions used for this modeling effort are documented in Modeling Request Forms and in AoA Model Results Report. Although minor changes were made to facility terminology after the WRPS modeling effort, these differences do not affect the modeling results.

2 Alternative 1 – HLW Characterization and Staging in New TWCSF with HLW (and LAW) Pretreatment in PT Facility (Baseline Scenario)

In Alternative 1, HLW sludge from the DST system is sampled, characterized, and staged in a new TWCSF. The PT Facility pretreats the HLW feed received from the TWCSF (note this includes a "modified baseline" that assumes the PT Facility is modified to address the DNFSB TIs[o]). The pretreated slurry from the PT Facility is sent to the HLW Vitrification Facility to be vitrified.

The process flow for Alternative 1 is depicted in Figure 1. The results from the process modeling for Alternative 1 are provided in the *HLW AoA Model Results Report*[k]. In Alternative 1, the tank waste treatment mission completes in 08/2084. This is 23 years later than Alternative 2, and 20 to 22 years later than Alternatives 5, 14, 15, and 16. The reason for the longer mission duration is that HLW processing is restricted by the capacity of the PT Facility. The HLW Vitrification Facility can only operate at approximately 50% of design capacity because of the limited HLW feed rate from the PT Facility. Because of the DST space availability constraints throughout the mission, SST retrievals are not completed until 06/2073 in Alternative 1. This is 17 years later than Alternative 2, and 14 to 16 years later than Alternatives 5, 14, 15, and 16.

2.1 HLW Feed Sampling, Characterization, and Staging

In Alternative 1, slurry in the DST system is transferred to a designated HLW Feed Tank within the DST system. These designated DSTs will stage feed for delivery to the TWCSF. The slurry from the designated HLW Feed Tank is received in one of six Characterization and Staging Vessels in the TWCSF. It is assumed that supernate will be decanted after settling, and the remaining slurry will be mixed and sampled. After the sample results are evaluated for compliance with the WTP WAC, the slurry is transferred from TWCSF to one of the HLW Lag Storage and Feed Blending Process (HLP) Vessels (HLP-VSL-00022A/B/C/D) within the PT Facility on an as-needed basis.

The TWCSF functions are described in the *Mission Analysis Report for Waste Feed Delivery*[gg]. The proposed facility layout and configuration of the vessels required for the facility are described in a follow-on *Tank Configuration Study*[hh]. This Study identifies the need for either a grade level or below-grade concrete vault for secondary containment of the process vessels and a pump and valve pit to facilitate transfers between the TWCSF vessels and between the TWCSF and the DST system and the PT Facility.

It should be noted that the HLW storage capability within TWCSF is assumed to be comprised of vessels designed and fabricated in accordance with American Society of Mechanical Engineers (ASME)[l, m]. Although the *Mission Analysis Report* and the *Tank Configuration Study* refer to "tanks," the AoA Report uses the term "vessels" for storage of HLW or high-activity or high-solids radioactive liquid waste in new facilities. The use of the term "tank" is restricted to storage of radioactive liquid waste within existing Tank Farm facilities (e.g., DSTs, SSTs, IMUSTS) or for storage of low-activity and low-solids liquid waste or non-radioactive liquids in new facilities.

The TWCSF vessels will contain a high radioactive material inventory (material at risk [MAR]). It is assumed that the MAR level will require that the facility be classified as Hazard Category 2. It also is assumed that the facility would need to be designed to Seismic Category-I requirements for protection from Natural Phenomena Hazards (NPH). Based on the need for safety-class (SC) structures, systems, and components (SSCs) for accident prevention/mitigation in the PT and HLW Vitrification Facilities, it is also assumed that the TWCSF will require similar SC SSCs.

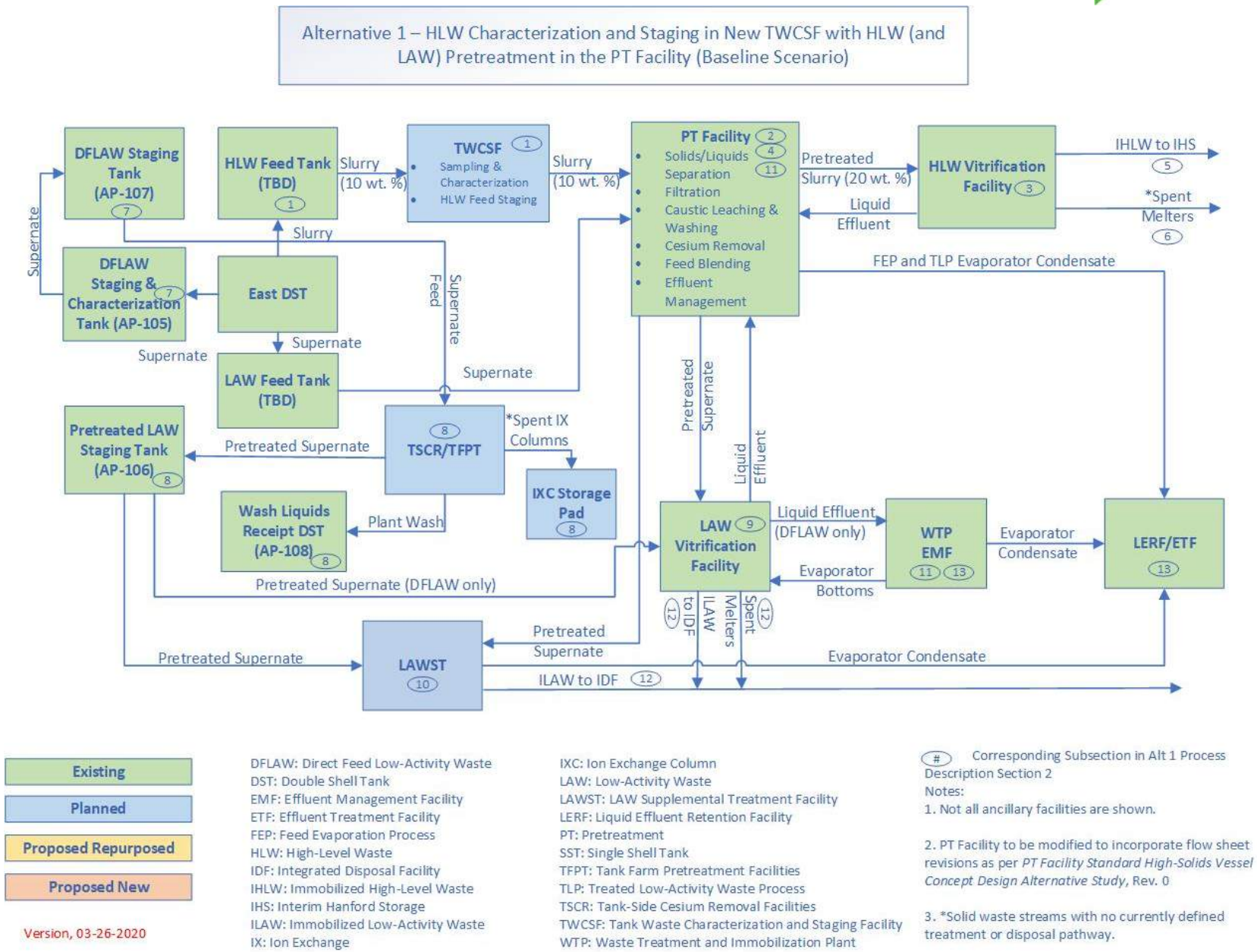

Figure 8: Alternative 1 Process Flow

These SC systems for TWCSF are assumed to include:

- Primary (vessels) and secondary confinement (vaults),
- Active vessel ventilation,
- Active confinement ventilation exhaust,
- Post-Design Base Event (DBE) vessel air sparging,
- Emergency electrical power, and
- Safe-shutdown monitoring and control.

The DST system infrastructure will need to be upgraded and modified to provide the capability to prepare HLW feed for delivery to the TWCSF. These upgrades and modifications include:

- Installation of mixer and slurry transfer pumps in the DSTs designated for preparation of HLW feed
- Refurbishment of pump and valve pits and leak detection pits
- Installation of new jumpers and valve manifolds
- Waste transfer pipeline integrity testing
- Waste transfer pipeline support system and component (e.g., cathodic protection, leak detection, risers) repairs/replacement
- Upgrades to Tank Farm primary and annulus ventilation systems
- Installation and routing of utility SSCs (e.g., electrical power, raw water, demineralized water, fire water, chemical addition, compressed air, instrumentation for remote monitoring); some new or upgraded SSCs may be classified as safety-significant (SS) or SC if required by the criticality and safety analyses.

The required DST system upgrades and modifications are described in more detail in Appendix B.

In addition to the physical upgrades of DSTs and associated infrastructure, the DSTs may require "integrity assessments" to evaluate the current condition of the tanks and their capability to perform any feed preparation or pretreatment functions. The specific requirements for DST integrity assessments are identified in a letter from the State of Washington Department of Ecology to the Office of River Protection (ORP) dated February 7, 2020[n].

The TWCSF is not part of the scope approved at Critical Decision 2 (2003) or Baseline Change Proposal 1 (2006) and represents a deviation from the Code of Record. The TWCSF is part of the current planned strategy to provide a consistent HLW waste feed that meets the WAC. The concept of a TWCSF emerged as the option to provide the needed connectivity and bridge any technical gaps both within the Hanford Tank Farms and between the Hanford Tank Farms and the WTP complex.

The existing Tank Farm DST configuration and aging infrastructure limits its capacity and capability to adequately mix, intentionally blend, precondition (where needed), accurately sample, and stage tank waste contents to meet the throughput demands of WTP. Scaled tank mixing and sampling performed by the national laboratories and Tank Farm contractor over a 5-year period demonstrated poor or inconclusive results, and when coupled at that time with narrowing WTP WAC requirements, potential internal line plugging, and corrosion challenges within WTP, the TWCS capability emerged as a viable inclusion in the RPP flowsheet.

No Tank Farm full-scale testing program had been envisaged; the government accepted the risk of using an existing DST, namely 241-AY-102, as the designated hot commissioning tank until its demise in 2012. This tank was also assumed to have a future mission as the waste feed staging and sampling tank for up to nine fill-mix-empty cycles. The prior strategy then had been to retrofit 22 of the 28 DSTs and associated Tank Farm infrastructure at an estimated cost of $955M (2012 data). The System Plan 6 baseline assumed all 28 tanks were fully operational for the 40-year treatment mission; sludge depth was maintained below limits that would not impede mixer pump installation; and two new Waste Receipt Facilities (WRF) would be operational in 2020. The TWCSF would replace the WRF in East Area.

2.2 HLW and LAW Feed Pretreatment in the PT Facility

With the exception of modifying the PT Facility to resolve the Defense Nuclear Facilities Safety Board (DNFSB) technical issues (Tis), Alternative 1 is the same as the Baseline Scenario (or Case) as described in the RPP System Plan 8[cc].

Design and construction of the PT Facility was put on hold in 2012 to resolve TIs identified by the DNFSB. Alternative 1 assumes that the PT Facility design will be revised to address TIs 1-8. These design changes are described in the *PT Facility Alternative Study*[o]. This study describes the changes to the pretreatment process functions and the facility flowsheet. The revised pretreatment functions are summarized below.

The LAW feed is blended with the HLW feed in a UFP-VSL-00001A/B vessel and transferred to a UFP-VSL-00002A/B vessel. The blended feed in UFP-VSL-00002A/B is concentrated by recirculation through an ultrafilter in the Ultrafiltration Process (UFP) system. The liquid permeate is bled off the filtration loop and collected in UFP-VSL-00062A/B/C where it is staged for Cs (cesium) removal in the Cs Ion Exchange Process (CXP) system. Once the solids concentration in UFP-VSL-00002A/B reaches the desired level, the slurry is leached if required.

If the Aluminum (Al) concentration of the solids meets the criteria for caustic leaching, the slurry in the UFP filtration vessel is heated to 60°C (140°F) and 19 M NaOH (sodium hydroxide or caustic) is added. After recirculating the mixture for a predetermined period, the slurry is cooled to 45°C (113°F). After cooling, the slurry is concentrated to approximately 20 weight % (wt %). The concentrated slurry is then washed by adding process condensate to UFP-VSL-00002A/B in 1 kilogallon (kgal) increments and recirculating the contents in the filtration loop to concentrate the mixture to 20 wt %. The washed slurry in the UFP vessel is sent to one of the HLP feed blending vessels (HLP-VSL-00028 A/B/C) where it is staged for delivery to HLW Vitrification Facility.

The UFP permeate in UFP-VSL-00062A/B/C is recirculated through a heat exchanger to increase temperature before cesium removal in the CXP system. The cesium-depleted permeate is collected in one of the permeate collection vessels (CXP-VSL-00026 A/B/C). The cesium-depleted liquid from the ion-exchange (IX) columns is collected in CXP-VSL-00026 A/B/C and sent to the Treated LAW Process (TLP) system evaporator.

The TLP evaporator concentrates the LAW feed to a specific gravity of approximately 1.33 or a sodium (Na) molarity of approximately 7. The concentrated LAW feed is collected in the Treated LAW Concentrate Storage Process (TCP) Vessel (TCP-VSL-00001) where it is staged for delivery to the LAW Vitrification Facility or the LAWST Facility. The low-activity condensate from the TLP evaporator is collected in one of the Radioactive Liquid Waste Disposal (RLD) tanks (RDL-TK-00006 A/B). The condensate in RLD-TK-00006 A/B is then transferred to the LERF.

The high-activity eluate from the CXP IX columns is sent to one of the Cs (cesium) Nitric Acid Recovery Process (CNP) Vessels (CNP-VSL-00003/4). After pH adjustment, the high-activity eluate is sent to one of the HLP feed blending vessels where it is blended with the concentrated solids.

The PT Facility scope of work for the Baseline Case also includes supplying utility and process support services to the HLW Vitrification Facility (e.g., a shared Control Room and Emergency Response Center, SC sparging air supply to the high-solids vessels, and shared reagent supply and utility services from the WTP Balance of Facilities [BOF]).

2.3 HLW Immobilization in HLW Vitrification Facility

The pretreated slurry from the HLP feed blending vessels in the PT Facility is transferred to one of the HLW Melter Feed Preparation (MFP) Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility. The HLW slurry is blended with glass forming materials in the HLW MFP vessels, and the mixture is sent to one of the Melter Feed Vessels (HFP-VSL-00002/6). The Melter Feed Vessels supply feed to a dedicated HLW melter. The feed slurry is introduced into the top of the melter and forms a cold cap on top of the melter pool. Water and volatile gases are drawn out of the melter by the melter off-gas system. The non-volatiles react to form oxides which become part of the molten glass.

The air-lift system inside the melter transfers the molten glass into a stainless-steel canister. The glass is sampled if required, and the canister lid is welded closed. The canisters are decontaminated with a nitric acid/cerium wash. The

decontaminated canisters are placed in a staging area within the HLW Vitrification Facility. The IHLW canisters in the staging area are then transferred to the IHS Facility.

The HLW Vitrification Facility produces secondary liquid effluents from the off-gas condensate and wastewater from IHLW canister decontamination and from waste transfer line flushes. These liquid effluents are collected in RLD system vessel RLD-VSL-00007/8 in the HLW Vitrification Facility and then transferred to one of the Plant Wash and Disposal (PWD) Vessels (PWD-VSL-00015/16) in the PT Facility.

It is assumed that the HLW melters installed for initial startup of the HLW Vitrification Facility will have a design capacity of 3.0 metric tons glass (MTG)/day each. Once the melters reach their design life, they will be replaced with upgraded melters with a design capacity of 3.75 MTG/day each.

It also is assumed that the HLW Vitrification Facility scope of work will include completion of the Melter Assembly Building (MAB) and other solid waste and equipment import/export upgrades as identified in the *Engineering Study for HLW Options E and F*[ll]. Since the PT Facility is completed per the baseline design, the HLW Vitrification Facility will rely on the utility and operational support services that were intended to be shared by both facilities. These shared services would include the BOF utility supply, Control Room, and Incident Command Post.

2.4 HLW Effluent Management in PT Facility

The PT Facility provides effluent management for the HLW (and LAW) pretreatment process liquid effluents as well as liquid effluents (melter off-gas condensate and wastewater from canister decontamination) from the HLW Vitrification Facility.

Wash and flush solutions from the UFP and CXP systems and the HLW Vitrification Facility and PT Facility liquid effluents are collected in one of the PWD system vessels (PWD-VSL-00015/16). The waste collected in PWD-VSL-00015/16 is transferred to one of the Feed Evaporator Process (FEP) System Vessels (FEP-VSL-00017 A/B) which is fed to the FEP evaporator. Transfer line flush solutions, ultrafilter cleaning liquids, and miscellaneous waste streams from PWD system vessels PWD-VSL-00033 and PWD-VSL-00043 are collected in one of the PWD system vessels (PWD-VSL-00044 A/B). The waste collected in PWD-VSL-00044 A/B is fed directly to the FEP evaporator.

The effluents collected in the PWD vessels are concentrated in the PT Facility FEP system evaporator. The evaporator bottoms (concentrate) are returned to UFP System Vessel (UFP-VSL-00001 C), and the FEP evaporator condensate is collected in one of the RLD system vessels (RLD-VSL-00006 A/B). The FEP evaporator concentrate collected in UFP-VSL-00001 C is transferred to one of the UFP system vessels (UFP-VSL-00001 A/B). The low-activity liquid waste collected in RLD-VSL-00006 A/B is transferred to the LERF/ETF.

2.5 IHLW Storage in IHS Facility

The IHS as described in the *Conceptual Design Report*[mm], and Appendix B includes two storage vaults with a capacity to store 2,016 IHLW canisters each. The design provides the capability to add additional vaults if more canister storage space is required.

The IHLW canisters are loaded into an On-Site Transportation Cask (OTC) in the HLW Vitrification Facility. The OTCs are transported by road to the IHS Facility. The OTC is placed on a transfer bogie in the IHS transfer tunnel. The canisters are removed from the OTC by an overhead transfer crane and placed in a storage rack within a storage vault.

ORP provided direction to the AoA Team to assume that an offsite geological repository, and presumably the necessary transportation infrastructure, is ready to ship and receive IHLW in calendar year [CY] 2034. In preparation for shipment, the IHLW canisters will be loaded into an OTC and transported to a separate Hanford Shipping Facility (HSF).

Although the HSF functions and design details are not developed, it is assumed that the HSF will receive OTCs from the IHS Facility, remove the canisters from the OTC, and load the canisters into off-site transportation containers approved for shipment to an offsite geological repository. The details of the transportation network for IHLW canister shipments,

and for receiving and disposing of the canisters at an offsite geological repository, are outside of the scope of the WTP HLW AoA.

For purposes of the WTP HLW AoA, it is assumed that the Hanford IHLW canisters can be shipped to an offsite geological repository beginning in CY 2034. The IHS Facility provides storage space for 4,032 IHLW canisters[mm]. Since the assumed to start immediately after completion of hot commissioning of the HLW Vitrification Facility (note that for the unconstrained funding case, hot commission of the HLW Vit Facility is assumed to occur on 12/31/2033 per the ACD), the planned IHS will only be required to provide storage capacity for the number of IHLW canisters produced in one year. The average canister production rate for Alternative 1 is approximately 450 canisters per year. With a design storage capacity of 4,032 canisters, the IHS capacity is conservatively sized.

2.6 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not have a defined disposal pathway. The *Tank Closure & Waste Management Environmental Impact Statement (EIS)*[p] assumes that the spent HLW melters will be packaged in an overpack and stored at or near the IHS Facility until a final disposal pathway is established. Per ORP the EIS ROD includes long term storage of spent HLW melters and IHLW canisters pending final disposition in an offsite geological repository or other location which is a decision required at a national level. Hence, DOE HQ would be required to perform a NEPA review on the disposal path since it is a national issue while DOE ORP would be required to do a 'shipment analysis' for shipping spent HLW melters and IHLW canisters from Hanford to the final disposal location(s). The planning baseline regarding final disposal of spent HLW melters and IHLW canisters will be revised as required once DOE has selected the final disposal location(s) and performed the required NEPA review.

2.7 LAW Feed Staging and Characterization in DST System

During the DFLAW phase, supernate from source tanks is sent to a designated DFLAW Staging and Characterization DST (AP-105). The supernate received in AP-105 is mixed and sampled to verify compliance with the WTP WAC. After the sample analysis results are reviewed for compliance with the WTP WAC, the qualified LAW feed is transferred to a designated DFLAW Staging DST (AP-107). Tank AP-107 provides a continuous feed supply to the demonstration Tank-Side Cesium Removal (TSCR) Facility (and to the new TSCR or Tank Farm Pretreatment [TFPT] facilities after the TSCR demonstration phase) via a hose-in-hose waste transfer line.

LAW feed for the PT Facility will be staged and characterized in the same manner as during the DFLAW phase. Additional DSTs will need to be designated to stage and qualify LAW feed for delivery to the PT Facility.

The DST system infrastructure will need to be upgraded and modified to provide the capability to prepare LAW feed for delivery to the TSCR/TFPT Facility and the PT Facility. These upgrades and modifications include:

- Installation of supernate transfer pumps in the DSTs designated for characterization and staging of LAW feed
- Refurbishment of pump and valve pits and leak detection pits
- Installation of new jumpers and valve manifolds
- Waste transfer pipeline integrity testing
- Waste transfer pipeline support system and component (e.g., cathodic protection, leak detection, risers) repairs/replacement
- Upgrades to Tank Farm primary and annulus ventilation systems
- Installation and routing of utility SSCs (e.g., electrical power, raw water, demineralized water, fire water, chemical addition, compressed air, instrumentation for remote monitoring); some new or upgraded SSCs may be classified as SS or SC if required by the criticality and safety analyses.

The required DST system upgrades and modifications are described in more detail in Appendix B.

2.8 LAW Pretreatment in TSCR and TFPT Facilities

For Alternative 1, LAW feed is pretreated in the TSCR or TFPT Facility during the DFLAW phase. Initially, LAW pretreatment will occur in a TSCR Demonstration Facility. If the TSCR demonstration is successful, a new higher capacity TSCR Facility will be constructed and placed in operation 5 years after starting DFLAW. If the TSCR demonstration identifies the need for significant design changes, a new TFPT will be constructed and placed in operation in the same timeframe. Once the PT Facility is operational, LAW feed will be pretreated in the PT Facility in parallel with pretreatment in the new TSCR Facility or TFPT Facility. The pretreated LAW feed from the new TSCR or TFPT Facility and the PT Facility will be provided to the LAW Vitrification Facility as a first priority. The excess pretreated LAW will be provided to the LAWST Facility.

The TSCR design includes solids removal by particulate filters. The solids are backflushed from the filters and the flush solution is transferred to a designated Wash Liquids Receipt Tank in the DST system (AP-108). Cesium is removed from the LAW feed by IX columns with non-elutable resin in a lead, lag, and polishing column configuration. The design capacity/throughput of the first TSCR Demonstration Facility is 5.0 gallons per minute (gpm). The TSCR process design is described in more detail in *Volume 1 of the Integrated Waste Feed Delivery Plan*[q].

IX columns are removed and replaced once the resin capacity limit for absorbing cesium is reached (referred to as column "breakthrough"). At this point, the TSCR Facility is shut down and the spent IX column is replaced. Currently no disposal pathway is identified for the spent IX columns from the TSCR and TFPT Facilities. It is assumed that the spent IX columns will be packaged and stored on concrete pads to be constructed in the 200 East Area near the AP Tank Farm.

Pretreated supernate from the new TSCR or TFPT Facility is transferred to tank AP-106, where it is staged for delivery to the LAW Vitrification Facility. After startup of the LAWST Facility, pretreated supernate from the TFPT Facility will be delivered from Tank AP-106 to the LAWST Facility.

The first TSCR Facility to be constructed and operated is planned to be a demonstration of the TSCR pretreatment capabilities. This demonstration phase for TSCR operations is planned to be completed after five years of operation (12/31/2028). If the TSCR design proves to be efficient, reliable, and scalable, a new higher capacity TSCR Facility will be constructed. If the design requires significant changes, the newly constructed facility will be referred to as the TFPT Facility. For purposes of process modeling, the TFPT Facility is planned to use filters and non-elutable IX columns that would be similar to the TSCR Demonstration Facility. The TSCR Demonstration Facility and the new higher capacity TSCR or TFPT Facility will be Hazard Category 2 nuclear facilities.

The new TSCR or TFPT Facility is assumed to continue to operate after startup of the PT Facility to provide feed to the LAWST Facility. The LAW processing rate in the PT Facility will be sufficient to feed the LAW Vitrification Facility at its design capacity and to provide a fraction of the feed to the LAWST Facility. The TFPT Facility will be required to provide sufficient capacity to make up the deficit in LAW feed to the LAWST Facility from the PT Facility.

In Alternative 1, the HLW processing rate is limited by the PT Facility processing rate. The design capacity/throughput for producing pretreated HLW feed is only sufficient for the HLW Vitrification Facility to operate at approximately half of its design capacity (50% of 7.5 MTG/day). The LAW processing capacity is adjusted as necessary to allow LAW processing to complete at the same time that HLW processing would complete. For Alternative 1, the design capacity of the new TSCR or TFPT Facility is required to be 10.0 gpm (equivalent to 2x the processing rate of the TSCR Demonstration Facility).

2.9 LAW Immobilization in LAW Vitrification Facility

The LAW Vitrification Facility immobilizes the pretreated supernate feed provided by the TSCR/TFPT Facilities (via tank AP-106) or by the PT Facility. The LAW Vitrification Facility process operations are similar to the HLW Vitrification Facility. ILAW containers are decontaminated and staged in a temporary staging area in the LAW Vitrification Facility. The ILAW containers are subsequently transported to the Integrated Disposal Facility (IDF) for disposal.

The volume and the constituents of the secondary LAW generated by the HLW processing facilities are dependent on the HLW pretreatment processes. The ILAW container waste loading and the total volume of ILAW produced (number of ILAW containers) by the LAW Vitrification Facility depends on the HLW processing alternative that is selected. The values for these parameters will be determined based on the WTP HLW AoA flowsheet modeling results. Except for the ILAW

container waste loading and the number of ILAW containers produced, the processing operations within the LAW Vitrification Facility are the same for all alternatives.

In Alternative 1, the liquid effluents from the LAW Vitrification Facility are sent to the WTP Effluent Management Facility (EMF) for processing during the DFLAW phase. Once the PT Facility starts up, these liquid effluents are processed in the TLP evaporator within the PT Facility.

2.10 Supplemental LAW Immobilization in LAW Supplemental Treatment (LAWST) Facility

The LAWST Facility is needed to immobilize the remaining inventory of LAW that the LAW Vitrification Facility is unable to process within the required timeframe for completing tank waste treatment. Since HLW pretreatment and treatment (vitrification) operations generate secondary LAW, and since separation of supernate from solids in the Tank Farms results in both LAW and HLW waste streams, LAW and HLW pretreatment and treatment operations are required to complete at the same time. The intent is to prevent extending the duration of HLW treatment as a result of inadequate throughput of the LAW pretreatment and treatment capabilities. Since the capacity of the LAW Vitrification Facility cannot treat LAW feed fast enough to keep pace with HLW treatment, it is assumed that the LAWST Facility will be sized to make up the LAW treatment capacity deficit.

The treatment technologies being considered for LAWST were evaluated in a draft report prepared by the Savannah River National Laboratory (SRNL) in 2019[r]. The selection of the preferred LAWST technology is outside the scope of the WTP HLW AoA.

For the purposes of the WTP HLW AoA flowsheet modeling, the LAWST Facility is assumed to be based on the vitrification technology used in the LAW Vitrification Facility. The LAWST capability is modeled as additional LAW melters in a new facility based on the design of the existing LAW Vitrification Facility. The new LAWST Facility is assumed to generate ILAW containers of the same size and type as the LAW Vitrification Facility.

It is also assumed that the LAWST Facility will generate liquid effluents from the melter off-gas and ILAW container decontamination processes. It is further assumed that the LAWST Facility will include an evaporator that is similar to the WTP EMF. The concentrate from the LAWST evaporator would be recycled back to the LAWST melters and the condensate would be transferred to the LERF/ETF.

Once the PT Facility starts up, it will provide all the feed requirements for the LAW Vitrification Facility. The excess LAW processing capacity of the PT Facility will be used to provide pretreated LAW to the LAWST Facility. The new TSCR or TFPT Facility is assumed to continue to operate after PT Facility startup to provide additional feed to the LAWST Facility.

2.11 LAW Effluent Management in the WTP Effluent Management Facility (EMF) and PT Facility

Before PT Facility startup, the WTP EMF processes the liquid effluents from the LAW Vitrification Facility. The WTP EMF evaporates the water and other volatile compounds contained in the feed stream and produces a concentrated LAW effluent (evaporator bottoms) and a low-activity condensate. The evaporator concentrate is collected in an Evaporator Concentrate Receipt Vessel in the WTP EMF. The concentrate is transferred to the LAW Concentrate Receipt Vessel in the LAW Vitrification Facility and is provided as feed to the melters. The low-activity evaporator condensate is collected in a Condensate Storage Tank in the WTP EMF and staged for transfer to the LERF. The WTP EMF design and operations are described in more detail in the *EMF System Design Description*[vv] and Appendix B.

Once the PT Facility starts up, the LAW effluent management functions for the PT Facility and the LAW Vitrification Facility are performed in the PT Facility. It is assumed that the WTP EMF will shut down at this time. The LAW effluent processing operations in the PT Facility are described below.

Pretreated LAW feed from the CXP system within the PT Facility is collected in one of the CXP Permeate Collection Vessels (CXP-VSL-00026 A/B/C) and sent to the TLP evaporator to be concentrated. Liquid effluents from the LAW Vitrification Facility are collected in one of the TLP vessels (TLP-VSL-00009 A/B) and are also sent to the TLP evaporator

to be concentrated. The TLP evaporator concentrates the feed received from CXP and TLP vessels. The TLP evaporator concentrate is collected in the TCP system in vessel TCP-VSL-00001. The evaporator concentrate is then transferred to the LAW Concentrate Receipt Vessel in the LAW Vitrification Facility and provided as feed to the melters. The TLP evaporator condensate is collected in an RLD tank (RLD-TK-00006 A/B) within the PT Facility and staged for transfer to the LERF/ETF.

2.12 ILAW and Spent LAW Melter Disposal in IDF

The IDF is a landfill in the 200 Area of the Hanford Site that is permitted to receive solid low-level waste (LLW) and mixed low-level waste (MLLW). The IDF includes two existing cells that were completed in 2006, which are approximately 13 meters deep. Leachate that percolates through the cell is collected in a Leachate Collection and Recovery System installed between the primary and secondary liners of the cell. The design of the IDF is described in more detail in the *IDF Final Design Submittal*[s].

Additional information on the waste forms and the containers to be disposed of in the IDF are provided in the *IDF Performance Assessment (PA)*[t]. The IDF is designed to accommodate ILAW, spent LAW melters, solid waste from the ETF, and other secondary LLW and MLLW generated at the Hanford Site. The total IDF capacity is 900,000 cubic meters. Since the volume of the ILAW containers and the spent LAW melters is relatively small compared to the total IDF capacity, there is little risk that the IDF would need to be expanded if an alternative is selected that would generate a higher number of ILAW containers.

2.13 Staging of Process Condensate and Leachate in LERF and Treatment in ETF

As discussed in Section 2.11, the process condensate from the TLP evaporator is collected in RLD-TK-00006 A/B. The contents in RLD-TK-0006 A/B are then transferred to one of the LERF basins. The condensate produced by the WTP EMF evaporator is collected in a Condensate Collection Tank and staged for transfer to one of the LERF basins. The LERF basins stage feed for delivery to the ETF.

The ETF was designed to treat process condensate from the 242-A evaporator and Plutonium and Uranium Extraction (PUREX) Facility. The facility baseline treatment processes include a Main Treatment Train (MTT) and a Secondary Treatment Train (STT). The baseline treatment processes within the MTT include feed receipt, pH adjustment, filtration, ultraviolet oxidation (UV/OX), peroxide decomposition, degasification, reverse osmosis (RO), IX polishing, and effluent pH adjustment. The treated liquids from the MTT processes are collected in Verification Tanks. The concentrated liquid waste from the MTT is collected in a Secondary Waste Receiving Tank within the STT. The STT processes include evaporation, brine drying, powder handling, and off-gas treatment processes.

The treated liquids in the Verification Tanks are transferred to the State-Approved Land Disposal Site (SALDS) for disposal after the tank contents are sampled and evaluated for compliance with the SALDS WAC. In the baseline design the STT evaporator concentrate is dried in the Thin Film Dryer and packaged into drums for disposal at the Environmental Restoration Disposal Facility (ERDF) or IDF.

An assessment of the ETF flowsheet capabilities for treatment of the process condensate from the WTP EMF during the DFLAW phase was completed in January 2020. The results of this flowsheet assessment are documented in the *ETF Flowsheet Assessment Report*[qq]. This report provided recommendations for technology development, design of new ETF treatment processes, and installation of new systems and components to provide the treatment capability that will be needed for treatment of the process condensate from the WTP EMF. Based on this, the AoA Team has assumed that the existing ETF will need to be modified as necessary to implement the recommendations in the *ETF Flowsheet Assessment Report*. It is assumed that these modifications will have to be completed before completing hot commissioning of the LAW Facility and starting HLW treatment operations (note that for the unconstrained funding case, hot commissioning of the HLW Vit Facility is assumed to complete by 12/31/2023 per the Amended Consent Decree [ACD][xx]).

The AoA Team also evaluated the process modeling results to determine the rate that process condensate and leachate is generated during LAW and HLW processing for each alternative. The process condensate and leachate generation

rates were compared to the existing ETF design process rate (rated capacity/throughput) to determine if the existing ETF capacity was adequate. The general conclusion was that the capacity of the existing ETF would be marginally adequate for the DFLAW phase and inadequate for the Balance of Mission (BoM) phase for all alternatives except Alternative 17. The AoA Team therefore assumed that, for all alternatives except Alternative 17, a new higher capacity ETF will need to be constructed and commissioned before starting HLW processing in the BoM phase (assumed to be on or before 12/31/2033). A more detailed analysis of the process condensate and leachate generation rates for Alternative 1 is provided below.

Based on process modeling results for Alternative 1[k], the annual volume of process condensate generated during the DFLAW phase is relatively constant at approximately 6.6 million gallons (Mgal). This rate is based on the DFLAW processing facilities operating at a total operational efficiency (TOE) of 40%. After adjusting to a TOE of 100%, the highest annual volume of process condensate that will be generated during the DFLAW phase for Alternative 1 is 16.5 Mgal. The annual volume of leachate that is generated is estimated to be constant at 1.8 Mgal[k]. The highest annual volume of all secondary effluents sent to the LERF/ETF during the DFLAW phase is then 18.3 Mgal, which equates to an instantaneous rate of 35 gpm. Although this rate is below the ETF design process rate of 100 gpm (refer to Table 4-4 of the *ETF Flowsheet Assessment*[qq]), sustaining an average processing rate of 35 gpm over a one year period is assumed to be challenging given the operational history of the ETF and the operational restrictions that will be required for treating the process condensate from the LAW and HLW processing facilities.

As indicated in the Model Results Report[k], the ETF processing rate since 2012 has ranged between 2.2 and 3.9 Mgal/year. The process condensate generated during this period was limited to that produced by the 242-A evaporator. Although the feed rate to the LERF/ETF was lower during this period than during the DFLAW phase, the ETF process history suggests that the facility could not sustain processing rates that approach the design process rate of 100 gpm, or that are significantly higher than the historical norm.

The operational restrictions that will affect ETF capacity are described in section 5 of the *ETF Flowsheet Assessment Report*. These restrictions include:

- Administrative controls to limit the radioactive material inventory to keep the LERF and ETF within the limits for a Hazard Category 3 facility
- Permit requirement to drain the LERF basins once each year
- Segregation of waste streams within the LERF basins

Additionally, the ETF modifications that are recommended by the ETF Flowsheet Assessment Report[qq] are expected to directly affect the ETF processing rate. Given that new treatment technologies were recommended, the actual instantaneous process rate that the ETF will be able to achieve after installing these new technologies could be less than the predicted rate of 100 gpm.

The ETF capacity will become critical during the BoM phase, assumed to begin on or before 12/31/2033. The process modeling results for Alternative 1[k] show that the highest volume of process condensate that is generated annually during the BoM phase is 17.0 Mgal assuming a 40% TOE. The leachate production rate is assumed to remain constant at 1.8 Mgal/year. After adjusting the process condensate generation rate to reflect a TOE of 100%, and adding the leachate generation rate, the maximum annual volume that ETF will need to process during the BoM phase is 44.3 Mgal. This equates to an instantaneous processing rate of 84.0 gpm. Although this rate is below the ETF design process rate (100 gpm), the HLW AoA Team concluded that sustaining an average processing rate of 84.0 gmp over a one-year period would be a very high risk proposition.

Increasing the capacity of the existing ETF would require replacement of major components or systems within the MTT and STT with higher capacity units. At a minimum this would require a major reconfiguration of the facility. In the worst case, the building structures may not have adequate space to install higher capacity process systems.

The AoA Team conservatively assumed that a new replacement ETF will need to be constructed and commissioned no later than the scheduled start of BoM processing (12/31/2033). For Alternative 1 it is assumed that if the existing ETF is replaced to mitigate the risk associated with the facility feed rate versus capacity, the new facility could operate at an

average availability (TOE) of 70%. Based on this, and the design feed rate, the replacement ETF should be designed to have a capacity of 120 gpm (84 gpm/70% TOE).

2.14 Schedule Assumptions for Alternative 1

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the Alternative 1 HLW (and LAW) treatment mission is described in *Modeling Scenario Request (MSR)*[u] *Form MR-50520*. The assumed capabilities and facility startup dates that were used for Alternative 1 process modeling are identified below. Unless specified otherwise, these same assumptions apply to all other alternatives. Alternative 1 and all other alternatives are predicated on the assumption that the HLW Vitrification Facility will be fully operational (i.e., hot commissioning completed) by 12/31/2033 as specified in the ACD[xx].

- HLW pretreatment begins once the TWCSF is constructed and commissioned and the PT Facility is fully operational (Note that LAW pretreatment operations in the PT Facility are assumed to start immediately once the WTP Hot Startup milestone in the ACD has been met. In the unconstrained funding case, this date is assumed to be 12/31/2033 as specified in the ACD).
- TWCSF construction and commissioning is completed, and the facility is placed in operation by 6/2032.
- HLW pretreatment and vitrification begins once the HLW Vitrification and PT Facilities are fully operational.
- The PT Facility is considered fully operational when: (1) facility modifications to address the relevant *DNFSB TIs*[o] are completed, (2) remaining PT facility construction is completed, and (3) PT Facility hot commissioning is completed (Note that HLW pretreatment is assumed to start once items (1) – (3) have been completed. In the unconstrained funding case it is assumed that these items can be completed by 12/31/2033).
- The HLW Vitrification Facility is considered fully operational when: (1) facility modifications to address import/export design review issues (refer to *Engineering Study for HLW Options E and F*[ll]) are completed; (2) remaining facility construction is completed; and (3) facility hot commissioning is completed (Note that HLW vitrification is assumed to start once items (1) – (3) have been completed. In the unconstrained funding case, this date is assumed to be 12/31/2033).
- LAW pretreatment begins once the TSCR Demonstration Facility is constructed and commissioned.
- TSCR Demonstration Facility is constructed and commissioned and placed in operation by 3/24/2023.
- LAW vitrification begins once the LAW Vitrification Facility is fully operational.
- LAW Vitrification Facility is fully operational when: (1) remaining facility construction is completed, (2) facility modifications necessary to implement the design review recommendations for improving import/export capabilities (refer to *Engineering Study for HLW Options E and F*[ll]) are completed, and (3) facility hot commissioning is completed (Note that LAW vitrification is assumed to start immediately after items (1) – (3) have been completed. For the unconstrained funding case, this date is assumed to be 12/31/2023).
- TSCR Demonstration Facility is removed from service and new TSCR or TFPT Facility is constructed and commissioned by 3/24/2028.
- New TSCR/TFPT Facility will have a design capacity/throughput of 10 gpm.
- LAWST Facility is constructed and commissioned by 12/31/2034.
- LAWST Facility design capacity is equivalent to 7 LAW melters.
- ETF Facility modifications as recommended in the *ETF Flowsheet Assessment Report*[qq] are completed by 12/31/2023.
- New replacement ETF is constructed and commissioned by 12/31/2033.
- Overall TOE of all HLW processing facilities is 40% with TWCSF used for HLW characterization and feed staging and PT Facility used for HLW pretreatment and effluent management.
- Overall TOE for all LAW processing facilities is 40% with LAW pretreatment performed in the TSCR/TFPT Facility and PT Facility, and LAW effluent management performed in PT Facility.

All the LAW and HLW pretreatment and treatment facilities are designed to operate at a maximum processing rate (i.e., rated capacity or throughput). The overall TOE for LAW and HLW pretreatment and treatment is assumed to be 40% to account for disruptions in process facility operations.

The Alternative 1 pretreatment and treatment facilities include: DST system, TWCSF, TSCR/TFPT Facility, PT Facility, LAW and HLW Vitrification Facilities, and LAWST Facility. All these process facilities have built-in feed and product storage capabilities that allow operations to continue during temporary outages of upstream or downstream facilities. The TOE accounts for long-term process facility outages that result in a reduction in the overall rate at which all facilities are able to operate.

The typical measure of the overall processing system performance is the rate at which the HLW or LAW feed can be treated (immobilized). To simplify the process modeling effort, the LAW and HLW Vitrification Facility capacities were adjusted to 40% of their design capacity before the process model runs. All the resulting metrics (e.g., IHLW and ILAW production, process condensate generation, SST retrieval schedule, treatment mission duration) are based on the LAW and HLW Vitrification Facilities and the LAWST Facility operating at 40% of their rated capacities.

The process model also automatically adjusts the processing rate for the LAW and HLW Vitrification Facilities and the LAWST Facility based on feed availability. Feed availability is determined by the rate at which the SST can be retrieved, the timing of waste transfers, and the availability of DST space.

The actual overall TOE of the processing facilities could be different than 40% which would result in better or worse performance compared to the modeling result predictions.

3 Alternative 2 – HLW Pretreatment and Effluent Management in New HLW Feed Preparation and Effluent Management (HFPEM) Facility

In Alternative 2, HLW sludge is staged in the DST system, and a HLW slurry is subsequently transferred to a new HFPEM Facility where it is sampled, characterized, and pretreated in HLW Feed Preparation Vessels (HFPVs). The pretreated HLW feed is staged in an HLW Feed Vessel (HFV) located in an HLW Feed Preparation (HFP) Vault. The HFPEM Facility design (including preconceptual drawings) and the associated support SSCs are described in more detail in Appendix B.

To minimize the volume of secondary LAW that is returned to the DST system, the dilute decants from the HLW pretreatment process operations and the liquid effluent from the HLW Vitrification Facility are processed in an HLW evaporator that is part of the HFPEM Facility.

The vessels in the HFP Vault and the HLW evaporator require similar containment and confinement features and safety systems for tank ventilation, facility active confinement ventilation, post-DBE tank air sparging, and emergency power. The non-safety utility requirements are also similar. To maximize use of space, the process and support areas for HLW pretreatment and effluent management are housed in a single facility (i.e., the HFPEM Facility).

The process flow for Alternative 2 is depicted in Figure 9. The process modeling results for Alternative 2 are described in detail in the *HLW AoA Model Results Report*[k]. In Alternative 2, SST retrieval is completed in 04/2056 which is 17 years earlier than Alternative 1 and 2 to 3 years earlier than Alternatives 5, 14, 15, and 16. The tank waste treatment mission completes in 07/2061, which is 23 years earlier than Alternative 1 and 1 to 3 years earlier than Alternatives 5, 14, 15, and 16.

The primary reason for the shorter mission duration is that the new HFPEM Facility provides: (1) the ability to characterize HLW feed rather than dedicating a DST(s) to this purpose, and (2) provides most robust HLW pretreatment capabilities of all other Alternatives (e.g., longer settling, leaching and washing times). The added capabilities of the HFPEM Facility for Alternative 2 increases DST space availability which allows SST retrievals to be completed at a rate limited only by the retrieval and waste transfer system capabilities. In Alternative 2, HLW processing is limited only by the design capacity of the HLW Vitrification Facility.

3.1 HLW Feed Staging in DST System

In Alternative 2, HLW feed is prepared and staged in the DST system and the feed is sent to the HFPEM Facility to be characterized and pretreated. To prepare the HLW feed, sludge is transferred from source DSTs to a designated HLW Feed Tank in the DST system. After blending and mixing in the HLW Feed Tank, the slurry is transferred to the HFPEM Facility.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments also are the same as those described in Section 2.1 for Alternative 1.

3.2 HLW Feed Sampling, Characterization, Pretreatment, and Staging in New HFPEM Facility

In Alternative 2, the HFPEM Facility provides all the HLW sampling, characterization, pretreatment, and staging capabilities required to provide pretreated HLW feed to the HLW Vitrification Facility. The slurry from the designated HLW Feed Tank (DST System) is received in a HFPV within the HFPEM Facility HFP Process Vault. The slurry received from the DST system is allowed to settle, and the supernate is decanted. The slurry is then mixed and sampled. A "sample hold" is imposed at this point to preclude transferring the slurry to the HLW Vitrification Facility until the sample results are evaluated to verify compliance with the WTP WAC[j]. While the samples are being analyzed, the slurry is pretreated by caustic leaching, solids washing, and feed concentration in the HFPV as required.

If the aluminum (Al) concentration in the solids exceeds a predetermined value where aluminum loading is likely to drive up HLW glass mass (refer to the Alternative 2 *MSR Form MR-50512*[v] for leaching rules), caustic leaching steps are performed within the HFPV. If the aluminum concentration in the solids does not warrant caustic leaching, the leaching steps are not performed and the slurry solids are washed (if required) without leaching. The aluminum concentration in the solids and the effect that this will have on the number of IHLW canisters produced for each macro-batch will dictate the need for caustic leaching.

The caustic leaching process begins with adding 19 moles per liter (M) NaOH (sodium hydroxide) as required to solubilize the gibbsite (refer to solubility rules in the Alternative 2 *MSR Form*). The mixer pumps are run long enough to heat the slurry to 55°C (131°F). After reaching the required temperature, the mixer pumps are turned off, and the tank contents are settled and allowed to cool. After a reaction and settling time of 14 days, the supernate layer is decanted. The leaching steps are repeated as required until the aluminum concentration in the solids is below the leaching threshold.

If the sodium (Na) concentration of the slurry is 1 M or greater, the solids are washed. The washing process begins with adding a mixture of water and a small amount of 19 M NaOH (sodium hydroxide) to fill the HFPV. The amount of 19 M NaOH added is based on the solubility rules for leaching. The tank contents are mixed and settled. The supernate layer is then decanted. Additional washing steps are performed as required to concentrate the slurry to nominally 15 wt % to reduce the sodium (Na) concentration to 1 M or less. After washing, the pretreated slurry remains in the HFPV until the sample results are evaluated. Provided that the sample results comply with the WTP WAC, the HFPV contents are transferred to the HFV to be staged for delivery to the HLW Vitrification Facility.

The entire solids/liquid separation, caustic leaching, washing, and concentration cycle time is estimated to be approximately 112 days on average. The timeframe for analyzing the HFPV samples and to evaluate the results is assumed to take 120 days.

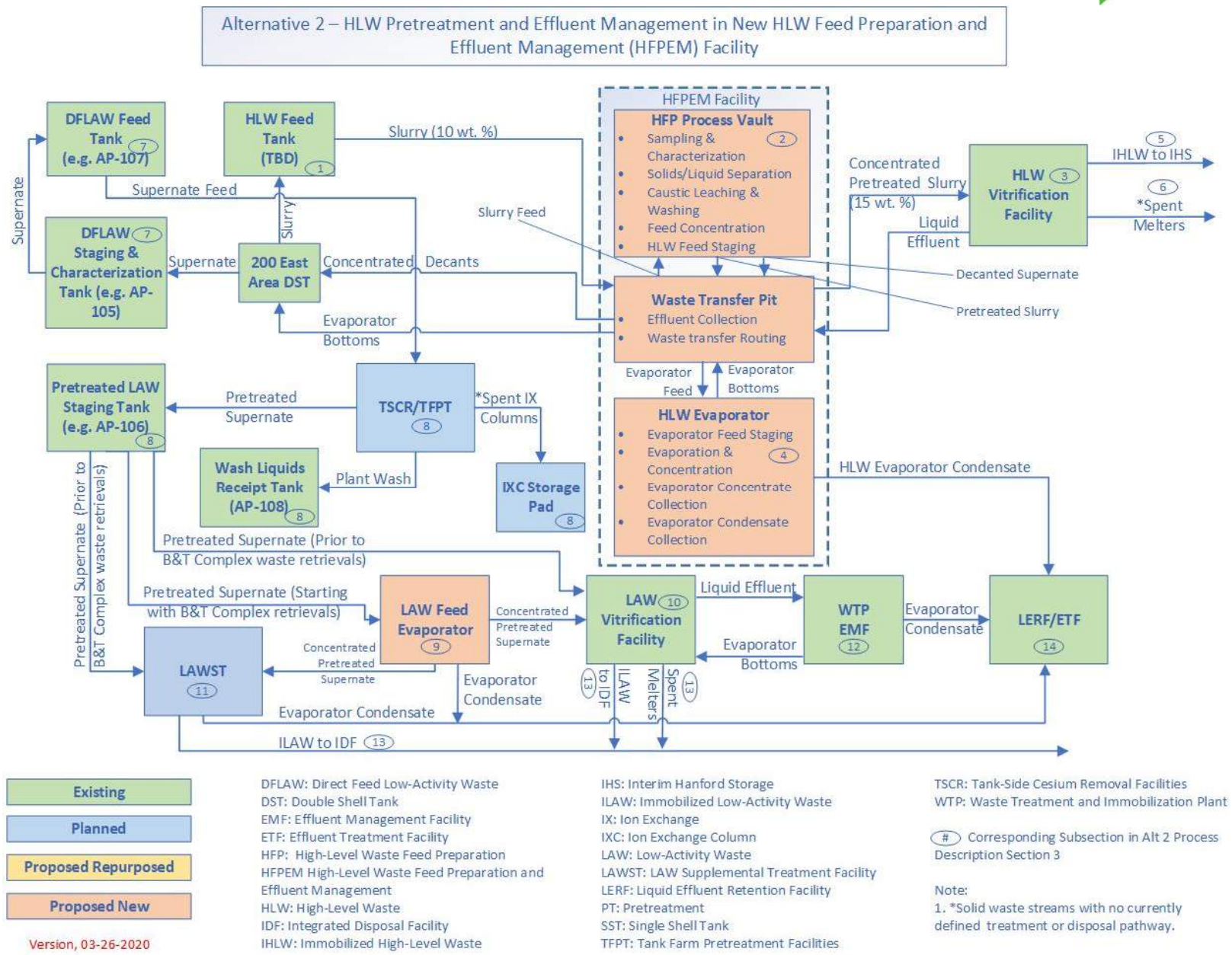

Figure 9: Alternative 2 Process Flow

Based on the process cycle time for the pretreatment process steps and for sample analysis and evaluation, seven HFPVs of 300 kgal each are required to enable the HLW Vitrification Facility to operate at its design capacity (7.5 MTG/day) without interruption due to feed availability. One HFV of 120 kgal is sufficient to feed the HLW Vitrification Facility when operating at design capacity long enough for the HFPVs to have pretreated enough feed to refill the HFV.

Given the large MAR inventory, it is assumed that the HFPEM Facility would be classified as a Hazard Category 2 facility. It also is assumed that facility would need to be designed to Seismic Category - I requirements for NPH protection.

The preconceptual design for the HFPEM Facility includes the following features:

- HFPVs and HFV in grade-level concrete vault (HFP Process Vault)
- Evaporator Feed and Concentrate Vessels in grade-level concrete vault (HEMF Process Vault)
- Below-grade Waste Transfer Pit with Effluent Collection and Drain Vessels and transfer line nozzle connections and jumpers
- Pump and Valve Pit
- HLW evaporator boiler and associated process equipment in a grade-level concrete structure (HLW Evaporator Process Building)
- Safety Systems Building for vessel ventilation and active confinement ventilation exhaust systems, compressed air system, and emergency electrical power system
- Control Room with monitoring and control systems
- Non-safety Cold Chemical Pad with non-radioactive chemical supply tanks
- Separate non-safety Mechanical and Electrical Building (MEB)

The MAR in the HFP Process Vault and the HLW Evaporator Process Building are expected to be high enough to require classification as Hazard Category 2 facilities if they were configured as separate facilities. Combining the process areas for pretreatment and effluent management reduces the combined footprint for containment and confinement and allows use of common support systems. The hardened part of the facility (i.e., Seismic Class I) is therefore a common structure with shared walls. The Waste Transfer Pit, Pump and Valve Pit, Safety Systems Building, Cold Chemical Pad, and MEB serve both the HFP and HEMF Process Vaults. A more complete description of the pre-conceptual design for the HFPEM Facility is provided in Appendix B.

Because of the high radiation levels in the process areas and the vaults, all these areas are provided with overhead cranes with manipulator capabilities to facilitate remote-handled operations and maintenance (O&M).

It is assumed that the HFPEM Facility will be in an area northeast of the AP Tank Farm in the location previously reserved for the LAW Pretreatment System (LAWPS) Facility (refer to Site Layout drawing in Appendix B). The Waste Transfer Pit is located below-grade and would connect to the new waste transfer lines on the WTP side of the “Interface Point.” This pit would include an Effluent Collection Vessel to collect liquid effluents from the HLW Vitrification Facility and flush water from the waste transfer lines.

3.3 HLW Immobilization in HLW Vitrification Facility

The slurry in the HFV in the HFPEM Facility is transferred to one of the MFP Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility. The HLW melter process operations are the same as described in Section 2.3 for Alternative 1.

The liquid effluent from the HLW Vitrification Facility is collected in RLD-VSL-00007. After chemical adjustment, the liquid effluents in RLD-VSL-0007 are transferred to RLD-VSL-00008. RLD-VSL-00008 is transferred to the Effluent Collection Vessel in the HFPEM Waste Transfer Pit. It is assumed that modifications will be required to the RLD system to pump or gravity drain the RLD-VSL-00007/8 effluents and the flush water from the waste transfer lines to the Effluent Collection Vessel.

3.4 HLW Effluent Management in HFPEM Facility

The HFPEM Facility provides the HLW effluent management capabilities for Alternative 2. The HLW evaporator concentrates the liquid effluents received from the HLW Vitrification Facility and the dilute decants from the HFPVs. The general HLW evaporator process operations are the same as the WTP EMF for Alternative 1, except that the processing rate for the HLW evaporator is lower than the WTP EMF. The specific operating parameters for the HLW evaporator will be based on variables which affect glass loading, criticality, erosivity, and the rheology of the slurry.

The dilute (less than 2M sodium) decants from the HFPVs are sent to the Evaporator Feed Vessel and are processed by the HLW evaporator within the HFPEM Facility. Concentrated (greater than 2M sodium) decants from the HFPVs are sent to the Evaporator Concentrate Vessel and are ultimately returned to the DST system.

The liquid effluents collected in RLD-VSL-00008 within the HLW Vitrification Facility are transferred to the Effluent Collection Vessel in the Waste Transfer Pit in the HFPEM Facility. The Effluent Collection Vessel is transferred to the Evaporator Feed Vessel located in the HEMF Process Vault, also within the HFPEM Facility. Based on the rate that dilute supernate and HLW liquid effluents are generated, two 72 kgal Evaporator Feed Vessels are required to keep the evaporator running at design capacity for six days.

The evaporator bottoms (concentrate) are collected in two Evaporator Concentrate Vessels located in the HEMF Process Vault. After adding sodium nitrite ($NaNO_2$) or sodium hydroxide (NaOH) for DST corrosion protection, the concentrate in the Evaporator Concentrate Vessel is transferred to the DST system. To avoid having to designate a DST to be dedicated to receiving transfers from the HFPEM Facility, two 150 kgal Evaporator Concentrate Vessels were determined to be necessary to hold the concentrate for provide 2 weeks until a DST becomes available.

The condensate from the HLW evaporator is planned to be transferred on a nearly continuous basis to the LERF. As a result, there is no need for collecting and staging condensate for batch delivery.

The process modeling results for Alternative 2^k show that the highest boil-off rate that the HLW Evaporator would need to sustain in any year is 13.3 gpm, assuming that the HLW processing facilities operate at a TOE of 40%. After correcting to a TOE of 100%, the required design boil-off rate for the HLW Evaporator for Alternative 2 is greater than 33.2 gpm.

3.5 IHLW Storage in IHS Facility

The IHLW storage process operations (e.g., canister receipt, emplacement, and monitoring) for Alternative 2 are the same as described in Section 2.5 for Alternative 1.

3.6 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not have a defined disposal pathway. As described in Section 2.6, for purposes of the alternative cost estimates and the alternative evaluation process, it is assumed that the spent HLW melters will be transported to a concrete pad near the IHS for interim storage pending a decision on the disposal pathway.

3.7 LAW Feed Staging and Characterization in DST System

For Alternative 2, the LAW staging and characterization process for DFLAW is the same as Alternative 1 as described in Section 2.7. Once the new TSCR/TFPT Facility starts up and the demand for LAW feed increases, additional LAW Staging and Characterization Tanks and LAW Feed Tanks may need to be designated within the DST system.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments also are the same as those described in Section 2.7 for Alternative 1.

3.8 LAW Pretreatment in TSCR and TFPT Facilities

The DFLAW processing operations for Alternative 2 are the same as described in Section 2.8 for Alternative 1. Since the PT Facility is not used in Alternative 2, the new TSCR or TFPT Facility is required to operate for the remainder of the LAW treatment mission after the initial TSCR demonstration phase.

The HFPEM Facility increases the HLW pretreatment capacity by a factor of approximately 2 over the Baseline Case (Alternative 1). As a result, HLW processing completes 23 years earlier than the Baseline Case (07/2061 versus 08/2084). To complete LAW processing at the same time, the design capacity of the new TSCR/TFPT Facility must increase from 10 gpm to 40 gpm (equivalent to 8x the capacity of the initial TSCR Demonstration Facility).

3.9 LAW Feed Concentration in New LAW Feed Evaporator (LFE) Facility

In Alternative 1, the TLP evaporator in the PT Facility concentrates the pretreated LAW feed before delivery to the LAW Vitrification Facility or the LAWST Facility. Since the PT Facility is not operated in Alternative 2, a new LAW Feed Evaporator (LFE) Facility is required to concentrate the LAW feed once retrieval of the high-phosphate SSTs begins.

To prevent the reprecipitation of phosphate in the pretreated LAW, the feed is kept dilute during retrieval and pretreatment of supernate from the SSTs in the B and T complex. To keep the LAW melters operating at their design capacity, the pretreated LAW is concentrated in a new LFE for Alternative 2. The LFE Facility will receive pretreated LAW feed from DST AP-106 and concentrate the feed in an evaporator. The evaporator concentrate will be sent to the LAW Vitrification Facility or LAWST Facility and the evaporator condensate will be sent to the LERF/ETF.

The composition of the LAW feed processed by the LFE Facility is not significantly different than the LAW processed by the WTP EMF. Based on the similarity of the feed, it is assumed that the design features and the general layout of the LFE Facility are similar to the WTP EMF.

The LFE Facility concentrates the pretreated LAW feed to 3.4 wt % solids or a specific gravity of 1.33. The concentrated evaporator bottoms will be collected and transferred to the LAW Vitrification Facility (first priority) or to the LAWST Facility (second priority). The evaporator condensate and liquid effluents are collected and transferred to the LERF/ETF for final processing.

The process modeling results for Alternative 2[k] show that the LFE would need to operate at a maximum boil-off rate of 14.7 gpm to provide concentrated feed at the required rates assuming that the LAW processing facilities operate at a TOE of 40%. After adjusting the TOE to 100%, the design boil-off rate for the LFE for Alternative 2 would need to be greater than 36.8 gpm.

Because the LFE processes LAW only, the MAR is expected to be low enough to classify the facility as Hazard Category 3. It also is assumed that, due to the lower MAR and NPH consequences, the process related parts of the facility would be designed to SC-II requirements. It also is assumed that the safety analysis would not identify the need for SS or SC controls. Except for the LFE Process Vault that houses the Evaporator Feed Vessels and the Evaporator Concentrate Vessels, the radiation levels in all areas of the LFE Facility are expected to be low enough to allow contact-handled O&M within the Process Area.

Although the scope of the ECMS HLW AoA focused on HLW processing, the AoA Team developed a preconceptual design for the LFE Facility. This level of design information was needed to estimate the capital cost for the LFE Facility. The preconceptual layout for the LFE Facility is similar to the HEMF as described in Section 6.4 for Alternative 15. Although the LFE Facility does not require the same shielding and remote O&M features as the HEMF, the facility layout is similar to the HEMF. Since no SC or SS controls are required for the LFE Facility, the process support systems for active confinement ventilation, compressed air, monitoring and control are in an SC-III structure rather than a Safety System Building. It also is assumed that the Tank Farm central control room would provide the necessary LFE monitoring functions.

A more complete description of the preconceptual design for the LFE Facility is provided in Appendix B.

3.10 LAW Immobilization in LAW Vitrification Facility

In Alternative 2, LAW feed is pretreated in the TSCR/TFPT facilities. The pretreated LAW feed is staged in AP-106. During the DFLAW phase and before starting retrieval of the high phosphate LAW in the SSTs in B and T complexes, the pretreated LAW in AP-106 is transferred directly to the LAW Vitrification Facility. Once the B and T complex waste retrievals begin, the pretreated LAW in AP-106 is transferred to the LFE Facility. The LFE concentrates the pretreated LAW, and the concentrate is collected in an Evaporator Concentrate Vessel within the LFE. The concentrated pretreated LAW feed in the Evaporator Concentrate Vessels (two sized at 65 kgal each) is then transferred to the LAW Vitrification Facility.

The LAW Vitrification Facility process operations are the same as described in Section 2.9 of Alternative 1.

As in Alternative 1, the liquid effluents from the LAW Vitrification Facility are processed by the WTP EMF for Alternative 2. Since the PT Facility does not operate in Alternative 2, the WTP EMF is required to operate for the duration of the LAW treatment mission.

3.11 Supplemental LAW Immobilization in LAWST Facility

During the DFLAW phase and before starting retrieval of the SSTs in B and T complex, pretreated LAW is transferred from AP-106 to the LAWST Facility as described in Section 2.10 for Alternative 1. After starting retrieval of the SSTs in the B and T complex, the pretreated LAW feed in AP-106 is concentrated in a new LFE before delivery to the LAWST Facility.

Since the HFPEM Facility provides the capability to provide pretreated HLW at the rate needed to allow the HLW Vitrification Facility to operate at its design capacity (7.5 MTG/day), the LAW processing rate must be increased from that provided in Alternative 1 to allow LAW processing to be completed at the same time that HLW processing would be completed. This requires increasing the capacity of the LAWST Facility from 7 LAW melters for Alternative 1 to 12 LAW melters for Alternative 2.

3.12 LAW Effluent Management in WTP EMF

In Alternative 2, the PT Facility is not available to process the liquid effluents from the LAW Vitrification Facility and the WTP EMF is required to operate for the duration of the LAW treatment mission. The WTP EMF process operations are the same as described in Section 2.11 for Alternative 1.

3.13 ILAW and Spent LAW Melter Disposal in IDF

The IDF receipt, emplacement, and disposal functions for ILAW containers and spent LAW melters in Alternative 2 are the same as described in Section 2.12 for Alternative 1.

3.14 Staging of Process Condensate and Leachate in LERF and Treatment in ETF

In Alternative 2, the condensate produced by HLW and LAW processing is transferred to the LERF basins. The leachate collected in the ERDF and the IDF also is transferred to the LERF basins. The LERF basins stage these secondary effluents for delivery to the ETF. The treatment processes in the ETF for Alternative 2 are the same as described in Section 2.13 for Alternative 1.

The volume of process condensate and leachate that is generated during the DFLAW phase is the same as described in Section 2.13 for Alternative 1. As is the case for all alternatives, it is assumed that the existing EMF is modified to implement the recommendations in the *ETF Flowsheet Assessment*[qq] before start of DFLAW operations (12/31/2023).

The process modeling results for Alternative 2[k] show that the highest volume of process condensate generated in any one-year period during the BoM phase is 33.7 Mgal based on a TOE of 40%. After adjusting to a TOE of 100% and adding in the leachate that is generated, the highest volume of process condensate and leachate that will be generated in any

year is 86.1 Mgal. This equates to an instantaneous generation rate of 164 gpm. Based on this, the new ETF to be constructed for Alternative 2 would need to have a capacity of approximately 234 gpm (164 gpm/70% TOE). It is assumed that the new higher capacity EMF is constructed and commissioned before start of HLW processing in the BoM phase (Note that starting BoM operations occurs immediately after achieving the ACD milestone for completing hot commissioning of the HLW Vit Facility. For the unconstrained funding case, this date is 12/31/2033 as specified in the ACD).

3.15 Schedule Assumptions for Alternative 2

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the HLW (and LAW) treatment mission for Alternative 2 is described in an *MSR Form MR-50512*[v]. The schedule assumptions that are different than those specified in Section 2.14 for Alternative 1 are identified below.

- HLW pretreatment begins once the new HFPEM Facility is constructed and commissioned (assumed date is 6/2032).
- HLW vitrification begins once the HLW Vitrification Facility is operational.
- The HLW Vitrification Facility is considered operational when: (1) process vessel analyses required to address the relevant DNFSB TIs are completed; (2) facility modifications necessary to address operability, maintainability, and nuclear safety recommendations in *Engineering Study for HLW Options E and F*[ll] are completed; (3) remaining facility construction is completed; (4) new facilities required to allow the HLW Vitrification Facility to operate independent of the PT Facility (e.g., Control Room, Incident Command Post, and facilities to house SC emergency electrical power supply and compressed air systems) are constructed and commissioned; and (5) hot commissioning is completed (Note that HLW vitrification is assumed to start immediately after items (1) – (5) have been completed. For the unconstrained funding case, this date is assumed to be 12/31/2033).
- Design capacity/throughput of new TSCR/TFPT Facility is 40 gpm.
- LAWST Facility capacity is equivalent to 12 LAW melters.
- LFE Facility starts up before beginning retrieval of the high phosphate SSTs (WRPS modeling assumed completion in FY 2035).
- Overall TOE of all HLW processing facilities remains at 40% with HLW pretreatment performed in a new HFPEM Facility.
- Overall TOE for all LAW processing facilities remains at 40% with LAW pretreatment performed in TFPT Facility without reliance on PT Facility, LAW effluent management performed in WTP EMF, and LAW feed concentration performed in LFE Facility.

4 Alternative 5 – HLW Pretreatment and Effluent Management in Repurposed PT Facility

In Alternative 5, the PT Facility is repurposed for HLW pretreatment and effluent management functions as described in Appendix B. New HFPVs, Filter Feed Vessels (FFVs), and HFVs will be installed in PF Facility Planning Areas 3 and 4 in cells previously designated as “Dark Cells.” The cells will be modified to provide access through removeable roof covers to allow removal/replacement of tank equipment by external cranes. To limit the size of the pretreatment process vessels that would need to be installed in the RPT, Alternative 5 relies on the DST system to characterize the HLW feed and adds the capability to filter the decanted liquids removed during the pretreatment process. These flowsheet changes allow shorter pretreatment cycle times which in turn allows for a reduction in the pretreatment tank sizes.

The PT Facility construction effort was estimated to be 43% complete at the time that work was suspended in 2012. Many of the PT Facility process vessels were already installed by this time. Considering the difficulty in ‘sectioning’ and removing these vessels, the AoA Team evaluated the areas within the Hot Cell and Dark Cells that did not have equipment installed to determine the space that was available for installation of new pretreatment and filtration tanks. The results of this evaluation are presented in Appendix B.

Alternative 5 will use the FEP and TLP evaporators in the PT Facility to concentrate the liquid effluents from the HLW Vitrification Facility and the LAW Vitrification Facility, respectively. The TLP evaporator also will be used to concentrate the pretreated LAW feed before delivery to the LAW Vitrification Facility. To address the DNFSB TIs that are associated with high-solids processing, the PWD and FEP systems will be modified to implement the Standard High-Solids Vessel (SHSV) flowsheet changes described in the *PT Facility Alternative Study*[o].

The process flowsheet for Alternative 5 is depicted in Figure 10. Process modeling was not performed for Alternative 5. However, since the flowsheet for Alternative 5 is similar to Alternative 14, it is assumed that the modeling results for Alternative 14 would be close to the results that would be obtained for Alternative 5. The Alternative 14 process modeling results are described in detail in the *HLW AoA Model Results Report*[k].

4.1 HLW Feed Staging and Characterization in DST System

HLW sludge from source DSTs is transferred as a slurry to a designated HLW Staging DST. HLW slurry is then settled and decanted. The remaining sludge is then mixed and sampled. Once the sample results are reviewed to confirm compliance with the WTP WAC, the slurry is transferred to a designated HLW Feed DST and staged for delivery to the HFPVs in the RPT.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments are the same as those described in Section 2.1 for Alternative 1.

4.2 HLW Pretreatment in Repurposed PT Facility

Except for the filtration of the decanted supernate, the HLW pretreatment process operations for Alternative 5 are the same as described in Section 3.2 for Alternative 2. Characterized HLW feed is transferred from the designated HLW Feed DST to one of the HFPVs in the RPT. The same solids/liquid separation, caustic leaching, solids washing, and feed concentration steps described for Alternative 2 are performed in the HFPVs. The pretreated HLW feed in the HFPV(s) is sent to one of the new HFVs in the RPT.

The decanted supernate from the pretreatment process steps is sent to one of the two new FFVs. The supernate in the FFV is recirculated through a cross-flow filter. The permeate is sent to the FEP Evaporator Feed Staging Vessel (FEP-VSL-00017 A/B). As the slurry recirculates in the filtration loop, the solids concentration in the FFV increases. Once the concentration of the solids reaches a nominal value of 15 wt %, the slurry is transferred to one of the HFVs. The pretreated slurry in the HFPV is blended with the slurry from the FFV in the HFVs. The combined slurry is staged in the HFVs for delivery to the HLW Vitrification Facility.

Since the HLW feed is sampled and characterized in the DST system, the HFPV sizing is driven solely by the pretreatment and filtration cycle times. Adding the capability to filter the decanted supernate reduces the settling time before decanting in the HFPVs which then reduces the overall HLW feed pretreatment cycle time.

The capacity for the HFPVs and HFVs must be sufficient to pretreat and store enough feed for the HLW Vitrification Facility to operate at full capacity for the time required to complete the pretreatment and filtration cycle. The tank capacity and sizing calculation for Alternative 5 shows that two 85 kgal HFPVs, two 21 kgal FFVs, and two 35 kgal HFVs are required.

The preconceptual layout of the new HLW pretreatment vessels and equipment that would be located within the RPT for Alternative 5 are included in Appendix B.

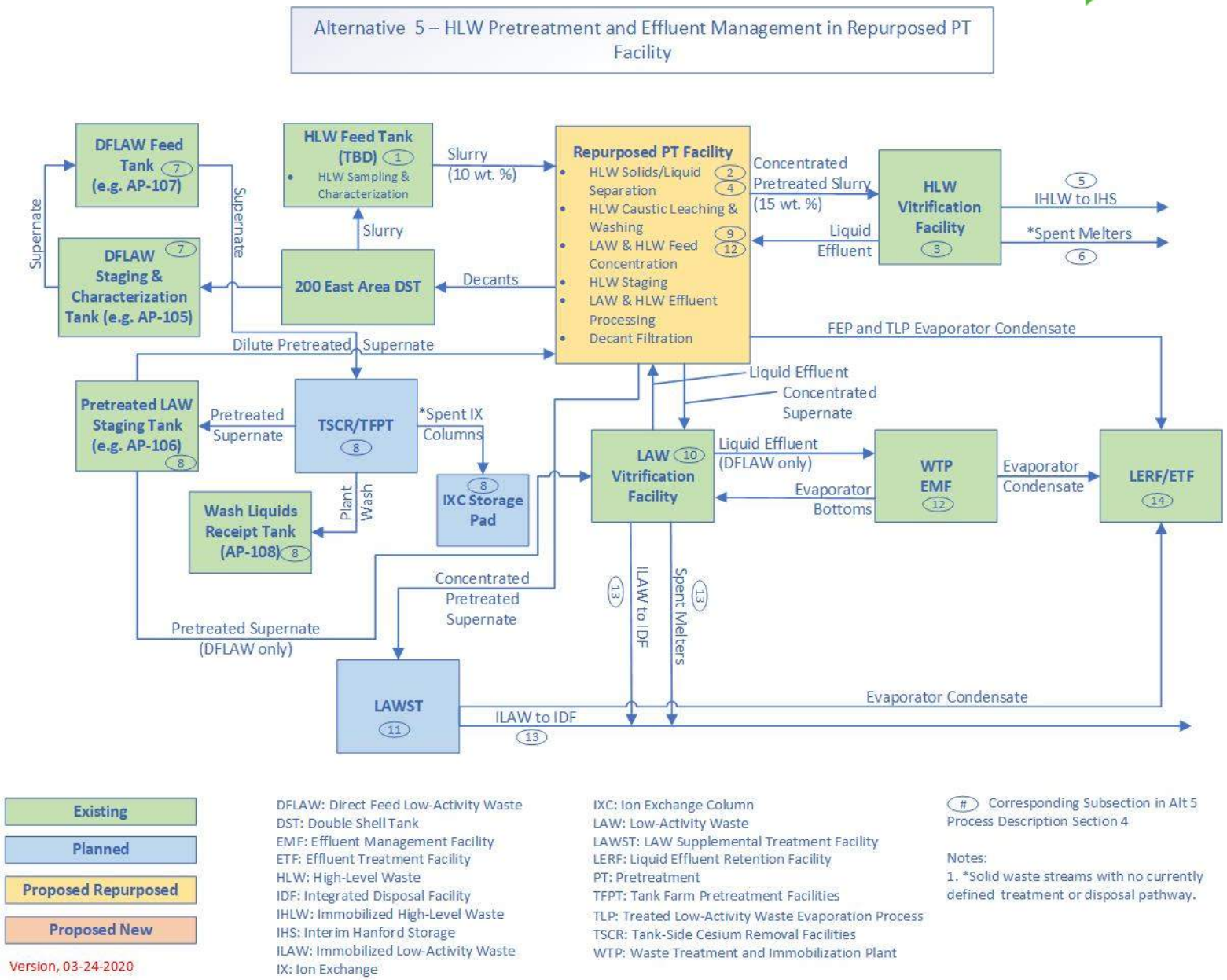

Figure 10: Alternative 5 Process Flow

4.3 HLW Immobilization in HLW Vitrification Facility

The pretreated slurry from the HFV in the RPT is transferred to one of two MFP Vessels HFP-VSL-00001/5 in the HLW Vitrification Facility. The HLW Vitrification Facility process operations are the same as described in Section 2.3 for Alternative 1. The liquid effluents from the HLW Vitrification Facility are transferred to PWD-VSL-00015/16 in the RPT for concentration in the FEP evaporators.

4.4 HLW Effluent Management in Repurposed PT Facility

In Alternative 5, the HLW effluents are concentrated in the FEP evaporators as described in Section 2.4 for Alternative 1. The design of the HLW effluent management systems (e.g., PWD and FEP systems) is assumed to be the same as Alternative 1.

As in Alternative 1, the PWD and FEP vessels and equipment will be modified to resolve the DNFSB TIs as described in the *PT Facility Alternative Study*[o]. Other modifications will be required to the PT Facility to allow for collecting and rerouting of slurry and supernate between the DST system, RPT, and HLW Vitrification Facility.

4.5 IHLW Storage in IHS Facility

The IHLW storage process operations (e.g., canister receipt, emplacement, and monitoring) for Alternative 5 are the same as described in Section 2.5 for Alternative 1.

4.6 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not currently have a defined disposal pathway. As described in Section 2.6 for Alternative 1, for purposes of the alternative cost estimates and the alternative evaluation process, it is assumed that the spent HLW melters will be transported to a concrete pad near the IHS for interim storage pending a decision on the disposal pathway.

4.7 LAW Feed Staging and Characterization in DST System

The LAW feed preparation and delivery functions and the DST configuration for LAW processing by DFLAW in Alternative 5 are the same as described in Section 2.7 for Alternative 1.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments are also the same as those described in Section 2.7 for Alternative 1.

4.8 LAW Pretreatment in TSCR and TFPT Facilities

The DFLAW processing operations for Alternative 5 are the same as described in Section 2.8 for Alternative 1. Since the RPT is not used in Alternative 5 for LAW pretreatment, the new TSCR or TFPT Facility is required to operate for the remainder of the LAW treatment mission after the initial TSCR demonstration phase.

To complete LAW processing at the same time that HLW Processing would be completed, the design capacity/throughput of the new TSCR or TFPT Facility is required to be 40 gpm (equivalent to 8x the capacity of the TSCR Demonstration Facility).

4.9 LAW Feed Concentration in Repurposed PT Facility

Since the TLP evaporator in the RPT is used for LAW effluent management, this evaporator also is available for concentrating the pretreated LAW feed from tank AP-106. The pretreated LAW feed from tank AP-106 will be routed to the RPT liquid effluent collection vessels (TLP-VSL-00009A/B) to stage the feed for concentration in the TLP evaporator.

As is the case for Alternative 1, the TLP evaporator concentrate is collected in TCP-VSL-00001. This vessel stages the concentrated pretreated LAW feed for delivery to the LAW Vitrification Facility or LAWST Facility. The TLP process condensate is collected in a secondary effluent collection tank (RDL-TK-00006 A/B) in the RPT. This tank stages the TLP evaporator condensate for delivery to the LERF/ETF.

4.10 LAW Immobilization in LAW Vitrification Facility

The LAW Vitrification Facility vitrifies the pretreated supernate feed provided by the TSCR/TFPT facilities (via Tank AP-106). The LAW Vitrification Facility process operations are the same as described in Section 2.9 for Alternative 1.

4.11 Supplemental LAW Immobilization in LAWST Facility

The LAWST Facility process operations are the same as described in Section 2.10 for Alternative 1. Since HLW and LAW processing operations are completed 3 years later than Alternative 2, the design capacity for the LAWST Facility is lower than that required for Alternative 2 (nine LAW melters are required for Alternative 5 versus 12 LAW melters for Alternative 2).

4.12 LAW Effluent Management in WTP EMF and in Repurposed PT Facility

The LAW processing operations in the WTP EMF and in the RPT are the same as described in Section 2.11 for Alternative 1. The WTP EMF is not used after startup of the RPT.

4.13 ILAW and Spent LAW Melter Disposal in IDF

The IDF receipt, emplacement, and disposal functions for ILAW containers and spent LAW melters in Alternative 5 are the same as described in Section 2.12 for Alternative 1.

4.14 Staging of Process Condensate and Leachate Collection in LERF and Treatment in ETF

In Alternative 5, the condensate produced by HLW and LAW processing is transferred to the LERF basins. The leachate collected in the ERDF and the IDF also is transferred to the LERF basins. The LERF basins stage these secondary effluents for delivery to the ETF. The treatment processes in the ETF for Alternative 5 are the same as described in Section 2.13 for Alternative 1.

The volume of process condensate and leachate that is generated during the DFLAW phase is the same as described in Section 2.13 for Alternative 1. As for Alternative 1, Alternative 5 assumes that the existing ETF will be modified as recommended in the *ETF Flowsheet Assessment*[qq] before starting DFLAW operations (12/31/2023).

Since the flowsheets for Alternatives 5 and 14 are similar, the Alternative 14 modeling results for liquid effluent generation are assumed to be valid for Alternative 5. The process modeling results for Alternative 14 predict that the highest volume of process condensate that is generated in any one-year period during the BoM phase is 30.0 Mgal based on a TOE of 40%. After adjusting to a TOE of 100% and adding in the annual leachate generation, the highest volume of process condensate and leachate that would be generated in any year is 76.8 Mgal. This equates to an instantaneous generation rate of 146 gpm. Based on this, the new ETF to be constructed for Alternative 5 would need a capacity of 209 gpm (146 gpm/70% TOE). It is assumed that the new higher capacity ETF is constructed and commissioned before starting BoM operations (Note that starting BoM operations occurs immediately after achieving

the ACD milestone for completing hot commissioning of the HLW Vit Facility. For the unconstrained funding case, this date is 12/31/2033 as specified in the ACD).

4.15 Schedule Assumptions for Alternative 5

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the HLW (and LAW) treatment mission for Alternative 5 is described in an *MSR Form MR-50508*[w]. The schedule assumptions that are different than those specified in Section 2.14 for Alternative 1 are identified below.

- HLW pretreatment begins once the RPT is operational for HLW pretreatment and effluent management.
- The RPT is considered operational when: (1) installation of new process vessels and equipment needed for HLW pretreatment is completed; (2) process support and utility connections to newly installed process vessels and equipment are completed; (3) facility modifications to address the relevant DNFSB TIs (refer to *PT SHSV Alternative Study*[o]) are completed; (4) remaining facility construction necessary for HLW pretreatment and liquid effluent processing are completed; and (5) hot commissioning of the HLW pretreatment and effluent management systems are completed (Note that HLW pretreatment in the PT Facility is assumed to start once items (1) – (5) have been completed. For the unconstrained funding case, it is assumed that these items can be completed by 12/31/2033).
- HLW vitrification begins once the RPT is operational and the HLW Vitrification Facility is operational;
- The HLW Vitrification Facility is considered operational when: (1) process vessel analyses required to address the relevant DNFSB TIs are completed; (2) facility modifications necessary to address operability, maintainability, and nuclear safety recommendations in *Engineering Study for HLW Options E and F*[l] are completed; (3) remaining facility construction is completed; (4) new facilities required to allow the HLW Vitrification Facility to operate independent of the RPT (e.g., Control Room, Incident Command Post, and facilities to house SC emergency electrical power supply and compressed air systems) are constructed and commissioned; and (5) hot commissioning is completed (Note that HLW vitrification is assumed to start once items (1) – (5) have been completed. For the unconstrained funding case, it is assumed that these items can be completed by 12/31/2033).
- New TSCR or TFPT throughput is 40 gpm (equivalent to the capacity of 8 TSCR demonstration units).
- RPT LAW feed concentration capability is operational before starting retrieval of high phosphate SSTs.
- LAW Facility capacity is equivalent to 9 LAW melters.
- Overall TOE of all HLW processing facilities remains at 40% with HLW pretreatment and effluent management performed in RPT.
- Overall TOE for all LAW processing facilities remains at 40% with LAW pretreatment performed in TSCR/TFPT Facility, and with LAW effluent management and LAW feed concentration performed in RPT.

5 Alternative 14 – HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility

In Alternative 14, HLW sludge is staged and characterized in the DST system. The HLW feed is transferred to a new HFPEM Facility (described in Appendix B) to be pretreated and staged for delivery to the HLW Vitrification Facility. The HLW pretreatment functions and capacities are similar to those for Alternative 5. As in Alternative 5, adding the capability to filter decants allows a reduction in the settling time which results in a significant reduction in the HLW feed pretreatment cycle time. By sampling and characterizing the HLW feed in the DST system, and reducing the pretreatment cycle time, the capacity of the HLW pretreatment tanks was reduced from that which was required for Alternative 2.

The HLW Vitrification Facility liquid effluents and decanted supernate from the HFPVs are processed in an HLW evaporator within the HFPEM Facility. As discussed in Section 3.2 of Alternative 2, the HLW pretreatment and evaporative capabilities are provided in a common facility to minimize the interface complexities and the construction and operational costs.

A summary of the process flow for Alternative 14 is depicted in Figure 11. The Alternative 14 process modeling results are described in detail in the *HLW AoA Model Results Report*[k].

To reduce the pretreatment vessel sizes for Alternative 14, the cycle time for HLW pretreatment was reduced, and a filtration capability was added to remove the high solids concentration from the vessel decants. The other flowsheet change that was necessary for Alternative 14 was to perform HLW feed sampling and characterization within the DST system.

5.1 HLW Feed Sampling, Characterization, and Staging in DST System

Sludge slurry is transferred from source DSTs to a designated HLW Staging DST where the contents are mixed and sampled for characterization. After the sample results are analyzed and evaluated for compliance with the WTP WAC, HLW slurry is transferred from the HLW Staging DST to a designated HLW Feed DST where it is staged for delivery to the HFPEM Facility. HLW feed batches are transferred from the HLW Feed DST to the HFPVs in the new HFPEM Facility on an as needed basis.

5.2 HLW Feed Pretreatment and Filtration in HFPEM

The HFPEM Facility pretreatment process operations for Alternative 14 are the same as described in Section 4.2 for Alternative 5. The same solids/liquid separation, filtration, caustic leaching, solids washing, and feed concentration steps described for Alternative 5 are performed in the HFPVs and the FFVs.

The supernate in the FFV(s) is recirculated through a Cross-Flow Filter. The dilute liquid permeate is sent to one of the HLW Evaporator Feed Vessels. Concentrated permeate is sent to one of the four HLW Evaporator Concentrate Vessels and ultimately returned to the DST system. As the slurry is recirculated in the filtration loop, the solids concentration of the Filter Feed increases. Once the concentration of the solids reaches nominally 15 wt %, the slurry is transferred to one of the two HFVs. The slurry in the HFPVs is blended with the slurry from the FFVs in the HFVs. The combined slurry is staged in the HFVs for delivery to the HLW Vitrification Facility.

The HFPEM Facility vessel sizes are smaller than those in Alternative 2 due to reduced pretreatment and filtration cycle times. Adding the capability to filter the decanted supernate reduces the settling time before decanting in the HFPVs which then reduces the overall HLW feed pretreatment cycle time.

The capacity for the HFPVs and HFVs must be sufficient to pretreat and store enough feed for the HLW Vitrification Facility to operate at full capacity for the time required to complete the pretreatment and filtration cycle. The tank capacity and sizing calculation for Alternative 14 shows that two 85 kgal HFPVs, two 21 kgal FFVs, and two 35 kgal HFVs are required.

Except for the addition of the supernate filtration capability, the HLW pretreatment capabilities for Alternative 14 are the same as Alternative 2. Also, except for a much smaller HFP Process Vault, the notional facility layout for the HFPEM Facility for Alternative 14 is similar to the HFPEM Facility for Alternative 2.

5.3 HLW Immobilization in HLW Vitrification Facility

The slurry in the HFVs in the HFPEM Facility is transferred to one of the MFP Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility. The HLW melter process operations are the same as described in Section 2.3 for Alternative 1.

The liquid effluent from the HLW Vitrification Facility is collected in RLD-VSL-00007/8. It is assumed that modifications will be required to the RLD system to pump or gravity drain the RLD-VSL-00007/8 contents to the below grade waste transfer pit in the HFPEM Facility.

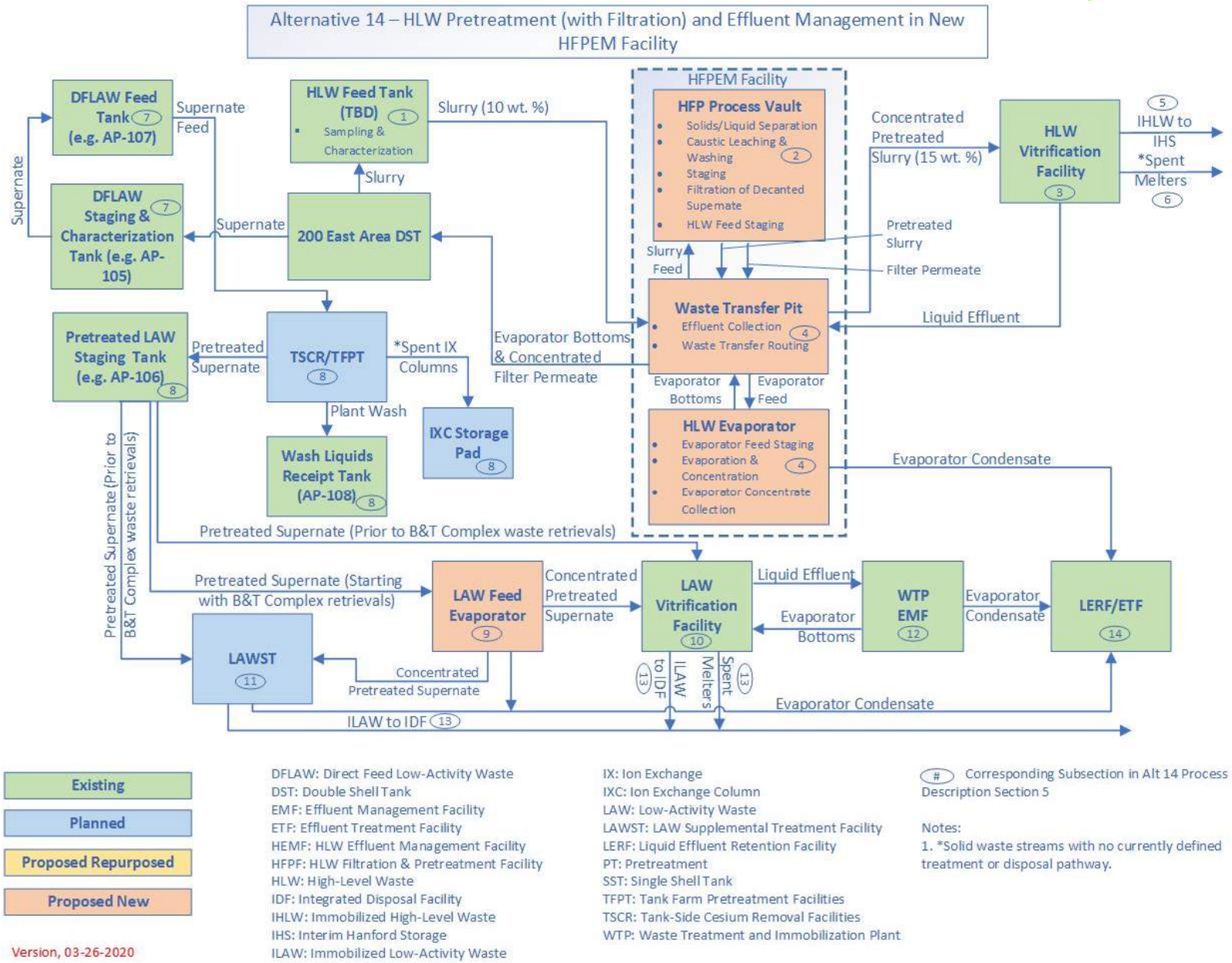

Figure 11: Alternative 14 Process Flow

5.4 HLW Effluent Management in HFPEM Facility

The HLW evaporator in the HFPEM Facility concentrates the permeate received from the Cross-Flow Filter and the liquid effluents from the HLW Vitrification Facility. The HLW evaporator process operations and design features are the same as described in Section 3.4 of Alternative 2.

The process modeling results for Alternative 14[k] show the HLW evaporator would need to achieve a boil-off rate of 10.4 gpm in the worst-case year, assuming the TOE for HLW processing is 40%. After adjusting for a TOE of 100%, the design capacity for the HLW evaporator for Alternative 14 is required to be greater than 26 gpm.

5.5 IHLW Storage in IHS Facility

The IHLW storage process operations (e.g., canister receipt, emplacement, and monitoring) for Alternative 14 are the same as described in Section 2.5 for Alternative 1.

5.6 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not currently have a defined disposal pathway. As described in Section 2.6, for purposes of the alternative cost estimates and the alternative evaluation process, it is assumed that the spent HLW melters will be transported to a concrete pad near the IHS for interim storage pending a decision on the disposal pathway.

5.7 LAW Feed Characterization and Staging in DST System

The LAW feed preparation and delivery functions and the DST configuration for LAW processing by DFLAW for Alternative 14 are the same as described in Section 2.7 for Alternative 1.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments are also the same as those described in Section 2.7 for Alternative 1.

5.8 LAW Pretreatment in TSCR and TFPT Facilities

The DFLAW processing operations for Alternative 14 are the same as described in Section 2.8 for Alternative 1. Since the PT Facility is not used in Alternative 14, the new TSCR or TFPT Facility is required to operate for the remainder of the LAW treatment mission after the initial TSCR demonstration phase.

To complete LAW processing at the same time that HLW Processing would be completed, the design capacity/throughput of the new TSCR or TFPT Facility is required to be 40 gpm (equivalent to 8x the capacity of the TSCR Demonstration Facility).

5.9 Concentration of Pretreated LAW in LFE Facility

Since the PT Facility is not operated in Alternative 14, a new LFE Facility is used to concentrate pretreated supernate from AP-106 before transfer to the LAW Vitrification Facility or the LAWST Facility. The processing operations within the LFE Facility for Alternative 14 are the same as described in Section 3.9 for Alternative 2. The LFE Facility pre-conceptual design is described in more detail in Appendix B.

The process modeling results for Alternative 14[k] show that the LFE would have to operate at a maximum boil-off rate of 12.9 gpm to provide concentrated feed at the required rates assuming that the LAW processing facilities operate at a TOE of 40%. After adjusting the TOE to 100%, the design boil-off rate for the LFE for Alternative 14 would need to be greater than 32.2 gpm.

5.10 LAW Immobilization in LAW Vitrification Facility

The LAW Vitrification Facility process operations are the same as described in Section 2.9 for Alternative 1.

For Alternative 14, the liquid effluents from the LAW Vitrification Facility are processed in the WTP EMF throughout the processing mission.

5.11 Supplemental LAW Immobilization in LAWST Facility

The LAWST Facility process operations for Alternative 14 are the same as described in Section 2.10 for Alternative 1. Since HLW and LAW processing operations are completed 2.5 years later than Alternative 2, the design capacity for the LAWST Facility for Alternative 14 is lower than that required for Alternative 2 (nine LAW melters for Alternative 14 versus 12 LAW melters for Alternative 2).

5.12 LAW Effluent Management in the WTP EMF

In Alternative 14, the PT Facility is not available to process the liquid effluents from the LAW Vitrification Facility, and the WTP EMF is required to operate for the duration of the LAW treatment mission. The WTP EMF process operations for Alternative 14 are the same as described in Section 2.11 for Alternative 1.

5.13 ILAW and Spent LAW Melter Disposal in IDF

The IDF receipt, emplacement, and disposal functions for ILAW containers and spent LAW melters for Alternative 14 are the same as described in Section 2.12 for Alternative 1.

5.14 Staging of Process Condensate and Leachate Collection in LERF and Treatment in ETF

In Alternative 14, the condensate produced by HLW and LAW processing is transferred to the LERF basins. The leachate collected in the ERDF and the IDF also is transferred to the LERF basins. The LERF basins stage these secondary effluents for delivery to the ETF. The treatment processes in the ETF for Alternative 14 are the same as described in Section 2.13 for Alternative 1.

The volume of process condensate and leachate that is generated during the DFLAW phase for Alternative 14 is the same as described in Section 2.13 for Alternative 1. As for Alternative 1, Alternative 14 assumes that the existing ETF will be modified as recommended in the *ETF Flowsheet Assessment*[qq] before starting DFLAW operations (12/31/2023).

The process modeling results for Alternative 14 predict that highest volume of process condensate that is generated in any one-year period during the BoM phase is 30.0 Mgal based on a TOE of 40%. After adjusting to a TOE of 100% and adding in the annual leachate generation, the highest volume of process condensate and leachate that would be generated in any year is 76.8 Mgal. This equates to an instantaneous generation rate of 146 gpm. Based on this, the new ETF to be constructed for Alternative 14 would need a capacity of 209 gpm (146 gpm/70% TOE). It is assumed that the new higher capacity ETF is constructed and commissioned before starting BoM operations (Note that starting BoM operations occurs immediately after achieving the ACD milestone for completing hot commissioning of the HLW Vit Facility. For the unconstrained funding case, this date is 12/31/2033 as specified in the ACD).

5.15 Schedule Assumptions for Alternative 14

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the HLW (and LAW) treatment mission for Alternative 14 is described in an *MSR Form MR-50508*[w]. The schedule assumptions that are different from those specified in Section 2.14 for Alternative 1 are identified below.

- HLW pretreatment begins once the new HFPEM Facility is constructed and commissioned (assumed date is 6/2032).
- The HLW Vitrification Facility is considered operational when: (1) process vessel analyses required to address the relevant DNFSB TIs are completed; (2) facility modifications necessary to address operability, maintainability, and nuclear safety recommendations in *Engineering Study for HLW Options E and F*[l] are completed; (3) remaining facility construction is completed; (4) new facilities required to allow the HLW Vitrification Facility to operate independent of the PT Facility (e.g., Control Room, Incident Command Post, and facilities to house SC emergency electrical power supply and compressed air systems) are constructed and commissioned; and (5) hot commissioning is completed (Note that HLW vitrification is assumed to start immediately after items (1) – (5) have been completed. For the unconstrained funding case, this date is assumed to be 12/31/2033).
- New TSCR/TFPT Facility design capacity/throughput is 40 gpm (equivalent to the capacity of eight TSCR demonstration units).
- LAWST Facility design capacity is equivalent to nine LAW melters.
- LFE Facility starts up before beginning retrieval of the high phosphate SSTs (WRPS modeling assumed completion in FY 2035).
- Overall TOE of all HLW processing facilities remains at 40% with HLW pretreatment and effluent management performed in the HFPEM Facility.
- Overall TOE for all LAW processing facilities remains at 40%, with LAW pretreatment performed entirely in the TFPT without reliance on the PT Facility, LAW effluent management performed by WTP EMF, and LAW feed concentration performed in the LFE Facility.

6 Alternative 15 – Direct Feed HLW (DFHLW) from DSTs and Effluent Management in New HLW Effluent Management Facility (HEMF)

In Alternative 15, HLW feed is staged, characterized and pretreated in the DST system. The pretreated HLW slurry is transferred directly to HLW Vitrification Facility. This HLW feed delivery approach is referred to as DFHLW.

Long-term DFHLW operations place a higher demand on the 242-A Evaporator because the supernate decanted from the HLW Feed Preparation DSTs must be accommodated within the DST system. To partially mitigate the adverse effect on the 242-A Evaporator duty cycle and on the space margin within the DST system, Alternative 15 includes a new HEMF to concentrate the HLW liquid effluents from the HLW Vitrification Facility.

A summary of the process flow for Alternative 15 is depicted in Figure 12. The Alternative 15 process modeling results are described in detail in the *HLW AoA Model Results Report*[k].

6.1 HLW Characterization and Pretreatment in DST System

Sludge is mobilized in source DSTs and the resulting slurry is transferred to the designated HLW Pretreatment Tanks in the DST system (AP-101/103). The source DSTs that could be used for the DFHLW approach described in Alternatives 15 and 16 were evaluated in earlier studies of the DFHLW approach including *Preconceptual Engineering Study for Direct Feed High-Level Waste* issued in 2012[x].

The slurry in AP-101/103 is mixed and sampled and then pretreated. The pretreatment steps are similar to those described in Section 3.2 of Alternative 2. These steps include initial solids/liquid separation by settling/decanting, caustic leaching, and solids washing. After the final wash steps are completed and the sample results are evaluated for compliance with the WTP WAC, the pretreated slurry is transferred from AP-101/103 to the designated HLW Feed Tank in the DST system (AP-102). Pretreated HLW feed is transferred in batches from AP-102 to one of the MPF Vessels HFP-VSL-00001/5 in the HLW Vitrification Facility on an as-needed basis.

The feed that is provided to the HLW Vitrification Facility is limited to a solids concentration of 10 wt % to prevent transfer line plugs. As required in the *Engineering Standard for Waste Transfer, Dilution, and Flushing Requirements*[y], all waste transfers within, into and out of the DST system are required to be evaluated before transfer. For slurry transfers, the evaluation must demonstrate that the flow rate during the transfer would be at least 130% of the "Critical Velocity (CV)."

The CV is determined by engineering calculations as specified in *Engineering Data Transmittal (EDT) 820437*. The slurry and transfer line characteristics (e.g., solids fraction, particle size, density, viscosity, settling velocity, temperature, and transfer line diameter) are provided as data inputs into an equation that calculates CV. For slurry transfers through the existing waste transfer lines within the DST system, the transfer pump discharge pressure must be maintained below the design pressure of the transfer lines. In the case of high solids slurries, achievable flow velocity is generally less than 130% of the CV. To increase the flow velocity and stay below the operating pressure limits for the transfer lines, the solids concentration of slurry that is routed through the existing transfer lines in the DST system is limited to 10 wt %.

Note that in Alternatives 15 and 17, pretreated HLW feed is transferred from the DST system to the HLW Vitrification Facility. Although the newly installed transfer lines that deliver feed from the AP Tank Farm to the HLW Vitrification Facility have high enough design pressure ratings to allow transfer of high solids slurries (20 wt % or higher), the existing transfer lines within the AP Tank Farm have lower design pressure ratings and cannot be used to transfer high solid slurries. As a result, the solids concentration of the HLW feed transferred to the HLW Vitrification Facility in Alternatives 15 and 17 is limited to 10 wt %.

6.2 Routing HLW Feed from the Tank Farms to the HLW Vitrification Facility

Pretreated slurry will be transferred in batches from AP-102 to the HLW Vitrification Facility via the Waste Transfer Pit in the HEMF. This Waste Transfer Pit provides convenient waste transfer line connection points to the HLW Vitrification Facility. The pretreated slurry is routed from AP-102 to the HLW Vitrification Facility via jumpers or valve manifolds in the Waste Transfer Pit within the HEMF.

The Waste Transfer Pit within the HEMF also is used to receive and route effluents from the HLW Vitrification Facility and to route the concentrate from the HLW Evaporator to the DST system. An Effluent Collection Vessel located in the HEMF Waste Transfer Pit collects liquid effluents from the HLW Vitrification Facility and waste transfer line flush solutions. The HLW evaporator within the HEMF, processes these liquids and collects the concentrate in an Evaporator Concentrate Vessel. The contents of this vessel are then transferred to the DST system.

6.3 HLW Immobilization in HLW Vitrification Facility

The pretreated slurry from AP-102 is transferred to one of the MFP Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility. The waste transfer routing is the same as described in the previous Section 6.2. The HLW Vitrification Facility process operations for Alternative 15 are the same as described in Section 2.3 for Alternative 1.

Since the concentration of the pretreated HLW feed is limited to 10 wt %, the HLW melters require more time to boil off the excess water. As a result, the effective processing rate of the HLW feed received by the HLW Vitrification Facility is less than the design processing rate.

In Alternative 15, the liquid effluents from the HLW Vitrification Facility are collected in RLD-VSL-00007/8. It is assumed that modifications will be required to the RLD system to pump the contents of RLD-VSL-00007/8 to the Effluent Collection Vessel in the HEMF Waste Transfer Pit.

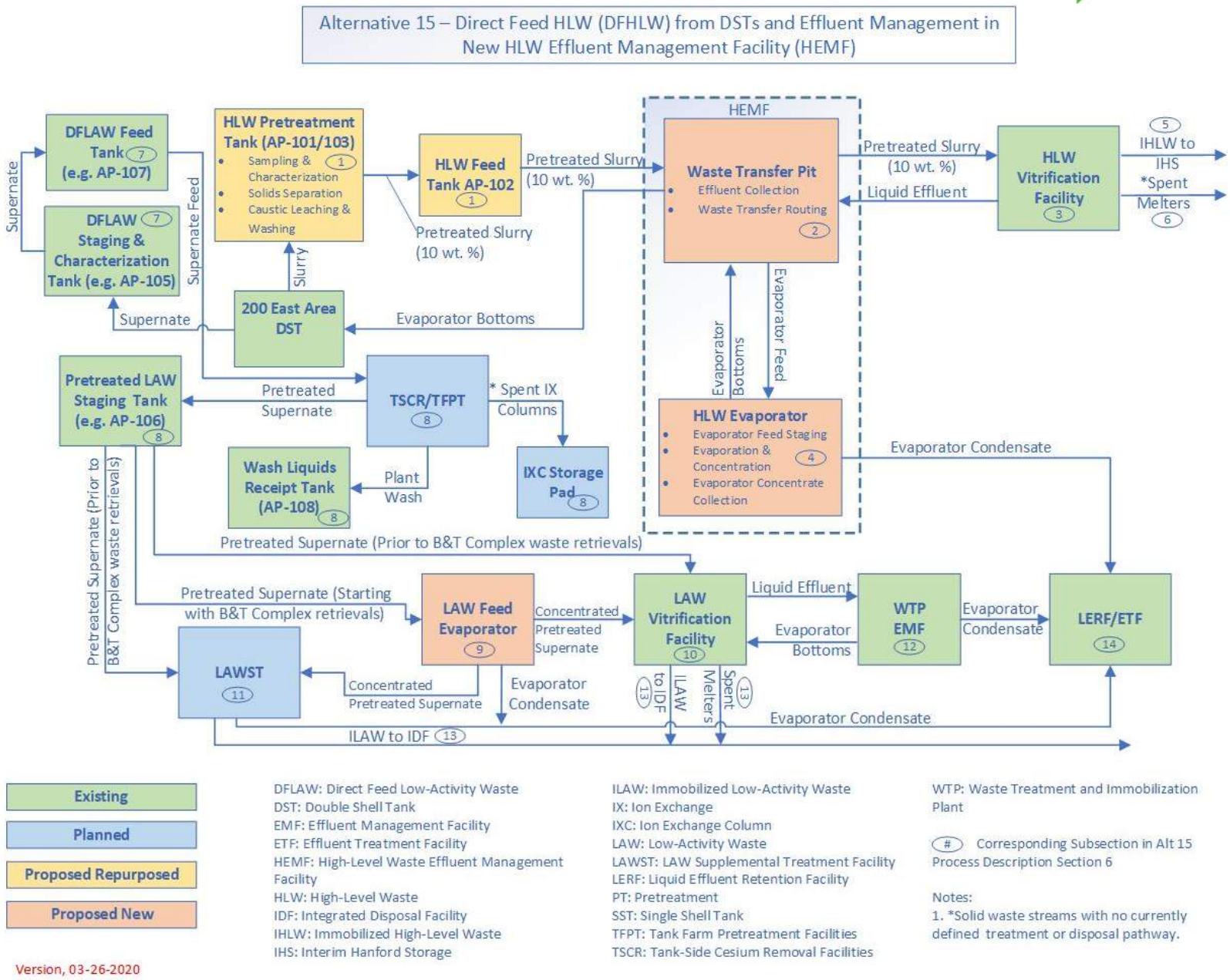

Figure 12: Alternative 15 Process Flow

6.4 HLW Effluent Management in HEMF

In Alternative 15, the HLW pretreatment operations are performed in the DST system and the decanted supernate from these operations is sent to the 242-A Evaporator for processing. The HEMF is used to process the liquid effluents from the HLW Vitrification Facility. The process modeling results[k] show that, for Alternative 15, the HEMF would need to operate at a boil-off rate of 7.0 gpm assuming the TOE for the HLW processing facilities is 40%. After adjusting to a TOE of 100%, the required design capacity for the HEMF for Alternative 15 is greater than 17.5 gpm.

The MAR in the HEMF (principally in the Evaporator Feed and Concentrate Vessels) is assumed to be high enough to require classifying the facility as Hazard Category 2. It also is assumed that the facility would be designed to SC-I requirements for NPH protection. The preconceptual design for the HEMF for Alternative 15 is similar to the HFPEM Facility for Alternative 2, except that the HFP Process Vault is not required for the HEMF. The pre-conceptual design for the HEMF includes the following design features:

- Evaporator Feed and Concentrate Vessels located in a grade-level Process Building with overhead crane
- Pump and Valve Pit (partly below-grade)
- Drain and Effluent Collection Vessels in a below-grade Waste Transfer Pit
- Evaporator Process Building at grade-level with overhead crane
- Safety System Building and Control Room at grade-level

It is conservatively assumed that the MAR in the HEMF and the high-solids content in the Evaporator Feed and Concentrate Vessels will require SC controls similar to the controls required for the PT Facility and the HLW Vitrification Facility. Based on this, the preconceptual design for the HEMF includes SC systems for active vessel ventilation, active confinement ventilation, compressed air for post-DBE vessel sparging, emergency electrical power, and post-shutdown monitoring and control. The SC and SS support systems are in the Safety System Building.

A more complete description of the preconceptual design of the HEMF is provided in Appendix B.

6.5 IHLW Storage in IHS Facility

The IHLW storage process operations (e.g., canister receipt, emplacement, and monitoring) for Alternative 15 are the same as described in Section 2.5 for Alternative 1.

6.6 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not currently have a defined disposal pathway. As described in Section 2.6, for purposes of the alternative cost estimates and the alternative evaluation process, it is assumed that the spent HLW melters will be transported to a concrete pad near the IHS for interim storage pending a decision on the disposal pathway.

6.7 LAW Feed Staging and Characterization in DST System

The LAW feed preparation and delivery functions and the DST configuration for LAW processing by DFLAW are the same as described in Section 2.7 for Alternative 1.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments are the same as those described in Section 2.7 for Alternative 1.

6.8 LAW Pretreatment in TSCR and TFPT Facilities

The DFLAW pretreatment operations for Alternative 15 are the same as described in Section 2.8 for Alternative 1. Since the PT Facility is not used in Alternative 15, the TSCR/TFPT Facility is required to operate for the remainder of the LAW treatment mission after the initial TSCR demonstration phase.

To complete LAW processing at the same time that HLW processing would be completed, the design capacity/throughput of the new TSCR or TFPT Facility for Alternative 15 is required to be 35 gpm (equivalent to 7x the capacity of the TSCR Demonstration Facility).

6.9 Concentration of Pretreated LAW in LFE Facility

Since the PT Facility is not used in Alternative 15, the new LFE Facility is used to concentrate the pretreated LAW feed from the TSCR/TFPT Facility. The processing operations within the LFE and the facility layout are the same as described in Section 3.9 of Alternative 2. The LFE Facility pre-conceptual design is described in more detail in Appendix B.

The process modeling results for Alternative 15[k] show that the LFE would have to operate at a maximum boil-off rate of 14.6 gpm to provide concentrated feed at the required rates assuming that the LAW processing facilities operate at a TOE of 40%. After adjusting the TOE to 100%, the design boil-off rate for the LFE for Alternative 15 would need to be greater than 36.5 gpm.

6.10 LAW Immobilization in LAW Vitrification Facility

The LAW Vitrification Facility process operations for Alternative 15 are the same as described in Section 2.9 for Alternative 1.

6.11 Supplemental LAW Immobilization in LAWST Facility

The LAWST Facility process operations for Alternative 15 are the same as described in Section 2.10 for Alternative 1.

6.12 LAW Effluent Management in WTP EMF

In Alternative 15, the PT Facility is not available to process the liquid effluents from the LAW Vitrification Facility, and the WTP EMF is required to operate for the duration of the LAW treatment mission. The WTP EMF process operations for Alternative 15 are the same as described in Section 2.11 for Alternative 1.

6.13 ILAW and Spent LAW Melter Disposal in IDF

The IDF processing operations (e.g., receipt, emplacement, and disposal) for ILAW containers and spent LAW melters in Alternative 15 are the same as described in Section 2.12 for Alternative 1.

6.14 Staging of Process Condensate and Leachate Collection in LERF and Treatment in ETF

In Alternative 15, the condensate produced by HLW and LAW processing is transferred to the LERF basins. The leachate collected in the ERDF and the IDF is also transferred to the LERF basins. The LERF basins stage these secondary effluents for delivery to the ETF. The treatment processes in the ETF for Alternative 15 are the same as described in Section 2.13 for Alternative 1.

The volume of process condensate and leachate that is generated during the DFLAW phase for Alternative 15 is the same as described in Section 2.13 for Alternative 1. Alternative 15 assumes that the existing ETF will be modified as recommended in the *ETF Flowsheet Assessment*[qq] before starting DFLAW operations (Note that starting BoM operations occurs immediately after achieving the ACD milestone for completing hot commissioning of the HLW Vit Facility. For the unconstrained funding case, this date is 12/31/2033 as specified in the ACD).

The process modeling results for Alternative 15 predict that highest volume of process condensate that is generated in any one-year period during the BoM phase is 32.0 Mgal based on a TOE of 40%. After adjusting to a TOE of 100% and adding in the annual leachate generation, the highest volume of process condensate and leachate that would be

generated in any year would be 81.8 Mgal. This equates to an instantaneous generation rate of 156 gpm. Based on this, the new ETF to be constructed for Alternative 15 would need a design capacity of 222 gpm (156 gpm/70% TOE). It is assumed that the new higher capacity ETF is constructed and commissioned before starting BoM operations (12/31/2033).

6.15 Schedule Assumptions for Alternative 15

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the HLW (and LAW) treatment mission for Alternative 15 is described in an *MSR Form MR-50535*[z]. The schedule assumptions that are different than those specified in Section 2.14 for Alternative 1 are identified below.

- HLW pretreatment begins once the DSTs designated for HLW pretreatment and staging are properly equipped, associated Tank Farm infrastructure is upgraded, and new HEMF is constructed, commissioned, and placed in operation (assumed date is 6/30/2032).
- The HLW Vitrification Facility is considered operational when: (1) process vessel analyses required to address the relevant DNFSB TIs are completed; (2) facility modifications necessary to address operability, maintainability, and nuclear safety recommendations in *Engineering Study for HLW Options E and F*[l] are completed; (3) remaining facility construction is completed; (4) new facilities required to allow the HLW Vitrification Facility to operate independent of the PT Facility (e.g., Control Room, Incident Command Post, and facilities to house SC emergency electrical power supply and compressed air systems) are constructed and commissioned; and (5) hot commissioning is completed (Note that HLW vitrification is assumed to start immediately after items (1) – (5) have been completed. For the unconstrained funding case, this date is assumed to be 12/31/2033).
- TFPT Facility design capacity is 35 gpm (equivalent to the capacity of seven TSCR demonstration units).
- LAWST Facility design capacity is equivalent to the design capacity of 10 LAW melters.
- LFE Facility starts up before beginning retrieval of the high phosphate SSTs (Note: WRPS modeling assumed completion in FY 2035).
- Overall TOE of all HLW processing facilities remains at 40% with DST system used for HLW pretreatment, PT Facility not used, and HEMF used for HLW effluent management.
- Overall TOE for all LAW processing facilities remains at 40% with LAW pretreatment performed entirely in the TFPT Facility without reliance on the PT Facility, LAW effluent management performed by the WTP EMF, and with LAW feed concentration performed by the LFE.

7 Alternative 16 – DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF

In Alternative 16, the HLW feed staging, characterization, and pretreatment operations are performed in the DST system in the same manner as Alternative 15. After pretreatment in the DST system, the pretreated slurry is transferred to a Settling Vessel in an HLW Slurry Vault in the HEMF. The pretreated slurry is concentrated in this vessel by settling and decant operations. After concentrating the pretreated slurry to 15 wt %, the slurry is sent to an HLW Feed Vessel where it is staged for delivery to the HLW Vitrification Facility.

The HEMF for Alternative 16 provides the same capabilities for collecting liquid effluents and flush water from waste transfer lines as Alternative 15. These liquids are collected in an Effluent Collection Vessel in the HEMF Waste Transfer Pit. For Alternative 16, the HLW evaporator in the HEMF Process Building concentrates the decanted supernate from the Slurry Settling Vessel and the secondary liquid waste in the Effluent Collection Vessel. The HLW evaporator process operations for Alternative 16 are the same as Alternative 15. A summary of the process flow for Alternative 16 is depicted in Figure 13. The Alternative 16 process modeling results are described in detail in the *HLW AoA Model Results Report*[k].

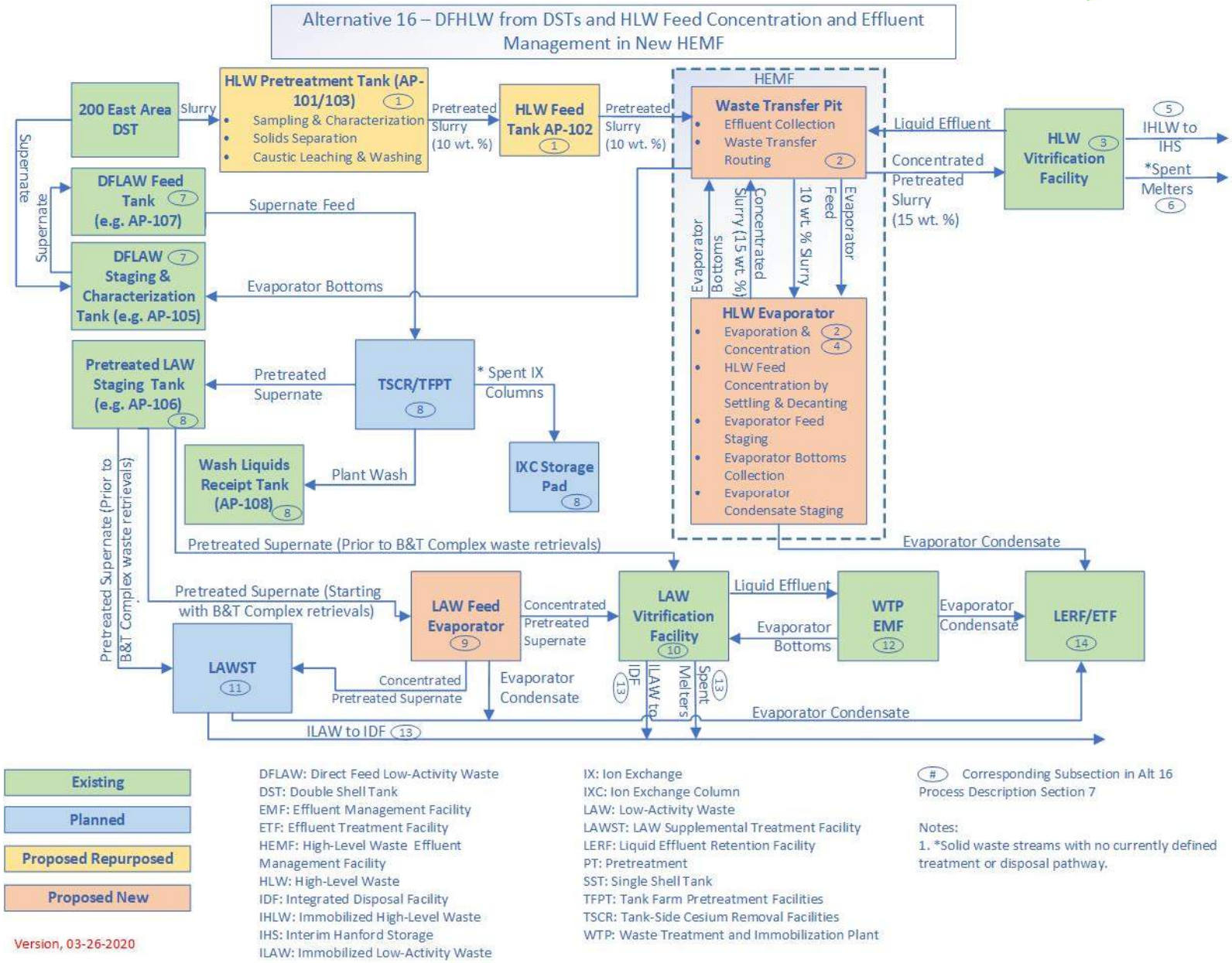

Figure 13: Alternative 16 Process Flow

7.1 HLW Characterization and Pretreatment in DST System

Sludge is mobilized in source DSTs and the resultant slurry is transferred to the designated HLW Pretreatment Tank in the DST system (AP-101 or AP-103). The source DSTs that could be used for the DFHLW approach described in Alternatives 15 and 16 were evaluated in earlier studies of the DFHLW approach including the *Preconceptual Engineering Study for Direct Feed High-Level Waste* issued in 2012[x].

The slurry in AP-101/103 is pretreated in the same manner as described in Section 6.1 for Alternative 15. The pretreated slurry is transferred from AP-101/103 to a designated HLW Feed Tank in the DST system (AP-102) where it is staged for delivery to the HEMF.

Due to the lower pressure rating of the existing waste transfer lines within the AP Tank Farm, the pretreated slurry from AP-102 is transferred to the HLW Slurry Settling Vessel in the HEMF at 10 wt %.

7.2 Concentration of Pretreated HLW in New HEMF

In Alternative 16, the 10 wt % slurry in AP-102 is transferred to the HLW Slurry Settling Vessel located in an HLW Slurry Vault within the HEMF. The slurry is allowed to settle, and the supernate layer is decanted after settling. The settling and decanting steps are repeated as required to achieve a slurry concentration of 15 wt %. The concentrated pretreated slurry is sent to the HFV in the HLW Slurry Vault where it is staged for delivery to the HLW Vitrification Facility.

The pre-conceptual design for the HLW Slurry Vault and the interfaces with the other vaults and pits within the HEMF is described in more detail in Appendix B.

The decanted supernate from the HLW Slurry Settling Vessel is sent to one of the two the HLW Evaporator Feed Vessels located in the HEMF Process Vault within the HEMF. The liquid effluents and transfer line flush water that is collected in the Effluent Collection Vessel in the HEMF Waste Transfer Pit also is sent to the HLW Evaporator Feed Vessel where it is mixed with the decanted supernate. Based on the cycle time for the concentration process operations, one 192 kgal Slurry Settling Vessel and one 40 kgal HFV are required.

7.3 HLW Immobilization in HLW Vitrification Facility

The pretreated slurry from the HFV in the HLW Slurry Vault within the HEMF is transferred to one of the MFP Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility. The HLW melter process operations for Alternative 16 are the same as described in Section 2.3 for Alternative 1.

The liquid effluents from the HLW Vitrification Facility are collected in RLD-VSL-00007. After chemistry adjustments, the effluent is transferred to RLD-VSL-00008. It is assumed that modifications will be required to the RLD system to pump or gravity drain RLD-VSL-00008 to the Effluent Collection Vessel in the Waste Transfer Pit within the HEMF.

7.4 HLW Effluent Management in HEMF

Since the HLW pretreatment operations are performed in the DST system, the decanted supernate from these operations is sent to the 242-A Evaporator for processing. The Slurry Settling Vessel and the HFV within the HEMF provide the settling and decant capabilities needed to concentrate the pretreated slurry received from AP-102. The decanted supernate from the Slurry Settling Vessel and the liquid effluents from the HLW Vitrification Facility are sent to one of the two HEMF Evaporator Feed Vessels and are concentrated in the HEMF evaporator. Similar to Alternative 15, the concentrate from the HLW evaporator is collected in one of the two Evaporator Concentrate Vessels in the HEMF Process Vault. The evaporator concentrate is transferred to the DST system, and the condensate is sent to the LERF/ETF.

Other than differences in capacity, the HEMF process operations are the same as described in Section 3.4 for Alternative 2. The process modeling results for Alternative 16[k] show the maximum boil-off rate that the HEMF evaporator

would need to sustain is 4.1 gpm assuming that the TOE for the HLW processing facilities is 40%. After adjusting to a TOE of 100%, the required design capacity for the HEMF for Alternative 16 is greater than 10.2 gpm.

The preconceptual design for the HEMF for Alternative 16 is similar to the HEMF for Alternative 15. The only significant difference in the facility configuration is the addition of the HLW Slurry Vault for Alternative 16. The vessels and structures associated with the HLW Evaporator are smaller for Alternative 16. This is a result of the lower design boil-off rate for the HLW evaporator. A more detailed description of the preconceptual design for the HEMF for Alternative 16 is provided in Appendix B.

7.5 IHLW Storage in IHS Facility

The IHLW storage process operations (e.g., canister receipt, emplacement, and monitoring) for Alternative 16 are the same as described in Section 2.5 for Alternative 1.

7.6 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not currently have a defined disposal pathway. As described in Section 2.6, for purposes of the alternative cost estimates and the alternative evaluation process, it is assumed that the spent HLW melters will be transported to a concrete pad near the IHS for interim storage pending a decision on the disposal pathway.

7.7 LAW Feed Staging and Characterization in DST System

The LAW feed preparation processes and the DST configuration for LAW processing by DFLAW are the same as described in Section 2.7 for Alternative 2.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments are the same as those described in Section 2.7 for Alternative 1.

7.8 LAW Pretreatment in TSCR and TFPT Facilities

The DFLAW processing operations for Alternative 16 are the same as described in Section 2.8 for Alternative 1. Since the PT Facility is not used in Alternative 16, the new TSCR or TFPT Facility is required to operate for the remainder of the LAW treatment mission after the initial TSCR demonstration phase.

To complete LAW processing at the same time that HLW Processing would be completed, the design capacity/throughput of the new TSCR or TFPT Facility is required to be 50 gpm (equivalent to 10x the capacity of the TSCR Demonstration Facility).

7.9 Concentration of Pretreated LAW in LFE Facility

Since the PT Facility is not used in Alternative 16, a separate LFE must be provided to concentrate the pretreated LAW Feed from the TSCR and TFPT facilities. The processing operations within the LFE are the same as described in Section 3.9 for Alternative 2. The LFE Facility pre-conceptual design is described in more detail in Appendix B.

The process modeling results for Alternative 16[k] show that the LFE would have to operate at a maximum boil-off rate of 15.3 gpm to provide concentrated feed at the required rates assuming that the LAW processing facilities operate at a TOE of 40%. After adjusting the TOE to 100%, the design boil-off rate for the LFE for Alternative 16 would need to be greater than 38.2 gpm.

7.10 LAW Immobilization in LAW Vitrification Facility

The process operations in the LAW Vitrification Facility for Alternative 16 are the same as described in Section 2.9 for Alternative 1.

The production rate of ILAW, the waste loading of the ILAW and the total number of ILAW containers produced varies for each alternative. The WTP HLW AoA flowsheet modeling results will determine the values of these parameters for each alternative.

7.11 Supplemental LAW Immobilization in LAWST Facility

The process operations in the LAWST Facility for Alternative 16 are the same as described in Section 2.10 for Alternative 1.

7.12 LAW Effluent Management in WTP EMF

In Alternative 16, the PT Facility is not available to process the liquid effluents from the LAW Vitrification Facility, and the WTP EMF is required to operate for the duration of the LAW treatment mission. The process operations in the WTP EMF for Alternative 16 are the same as described in Section 2.11 for Alternative 1.

7.13 ILAW and Spent LAW Melter Disposal in IDF

The IDF receipt, emplacement, and disposal functions for ILAW containers and spent LAW melters in Alternative 16 are the same as described in Section 2.12 for Alternative 1.

7.14 Staging of Process Condensate and Leachate Collection in LERF and Treatment in ETF

In Alternative 16, the condensate produced by HLW and LAW processing is transferred to the LERF basins. The leachate collected in the ERDF and the IDF also is transferred to the LERF basins. The LERF basins stage these secondary effluents for delivery to the ETF. The treatment processes in the ETF for Alternative 16 are the same as described in Section 2.13 for Alternative 1.

The volume of process condensate and leachate that is generated during the DFLAW phase is the same as described in Section 2.13 for Alternative 1. As for Alternative 1, Alternative 16 assumes that the existing ETF will be modified as recommended in the *ETF Flowsheet Assessment*[qq] before starting DFLAW operations (12/31/2023).

The process modeling results for Alternative 16 predict that highest volume of process condensate that is generated in any one-year period during the BoM phase is 30.7 Mgal based on a TOE of 40%. After adjusting to a TOE of 100% and adding in the annual leachate generation, the highest volume of process condensate and leachate that would be generated in any year would be 78.6 Mgal. This equates to an instantaneous generation rate of 149 gpm. Based on this, the new ETF to be constructed for Alternative 16 would need a capacity of approximately 213 gpm (149 gpm/70% TOE). It is assumed that the new higher capacity ETF is constructed and commissioned before starting HLW processing for BoM operations (Note that starting BoM operations occurs immediately after achieving the ACD milestone for completing hot commissioning of the HLW Vit Facility. For the unconstrained funding case, this date is 12/31/2033 as specified in the ACD). Schedule Assumptions for Alternative 16

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the HLW (and LAW) treatment mission for Alternative 16 is described in an *MSR Form MR-50535*[z]. The schedule assumptions that are different than those specified in Section 2.14 for Alternative 1 are identified below.

- HLW pretreatment begins once the DSTs designated for HLW pretreatment and staging (AP-101, AP-102, and AP 103) are properly equipped, associated Tank Farm pump and valve pits and waste transfer infrastructure is upgraded, and new HEMF is constructed, commissioned, and placed in operation (assumed date is 6/30/2032).

- HLW vitrification begins once the HEMF is constructed and commissioned, and placed in operation (assumed date is 12/31/2033), and the HLW Vitrification Facility is hot commissioned.
- The HLW Vitrification Facility is considered operational when: (1) process vessel analyses required to address the relevant DNFSB TIs are completed; (2) facility modifications necessary to address operability, maintainability, and nuclear safety recommendations in *Engineering Study for HLW Options E and F*[ll] are completed; (3) remaining facility construction is completed; (4) new facilities required to allow the HLW Vitrification Facility to operate independent of the PT Facility (e.g., Control Room, Incident Command Post, and facilities to house SC emergency electrical power supply and compressed air systems) are constructed and commissioned; and (5) hot commissioning is completed (Note that HLW vitrification is assumed to start immediately after items (1) – (5) have been completed. For the unconstrained funding case, this date is assumed to be 12/31/2023).
- New TSCR or TFPT Facility design capacity/throughput is 50 gpm (equivalent to the capacity of 10 TSCR demonstration units).
- LAWST Facility design capacity is equivalent to 10 LAW melters.
- LFE Facility starts up before beginning retrieval of the high phosphate SSTs (WRPS modeling assumed completion in FY 2035).
- Overall TOE of all HLW processing facilities remains at 40% with HLW pretreatment performed in DST system and HLW effluent management and HLW feed concentration performed in the HEMF.
- Overall TOE for all LAW processing facilities remains at 40% with LAW pretreatment performed entirely in the TSCR/TFPT Facility, with LAW effluent management performed by the WTP EMF, and with LAW feed concentration performed by the LFE Facility.

8 Alternative 17 – DFHLW from DSTs without HLW Effluent Management

Alternative 17 provides HLW pretreatment and treatment capabilities with the lowest possible capital investment. HLW feed is sampled, characterized, and pretreated (limited to solids washing) in a designated DFHLW Feed Pretreatment Tank in the DST system (AP-101). The pretreated HLW feed is then transferred to a designated DFHLW Feed Tank (AP-102) to be staged for delivery to the HLW Vitrification Facility via a new WTV. The WTV pre-conceptual design is described in Appendix B. The slurry in AP-102 is transferred to an HFV in the WTV. The WTV is located near the HLW Vitrification Facility to facilitate waste transfer line connections. The HLW Feed Vessel transfers the slurry to the HLW Vitrification Facility in a recirculating loop. An Effluent Collection Vessel in the WTV receives liquid effluents and waste transfer line flush water drainage from the HLW Vitrification Facility. The Effluent Collection Vessel contents are transferred to the DST system (AP-103).

Since Alternative 17 does not provide new HLW effluent management capabilities, the 242-A evaporator is used to concentrate the effluents received from the Effluent Collection Vessel. The chemical and water additions used for solids washing in the DST system also will need to be concentrated in the 242-A evaporator to make space available in the DST system to continue to prepare HLW (and LAW) feed and receive the HLW Vitrification Facility liquid effluents and receive waste from SST retrievals.

HLW processing continues using the DFHLW approach through completion of the HLW and LAW processing mission. No additional HLW processing capabilities are added after starting processing using the DFHLW approach for Alternative 17.

The new WTV Facility and Tank Farm upgrades that will be required for Alternative 17 provide features that will facilitate the addition of new facilities and capabilities at a later date. Spare transfer line nozzles, valving, and jumpers will be provided in the WTV Facility to facilitate routing to and from future pretreatment or effluent management facilities.

The HLW Vitrification Facility will operate with one melter in service. Except for the limitation on HLW feed availability, the HLW Vitrification Facility is assumed to operate in the same manner as assumed for all other alternatives.

LAW pretreatment is limited to filtration and cesium removal by the TSCR and/or TFPT facilities. Since the LFE is not provided, the dilute pretreated LAW feed is sent to the LAW Vitrification Facility.

A summary of the process flow for Alternative 17 is depicted in Figure 14. The Alternative 17 process modeling results are described in detail in the *HLW AoA Model Results Report*[k]. Because of the limited LAW processing capability and the resultant limitation on DST space availability, the tank waste treatment mission takes over 134 years to complete (beyond year 2168). An exact date cannot be determined, or extrapolated, due to model capability limitations.

Since Alternative 17 does not include an LAWST capability, the LAW processing rate is limited to the capacity of the LAW Vitrification Facility. Additionally, since Alternative 17 does not include an LFE to concentrate the LAW feed, the LAW Vitrification Facility operates at less than design capacity because of the time required for the melters to boil off the excess water in the LAW feed. Because of the limited LAW processing rate, the HLW processing is limited by the ability of the 242-A evaporator to remove liquids from the DST system and make space available for HLW feed preparation and to receive the HLW Vitrification Facility liquid effluents. The limited availability of DST space also severely restricts the ability to retrieve waste from the SSTs.

8.1 HLW Feed Sampling, Characterization, Pretreatment, and Staging in the DST System

Sludge is mobilized in the source DSTs and the resultant slurry is transferred to a designated DFHLW Feed Preparation Tank within the DST system (AP-101). The slurry in AP-101 is sampled and washed. After the washing operations are completed and the waste characterization samples are analyzed and evaluated for compliance with the WTP WAC, the pretreated slurry in AP-101 is transferred to a designated DFHLW Feed Tank in the DST system (AP-102). The pretreated slurry in AP-102 is transferred in small batches (approximately 20 kgal) to the HFV in the WTV Facility.

Since the pressure rating of the existing waste transfer lines in the AP Tank Farm is low, the slurry from AP-102 is transferred to the HFV in the WTV at 10 wt %. Elimination of the leaching operations requires a further reduction in the HLW feed concentration to keep the aluminum in solution. This results in a reduction in the efficiency of the HLW melters.

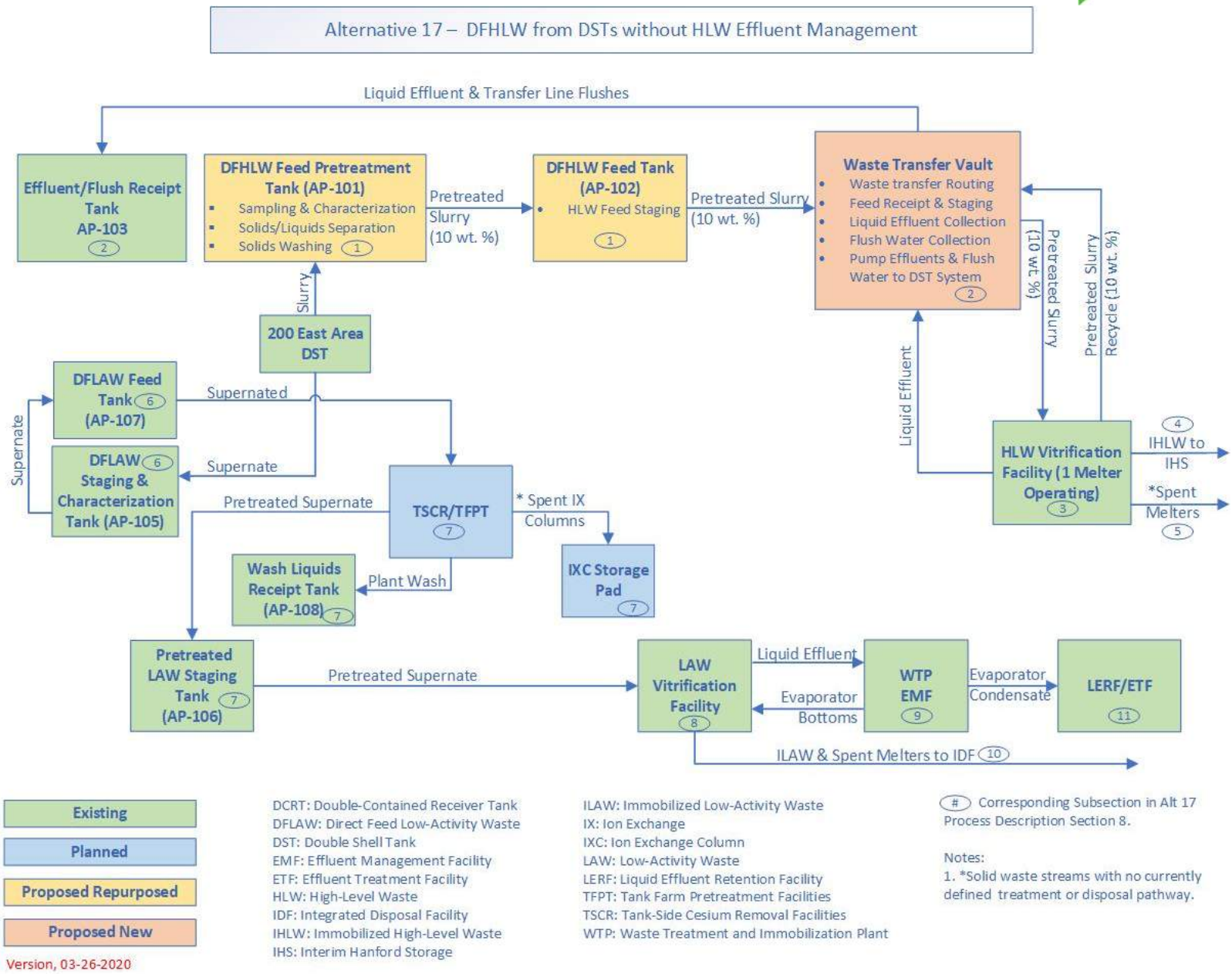

Figure 14: Alternative 17 Process Flow

8.2 HLW Feed Transfer from the WTV to the HLW Vitrification Facility

A 24 kgal HFV in the new WTV receives pretreated slurry from AP-102. The slurry in the HLW Feed Vessel is recirculated through waste transfer lines between the WTV Facility and the HLW Vitrification Facility. A portion of the slurry is diverted to one of the MFP Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility on an as-needed basis. The slurry in the MFP Vessel is blended with glass forming chemicals and transferred to one of the Melter Feed Vessels (HFP-VSL-00002/6). The Melter Feed Vessel provides HLW feed to the HLW melter.

The WTV is assumed to be a below-grade concrete pit with a stainless-steel liner. The vault provides secondary containment for the HFV and the HLW Effluent Collection Vessel located in the vault. The vessels are actively ventilated by a primary ventilation system. A separate active confinement ventilation system is provided for the vault. The HLW Feed Vessel is assumed to require post-DBE air sparging capability similar to the SHSVs for the PT Facility.

The WTV Facility is assumed to be a Hazard Category 2 facility. It also is assumed that the vault structure would be designed to SC-I requirements. The ventilation and compressed air systems are assumed to be functionally classified as SC. An SC emergency electrical power supply is also assumed to be required for the vessel and vault ventilation systems and compressed air system used to provide post-DBE air sparging for the HFV. The SC systems are assumed to be housed in a Safety System Building located adjacent to the WTV.

The NaOH (sodium hydroxide) and $NaNO_2$ (sodium nitrite) tanks that are needed to adjust the chemistry of the waste in the HLW Effluent Collection Tank are assumed to located on a Cold Chemical Supply Pad that abuts the WTV. Other non-safety support systems and utilities are assumed to be in a Utility Supply Building near the WTV. A more detailed description of the preconceptual design for the WTV Facility is provided in Appendix B.

To facilitate effluent collection and to transfer line gravity drainage, the new WTV Facility is assumed to be located as near as practicable to the HLW Vitrification Facility. An Effluent Collection Vessel in the WTV receives liquid effluents and waste transfer line flush water drainage from the HLW Vitrification Facility. The Effluent Collection Vessel contents are transferred to the DST system (AP-103). The HLW Vitrification Facility was designed to receive feed through a pipe tunnel near the north wall (approximately equidistant between the east and west sides). The waste transfer lines from the WTV Facility would tie in at this location.

The waste transfer line routing from AP-102 to the new WTV Facility will use existing waste transfer lines where possible. The existing HLW feed and the Tank Farm waste return transfer lines between the AP Tank Farm, and the WTP interface point will therefore be used. It is assumed that new waste transfer lines will be installed from the WTP interface point to the new WTV Facility. It also is assumed that new waste transfer lines will be installed between the WTV and the HLW Vitrification Facility.

8.3 HLW Immobilization in HLW Vitrification Facility

The pretreated slurry from the HFV in the WTV is transferred to one of the MFP Vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility.

Except for the number of melters that are in operation, the HLW melter process operations for Alternative 17 are the same as described in Section 2.3 for Alternative 1. In Alternative 17, both HLW melters are installed and commissioned. In Alternative 17, the LAW processing is rate limiting due to the elimination of the LAWST Facility, and the HLW pretreatment and treatment rate is curtailed to ensure that HLW processing completes at the same time that LAW processing completes. As a result, the HLW processing rate is less than the design capacity of one HLW melter. Alternative 17 therefore assumes that only one HLW melter is in operation at any given time. The second HLW melter is assumed to be idled.

The liquid effluents from the HLW Vitrification Facility are collected in RLD-VSL-00007. After chemistry adjustments, the effluent is transferred to RLD-VSL-00008. It is assumed that modifications will be required to the RLD system to pump or gravity drain RLD-VSL-00008 to the HLW Effluent Collection Vessel in the WTV.

8.4 IHLW Storage in IHS Facility

IHLW storage process operations (e.g., canister receipt, emplacement, and monitoring) in the IHS Facility for Alternative 17 are the same as described in Section 2.5 for Alternative 1.

8.5 Storage and Disposal of Spent HLW Melters

The spent HLW melters do not currently have a defined disposal pathway. As described in Section 2.6, for purposes of the alternative cost estimates and the alternative evaluation process, it is assumed that the spent HLW melters will be transported to a concrete pad near the IHS for interim storage pending a decision on the disposal pathway.

8.6 LAW Feed Staging and Characterization in DST System

The LAW feed preparation and delivery functions and the DST configuration for LAW processing by DFLAW are the same as described in Section 3.7 for Alternative 2.

The requirements for DST system infrastructure upgrades and modifications and for performing tank integrity assessments are the same as those described in Section 2.7 for Alternative 1.

8.7 LAW Pretreatment in TSCR and TFPT Facilities

The DFLAW pretreatment operations for Alternative 17 are the same as described in Section 2.8 for Alternative 1. Since the PT Facility is not used in Alternative 17, the new TSCR/TFPT Facility is required to operate for the remainder of the LAW treatment mission after the initial TSCR demonstration phase.

The design capacity of the new TSCR/TFPT Facility for Alternative 17 is 10 gpm (equivalent to the capacity of two TSCR demonstration units). This TSCR/TFPT Facility design capacity is sufficient to allow the LAW Vitrification Facility to operate at its design capacity.

8.8 LAW Immobilization in LAW Vitrification Facility

The LAW Vitrification Facility process operations for Alternative 17 are the same as described in Section 2.9 for Alternative 1. Since Alternative 17 does not provide the capability to concentrate the LAW feed (due to elimination of the LFE Facility), the feed provided to the LAW Vitrification Facility is dilute. As a result of the dilute feed, the LAW melters take a longer time to boil off the water from in the feed. The lower LAW melter efficiency in Alternative 17 further reduces the overall LAW processing rate.

8.9 LAW Effluent Management in WTP EMF

In Alternative 17, the PT Facility is not available to process the liquid effluents from the LAW Vitrification Facility and the WTP EMF is required to operate for the duration of the LAW treatment mission. The WTP EMF process operations for Alternative 17 are the same as described in Section 2.11 for Alternative 1.

8.10 ILAW and Spent LAW Melter Disposal in IDF

The IDF receipt, emplacement, and disposal functions for the ILAW containers and spent LAW melters in Alternative 17 are the same as described in Section 2.12 for Alternative 1.

8.11 Staging of Process Condensate and Leachate Collection in LERF and Treatment in ETF

In Alternative 17, the condensate produced by HLW and LAW processing is transferred to the LERF basins. The leachate collected in the ERDF and the IDF is also transferred to the LERF basins. The LERF basins stage these secondary effluents for delivery to the ETF. The treatment processes in the ETF for Alternative 17 are the same as described in Section 2.13 for Alternative 1.

The volume of process condensate and leachate that is generated during the DFLAW and BoM phase for Alternative 17 is the same as Alternative 1 (1.8 Mgal/year).

In Alternative 17, the only sources of process condensate are the 242-A evaporator and the WTP EMF. The process modeling results for Alternative 17[k] predict that highest volume of process condensate that is generated in any one-year period during the BoM phase is 7.5 Mgal based on a TOE of 40%. After adjusting for 100% TOE and adding in the leachate generation, the highest expected volume that the ETF would need to process in any year is 20.6 Mgal. This equates to an instantaneous feed rate to the ETF of 39 gpm.

The existing ETF, once modified to address the recommendations in the *ETF Flowsheet Assessment*[qq], is expected to have a design capacity of 100 gpm. Based on the above, the capacity of the existing ETF is adequate for the DFLAW and BoM phases for Alternative 17. It is assumed that the ETF will be modified as required to implement the recommendations in the *ETF Flowsheet Assessment* before starting DFLAW operations (12/31/2023). As is the case for all the facilities that would need to operate throughout the 130+ years of the HLW and LAW processing mission, it assumed that the ETF will have to be replaced multiple times over this period.

8.12 Schedule Assumptions for Alternative 17

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the HLW (and LAW) treatment mission for Alternative 17 is described in an *MSR Form MR-50555*[aa]. The schedule assumptions that are different from those specified in Section 2.14 for Alternative 1 are identified below.

- HLW pretreatment begins once the DSTs designated for HLW pretreatment and staging (AP-101, AP-102, and AP-103) are properly equipped and the associated Tank Farm pump and valve pits and waste transfer infrastructure are upgraded (assumed date is 6/30/2032).
- HLW vitrification starts once the WTV Facility is constructed and commissioned and the HLW Vitrification Facility is operational.
- New WTV Facility construction and commissioning is completed by 12/31/2033 (WRPS modeling assumed completion by FY 2032).
- The HLW Vitrification Facility is considered operational when: (1) facility modifications required to address the relevant DNFSB TS are completed; (2) modifications required to implement operability, maintainability, and nuclear safety recommendations in *Engineering Study for HLW Options E and F*[ll] are completed; (3) remaining facility construction is completed; (4) construction of new facilities required to allow the HLW Vitrification Facility to operate independent of the PT Facility (e.g., Control Room, Incident Command Post, and facility [facilities] for SC compressed air and emergency electrical power systems) are completed; and (5) hot commissioning is completed (Note that HLW vitrification is assumed to start immediately after items (1) – (5) have been completed. For the unconstrained funding case, this date is assumed to be 12/31/2023).
- New TSCR or TFPT Facility design capacity/throughput is 10 gpm (equivalent to the capacity of two TSCR demonstration units).
- LAWST Facility is not constructed.
- Overall TOE of all HLW processing facilities remains at 40%, with HLW pretreatment performed in the DST system and HLW pretreatment limited to sludge washing only.
- Overall TOE for all LAW processing facilities remains at 40%, with LAW pretreatment performed entirely in the TSCR/TFPT Facility, dilute LAW feed being provided to the LAW Vitrification Facility, and LAW effluent management performed by the WTP EMF.

APPENDIX B: FACILITY DESCRIPTIONS

1 Summary

The AoA Team developed notional pre-conceptual design features and facility layout drawings to support the AoA cost/schedule estimates and the alternative evaluation process. This Appendix provides a description of the preconceptual design features for new (and repurposed) HLW and LAW processing facilities included in the alternatives. These descriptions also provide the basis for assuming that the design features for each facility were necessary and appropriate.

The level of detail of the facility descriptions varies for each facility. The focus of the facility descriptions is on those facilities that are in the planning stages or early design stages. Existing facilities and new facilities that have an established design baseline (i.e., preliminary or final design) are not described in detail.

Pre-conceptual facility layout drawings were developed for each new facility that did not have an established design baseline. In addition, pre-conceptual overlay drawings were developed to show the proposed location of the new process vessels and equipment that would be installed in the Repurposed PT Facility (RPT) for Alternative 5.

The basis for the pre-conceptual design information developed for the new processing facilities in founded on the facility processing capabilities. The functional capabilities of these facilities are described in detail in Appendix A. The sizing of the facilities was based on the size of the new vessels and equipment to be in the facility and the size of other existing facilities that perform similar functions. The process and process support area configuration within each facility was developed to simplify internal process and utility routing and on risk-based considerations for nuclear safety. In general process and process support structures, systems and components (SSCs) that required nuclear safety controls for accident prevention/mitigation were in hardened structures for Natural Phenomena Hazards (NPH) protection.

2 Double-Shell Tank (DST) System

The double-shell tank (DST) system is operated by the Office of River Protection (ORP) Tank Operations Contractor (Washington River Protection Solutions [WRPS]). The DST system consists of the DSTs, the AN, AP, AW, AX, AY, and SY Tank Farm facilities, and the waste transfer systems (e.g., valve and pump pits, waste transfer lines within the East and West Tank Farms, and the cross-site transfer system).

The DST system provides the following functions for high-level waste (HLW) feed preparation and pretreatment:

- Sludge mobilization in source DSTs and transfer of the resulting slurry to a designated DST for characterization, pretreatment, or staging
- Characterization (sampling and storing feed until sample analysis results are evaluated for compliance with the Waste Treatment and Immobilization Plant [WTP] Waste Acceptance Criteria [WAC]) of HLW and low-activity waste (LAW) feed.
- Pretreatment of HLW feed (applicable to Alternatives 15, 16, and 17 only)
- Staging HLW and LAW feed

2.1 DST Modifications and Upgrades

The DSTs are grouped into six Tank Farms along with the associated Tank Farm SSCs. The six DST farms contain 28 DSTs that were constructed on the Hanford Site: three in the 200 West Area and 25 in the 200 East Area. The tanks were constructed over a period of roughly 18 years (from 1968 to 1986), with a design life of 20 to 50 years. The DSTs continue to operate well past their design life with only one confirmed leaker (AY-102) from the primary tank. The AP Tank Farm was the sixth and final DST Tank Farm constructed (between 1982 and 1986) and incorporated construction

method improvements after the AY Tank Farm was constructed that were judged to improve the AP Tank Farm quality and integrity[bb].

The DSTs contain liquids and settled solids, either salts or sludge. The DSTs currently play an integral role in completing the River Protection Project (RPP) mission, including:

- Storing tank waste in accordance with the Resource Conservation and Recovery Act (RCRA);
- Supporting single-shell tank (SST) retrievals by receiving retrieved SST waste;
- Supporting 242-A Evaporator operations;
- Staging waste for direct-feed LAW (DFLAW) and receiving DFLAW secondary waste; and
- Staging feed for delivery to the WTP and receiving secondary waste from the WTP.

The DSTs receive slurries and supernate from SST waste retrievals and store or pretreat the waste depending on the alternative selected. The DSTs differ from SSTs primarily by the secondary containment liner as shown in Figure 15[cc].

The source DSTs that contain sludge and the designated DSTs to be used for HLW feed delivery will require the installation of two mixer pumps capable of suspending (mobilizing) sludge solids and concentrated slurry material[dd]. Mixer pumps were used previously in some Hanford tanks and to support salt cake dissolution in SY-101, and they were also tested in AZ-101. Figure 16 shows a representative mixer pump system arrangement (slab mount) schematic[ee]. Pump motors are specified at 460 volts of alternating current (VAC) (i.e., 480 VAC at the power source). DSTs with significant accumulation of solids may require the installation of multiple adjustable height mixer pumps to provide adequate suspension of waste slurry. Mixer pumps also may be required for salt cake dissolution of Waste Group A tanks[dd].

New tank risers may need to be installed to accommodate the mixer pumps as specified (Note: there are only a few DSTs with sufficient risers in the right configuration). Tanks requiring height-adjustable mixer pumps (e.g., tanks with deep solids) will require actuated platforms and telescoping shaft shielding to enable the vertical motion.

New slurry transfer pumps will need to be installed in the DSTs containing sludge. Slurry distributors also will need to be installed in the designated HLW preparation and staging DSTs.

The DST primary and annulus ventilation system will need to be upgraded or replaced depending on the Tank Farm and the number of mixer pumps expected to operate simultaneously. The Tank Farm utility systems also will require upgrades to provide normal and backup power to the mixer pumps and primary and annulus ventilation systems, compressed air, waste transfer and leak detection interlocks, and remote monitoring.

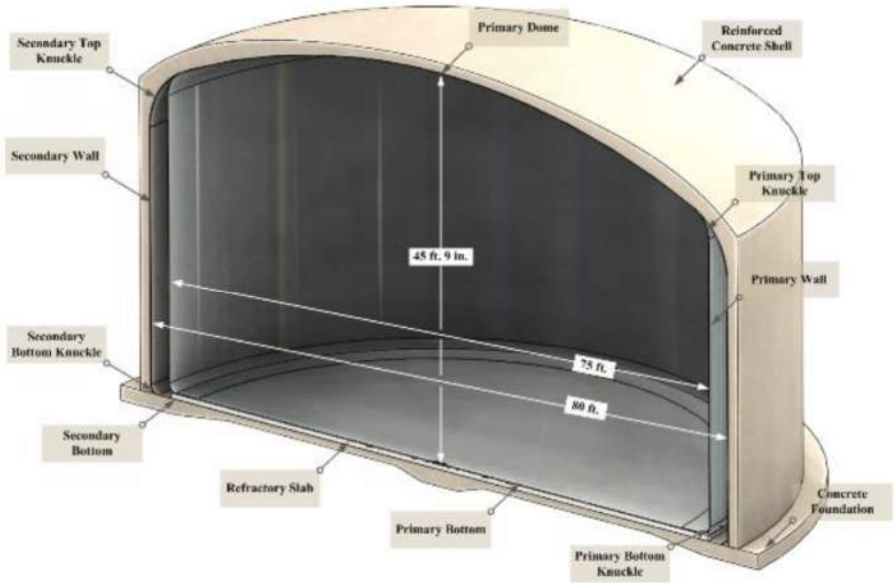

Figure 15: DST Schematic[cc]

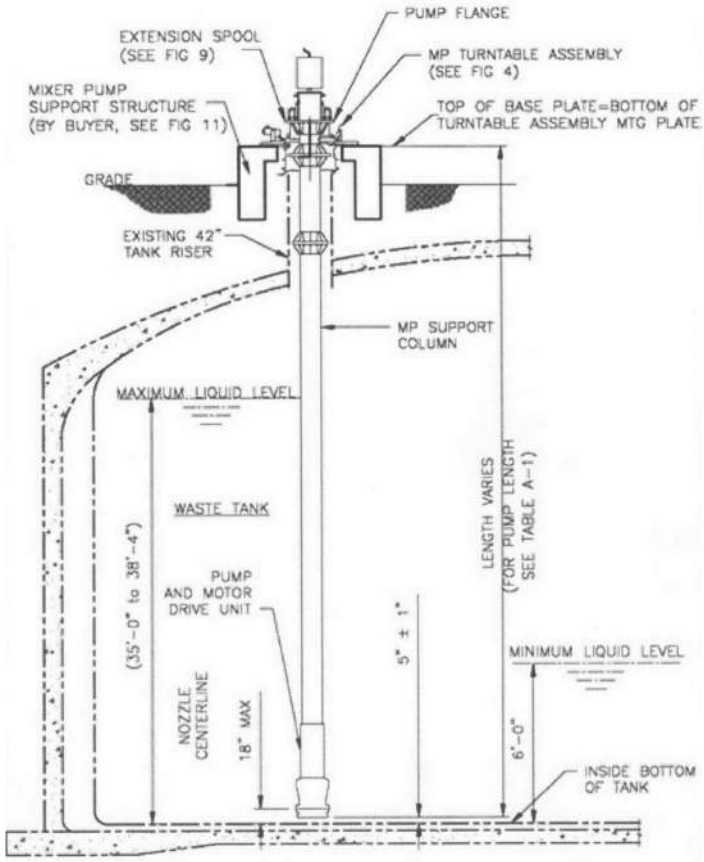

Figure 16: Mixer Pump System Arrangement (Slab Mount) Sketch[ee]

2.2 Waste Transfer System

The Waste Transfer System (WTS) is a key element supporting activities necessary to accomplish Waste Feed Delivery (WFD) to the WTP[ff]. The WTS consists of transfer lines, valve and pump pits, and in-pit connections necessary to safely move tank waste in the DST system. The WTS infrastructure requires upgrades including new transfer lines, jumpers, and transfer pumps to support waste transfers to facilities outside of Tank Farms and handling of off-normal operations return streams as summarized below.

- *Tank Farm Pump and Valve Pits, Diversion Boxes, and Associated Facilities*: most require upgrades to provide capability to transfer from source DSTs to designated WFD DSTs and between designated WFD DSTs.
- *New Waste Transfer Lines*: new waste transfer lines to be installed from the WTP interface point connect the dedicated WFD DSTs in the AP Tank Farm to the pretreatment and facilities or the facilities that interface with the HLW and LAW Vitrification Facilities and between these pretreatment and interface facilities and the HLW and LAW Vitrification Facilities.
- *New Valve/Jumper Pits*: need to construct and equip pits near HLW (and LAW) processing facilities to facilitate waste transfer line routing.
- *Cross-Site Transfer System*: need to refurbish and test systems and components within the cross-site transfer system and replace the supernate and/or slurry lines if necessary.

The DSTs are interconnected through a series of 3-inch inner diameter supernatant lines and two-inch inner diameter slurry lines. These lines are buried and typically connected to the central pump pit of each DST and to Tank Farm-specific valve pits. Additional pits are included with several DSTs with specific connectivity or functionality (e.g., a pit is provided that connects the AP Farm valve pit to the AZ Farm valve pit, allowing the transfer of waste between farms not otherwise connected).

HLW slurry will be transferred within the DST system via existing 2-inch slurry lines to prepare feed and deliver to waste characterization and staging facilities. Where 2-inch slurry lines are not available, the 3-inch supernatant lines will be used.

Previous Hanford W-211 project work installed three 3-inch transfer lines from the DST system to the WTP interface point. The W-211 lines will initially be used to feed DFLAW campaigns. Further analysis will be done to assess the possibility of the W-211 lines being repurposed for routing HLW to new pretreatment or effluent management facilities or to define the need for a new HLW transfer route and installation of new waste transfer lines.

The current baseline DST retrieval sequence blends material from multiple DSTs and multiple Tank Farms to optimize glass waste oxide loading before delivery to waste characterization and staging facilities. Each 200 East Area DST farm may require transfer lines capable of moving suspended sludge solids to these facilities. Transfers from 200 West Area are expected to use the existing cross-site transfer lines to move slurry to 200 East Area DSTs before delivery to these facilities.

2.3 Cross-Site Transfer Lines

In the 1990s, a cross-site transfer system was built to replace lines that were plugged and unusable. Completed in 1998, the resulting replacement consisting of separate supernatant and slurry transfer systems provided a RCRA-compliant transfer system to enable transfer of wastes from the 200 West Area to the 200 East Area. Over half the SSTs and three DSTs are in the 200 West Area. These lines are currently the responsibility of the ORP Tank Operations Contractor (WRPS). An operational readiness review was done on the supernatant portion of the cross-site transfer system; however, the slurry line was never cleared for use. The slurry and supernatant transfer systems are not currently in service, and a project is in place to identify and implement the repairs and upgrades necessary for activation in the 2020s[cc].

The cross-site transfer system consists of the following SSCs:

- Buried pipelines in the 600, 200 West, and 200 East Areas;
- SY and AN Tank Farms;
- Booster pumps, valving, and components at the 6241-A diversion box;
- Valving and components at the 6241-V vent station;
- Monitoring and control hardware and software; and
- Instrumentation.

The cross-site transfer system was designed, fabricated, and installed as part of Hanford Projects W-058, W-211, and W-314. The cross-site transfer system consists of two parallel, pipe-in-pipe lines. The supernatant line, WT-SNL-3150, extends from the SY-A valve pit in the 200 West Area to the AN Farm central valve pit in the 200 East Area (from where the line can be routed to AN Tank Farm DSTs), then to the AZ valve pit (from where the line can be routed to AY and AZ Tank Farm DSTs), and then finally to the AP valve pit (from where the line can be routed to AP or AW Tank Farm DSTs). The slurry line, WT-SLL-3160, extends from the SY-B valve pit in the 200 West Area directly into the DST AN-104 Riser 10 in the 200 East Area. The transfer route passes through a diversion box (6241-A) and a vent station (6241-V) located between the 200 West and 200 East Areas. When placed into service, the slurry line will be monitored by leak detectors on the existing master pump shutdown system.

An operations control system located in the control room at the 242-S Evaporator was intended to provide remote monitoring for the cross-site transfer system. The 242-S Evaporator control room was consolidated in the 274-AW facility.

2.4 Waste Retrieval Facilities

Retrieval of the SSTs requires the functional capabilities to: (1) add chemicals and sluicing water to mobilize saltcake and sludge from to SSTs; (2) provide interim storage of the retrieved waste; and (3) route the retrieved waste to the DST system. Waste Retrieval Facilities (WRFs) are planned to be constructed near the B and T Tank Farm complexes to

provide these SST retrieval support functions. The *WFD-WRF Mission Analysis Report*[gg] identifies the functional requirements and facility architecture for the East Area WRFs. This *WFD-WRF Mission Analysis Report* is assumed to be generally applicable to the West Area WRFs.

The high-level functions for each WRF include receipt and storage of supernate and slurries retrieved from the SSTs; recycling of supernate for waste mobilization; sampling and characterization; mixing and blending of batches; chemistry adjustment; feed staging; and routing of waste to the DST system. Optional functions include the capability to blend, sample, characterize, and stage HLW feed for delivery to the WTP.

The Enterprise Construction Management Services (ECMS) Analysis of Alternatives (AoA) Team assumed that the WRFs would require the following design features:

- Waste storage in vessels;
- Concrete vaults (at or below grade-level) to provide secondary containment;
- Vessel leak detection;
- Sludge mobilization provided by "Mixer Pumps" installed in vessels;
- Waste transfer by slurry and supernate transfer pumps;
- Pump and Valve pits;
- Remote monitoring;
- Remote waste sampling;
- Active vessel ventilation;
- Active confinement ventilation for the vault areas;
- Chemical and water supply;
- Double-contained waste transfer lines (assumed to be below grade pipe-in-pipe design) to connect the WRFs to the SST Tank Farms and to the DST Tank Farms;
- Waste transfer interlocks; and
- Waste transfer line leak detection.

It also is assumed that the following process support and utility capabilities will be required:

- Waste transfer line cathodic protection;
- Normal electrical power;
- Backup electrical power (if required);
- Uninterruptable power supplies (UPS) (if required);
- Compressed air supply;
- Cooling and/or chilled water supply;
- Demineralized water supply;
- Data transmission to Tank Farm Central Control Room;
- Local operations support facilities (i.e., trailers or permanent buildings for Radiological Buffer Areas [RBAs], Operator briefing area, and local monitoring and control area); and
- Site infrastructure interfaces (e.g., access roads, access control features, raw water supply).

After the *WFD-WRF Mission Analysis Report* was issued, a *2010 Engineering Study*[hh] evaluated alternatives for the location, tank sizing, and vault configurations for the 200 East Area WRF. This *2010 Engineering Study* added the functional requirements for WFD of tank sludge. These functions included: mixing, blending, conditioning, and characterization, and staging of tank sludge in providing HLW feed for the WTP. A separate facility (later identified as the Tank Waste Characterization and Staging Facility [TWCSF]) was recommended to provide these WFD capabilities. The East Area WRF was proposed to provide the functions required for retrieval of the tank waste from the B Complex. A West Area WRF also was proposed to provide the functions required for retrieval of the tank waste from the T Complex.

The *2010 Engineering Study* and the 2017 *River Protection Project System Plan*[cc] provides more specifics on the proposed architecture (e.g., facility layout including waste storage vessels and transfer lines) for the East Area WRF. The *2010 Engineering Study* recommends that the East Area WRF should consist of four vessels each with a working volume of 160 kilogallons (kgal) and a capacity of 180 kgal. It also recommended that these vessels be housed in a below-grade

concrete vault located adjacent to B Complex. The AoA Team assumed that the same vessel size and vault configuration recommendations would apply to the West Area WRF to be located adjacent to T Complex.

Considering the nuclear and criticality control requirements in the current U.S. Department of Energy (DOE) Orders and Standards, the potential for flammable gas generation and solids precipitation, and the overall Material at Risk (MAR), it is assumed that the WRFs would be Hazard Category 2 facilities which would require that a Documented Safety Analysis (DSA) be developed. The analyses supporting the DSA, and the DSA itself (referred to as the facility "safety basis"), would determine the required safety functions and the functional classification of the SSCs (i.e., non-safety, safety-significant [SS], or safety-class [SC]) that provide these functions. Based on the recommendations in the *2010 Engineering Study* and on the judgment of the ECMS, ORP, and WRPS technical subject matter experts (SMEs), the WRF safety basis is assumed to require the following safety controls:

- Seismic Category I[ii] design for vessels and vaults for NPH protection;
- SS or SC active vessel ventilation system (and additional air cooling and recirculation if required);
- SS or SC active confinement ventilation for vault areas;
- SS or SC post-NPH vessel air sparging; and
- SS or SC process support and utility systems required for the tank ventilation and air sparging systems to perform their safety functions (e.g., backup electrical power, UPS, compressed air).

3 Tank Waste Characterization and Staging Facility (TWCSF)

Alternative 1 includes a new TWCSF that provides the capability to sample, characterize, blend, and stage HLW feed for delivery to the PT Facility. The TWCSF mission and functions are described in the *WFD-WRF Mission Analysis Report*[gg]. As discussed in the previous section, the *WFD-WRF Mission Analysis Report* also addresses the need for a waste storage capability to support HLW waste feed delivery. This capability was later described as TWCSF. Critical Decision (CD) 0 was approved for the WRF in September 2015. No further work was done to develop project requirements or design baseline information for the TWCSF. For purposes of developing process flowsheet modeling assumptions, the assumed capabilities and facility layout for TWCSF are described in *System Plan*[cc]. The facility description information provided below is based on the *WFD-WRF Mission Analysis Report* and the *System Plan*.

WRPS and ORP nuclear safety and design engineering SMEs provided input on assumed facility Hazard Categories (1, 2, and 3 nuclear facilities[jj]), Seismic Categories (I, II, III, and IV) based on WTP application[ii], and required safety SSCs. Based on this input, the AoA Team assumed TWCSF would be a Hazard Category 2 nuclear facility and would be required to have Seismic Category I containment. It also was assumed that SC or SS active vessel and confinement ventilation and post-Design Basis Event (DBE) vessel air sparging capabilities would be required.

The SSCs that the AoA Team assumed to be required for TWCSF include:

- Six 500 kgal vessels equipped with mixer and slurry pumps;
- Concrete Vessel Vault (at or below grade level) to serve as secondary confinement for the vessels;
- Pump and Valve Pit; and
- Structure above the Vessel Vault and Pump and Valve Pit with overhead crane to allow removal/replacement of equipment and access to sampling ports, leak detection devices, and other systems and components.

Other safety functions that are assumed to require SC or SS systems include:

- Primary and annulus active ventilation for flammable gas mitigation and cooling of vessel contents;
- Annulus ventilation cooling system for cooling of vessel contents;
- Instrument air system to operate ventilation systems and waste transfer isolation valves;
- Post-DBE vessel air sparging for flammable gas mitigation;
- Vessel Vault and Pump and Valve Pit active confinement ventilation system;
- Fire protection;
- Emergency lighting;

- Emergency power supply and distribution to serve active ventilation and essential monitoring and control functions; and
- Essential monitoring and control systems.

The safety systems are assumed to be housed in structures immediately adjacent to the Tank Vault and Pump and Valve Pit. These structures also would be part of the Hazard Category 2 facility boundary and would be required to provide the appropriate level of NPH protection (e.g., Seismic Category I).

Other non-safety functions are assumed to include normal electrical power supply and distribution, normal monitoring and control, ventilation air handling units (AHUs), raw water supply, cold chemical supply, potable water supply, and compressed air supply. The systems that provide these functions are assumed to be housed in general service buildings or to be skid mounted on outdoor pads.

4 Pretreatment (PT) Facility

Alternative 1 uses the WTP PT Facility to provide the same general LAW and HLW pretreatment processes that are described in the current WTP technical baseline. Some changes to the process flowsheet were determined to be necessary to resolve technical issues (Tis) with the PT Facility design that were identified by the Defense Nuclear Facilities Safety Board (DNFSB). As a result, construction and engineering and procurement work on the PT Facility was put on hold in 2012.

The design changes needed to resolve the DNFSB TIs are described in a *PT Facility Standard High-Solids Vessel (SHSV) Alternative Study*[kk] issued by the WTP contractor (Bechtel National, Inc. [BNI]) in 2017. This study recommended changes to the PT Facility process flowsheet including removal of the baseline leaching and acid recovery process functions and rerouting of waste streams to prevent accumulation of solids accumulation in the process vessels. It was recommended that the vessels to be used for processing 'fast settling-solids' waste streams be replaced with SHSVs. Significant design changes also were recommended to the non-safety Process Control System (PCS) and the Pulse Jet Mixer (PJM) system fluidic and air sparging racks.

5 Repurposed PT Facility

Alternative 5 proposes to repurpose the PT Facility to perform HLW pretreatment before transfer to the HLW Vitrification Facility. New HFPVs, Filter Feed Vessels (FFVs), and HLW Feed Vessel (HFVs) will be installed in the PT Facility PAs 3 and 4 in cells previously designated as "Dark Cells." These cells were chosen to limit the cost of removing vessels or equipment already installed. These cells will be modified to provide access through removeable roof covers to allow removal/replacement of vessel equipment by external cranes.

The capacity for the HFPVs and HFVs must be sufficient to pretreat and store enough feed for the HLW Vitrification Facility to operate at full capacity for the time required to complete the pretreatment and filtration cycle. The tank capacity and sizing calculation for Alternative 5 shows that two 85 kgal HFPVs, two 21 kgal FFVs, and two 35 kgal HFVs are required. The pre-conceptual design locations of the HFPVs and filtration equipment in the RPT are shown by overlays on the existing as-built PT Facility General Arrangement drawing in Figure 17 and Figure 18.

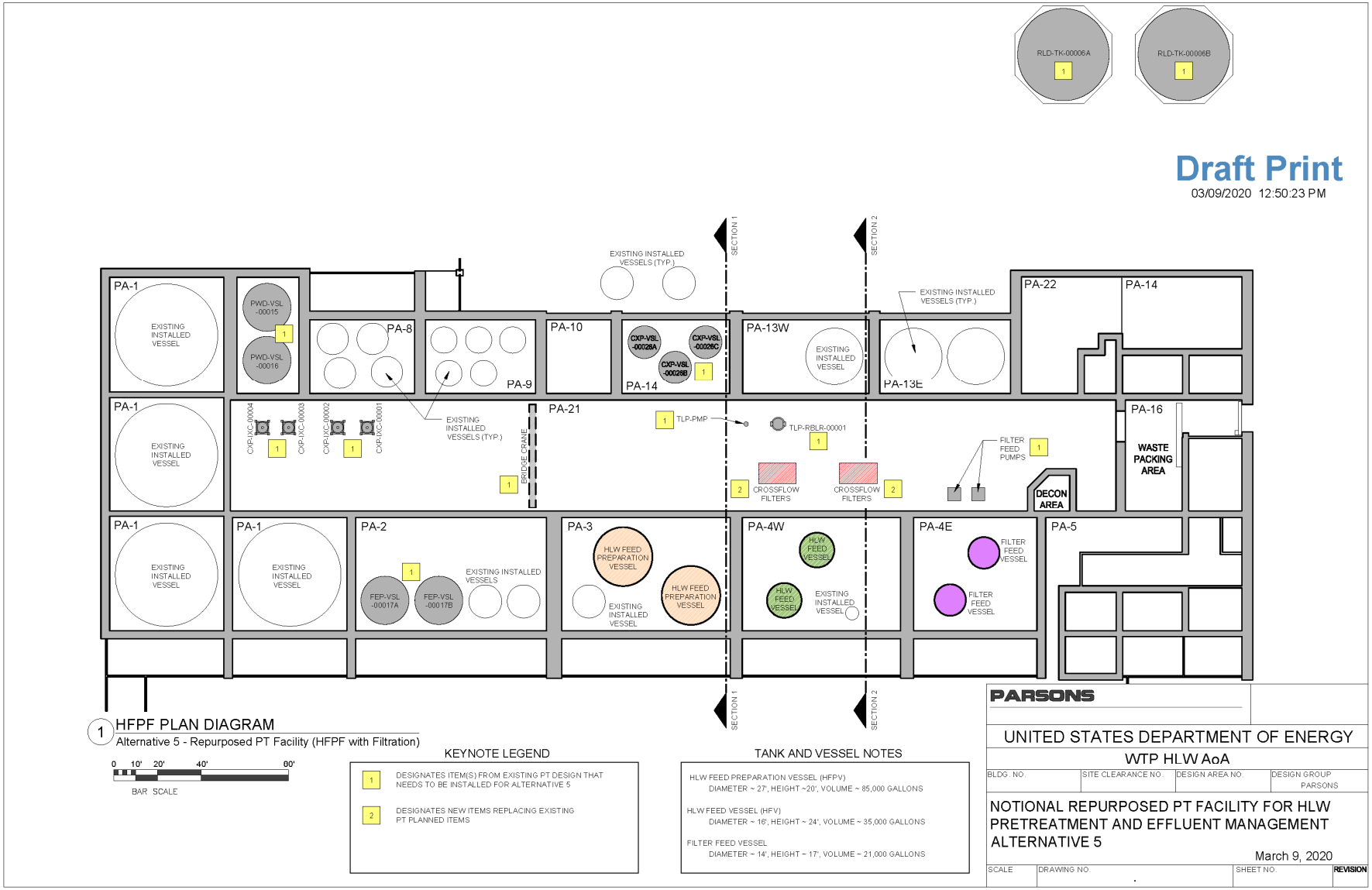

Figure 17: Alternative 5 Repurposed PT Facility Plan Diagram

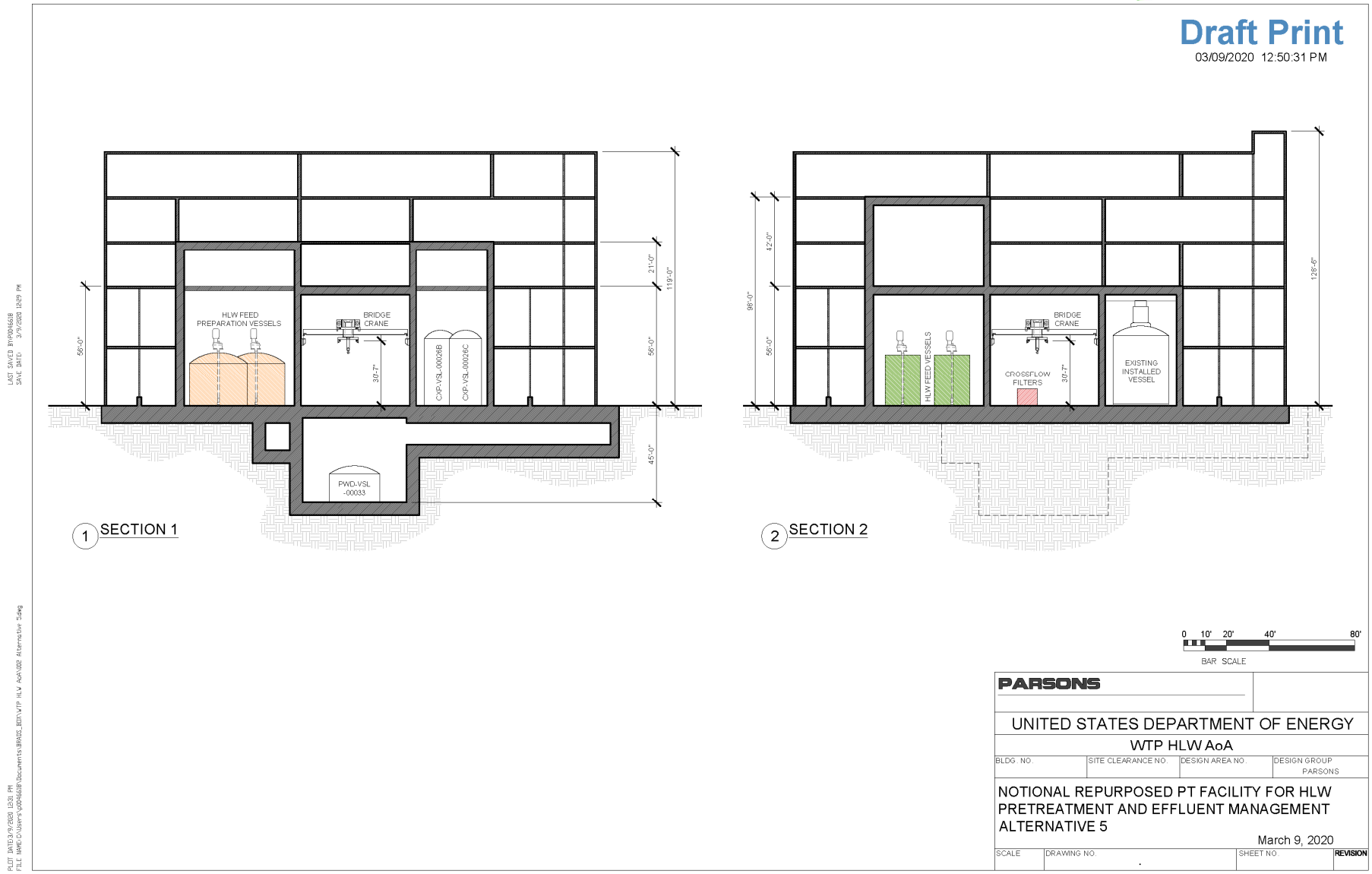

Figure 18: Alternative 5 Repurposed PT Facility Elevation Diagram

The AoA Team evaluated PT Facility PAs for reuse as part of Alternative 5. Table 63 provides the reuse evaluation results that showed just over 80 percent of the PT Facility would be reused. To limit the size of the pretreatment process vessels that would be installed in the RPT, Alternative 5 relies on the DST system to sample and characterize the HLW feed and adds the capability to filter the decanted liquids removed during the pretreatment process. These changes allow shorter pretreatment cycle times which in turn allows for a reduction in the pretreatment tank sizes.

Table 63: Planning Area Estimate for Repurposed PT Facility

PA #	Description of PA	Level	Area of PTF-PA (sqft)	% Needed for Alt 5	Area Required for Alt 5 (sqft)	Basis for % Needed
1	Waste Feed Receipt Process System	0'-0"	13,102	0%	-	New HLW vessels will be installed for Alt 5. These new vessels will receive characterized HLW feed from Tank Farms.
1A	C2/C3 Floor Drain Collection Vessels	(-19' and -45')	2,160	100%	2,160	Floor drain collection is required for Alt 5.
1B	Plant Wash & Disposal System/Effluent Collection; Future LAW Transfer Line Tunnel; Inter-Facility Transfer Line Tunnel	(-19' and -45')	12,968	100%	12,968	Plant Wash and Disposal (PWD) system is needed for Alt 5.
2	Waste Feed Evaporation Process System	0'-0"	5,429	100%	5,429	Feed Evaporation Process (FEP) Evaporator is required for Alt 5.
3	Plant Wash & Disposal System	0'-0"	4,862	100%	4,862	PWD system is required for Alt 5.
4W	HLW Lag Storage and Feed Blending Process (HLP) Vessels		4,607	0%	-	New HLW vessels will be installed for Alt 5. New HLW Feed Vessels will stage pretreated feed for delivery to HLW Vitrification Facility.
4E	HLP System	0'-0"	3,545	0%	-	New HLW vessels will be installed for Alt 5. New HLW Feed Vessels will stage pretreated feed for delivery to HLW Vitrification Facility.
5	Remote Decon Workshop Area	0'-0"	3,856	100%	3,856	Decon Area will be required for maintenance of equipment.
6	Access corridor and/or stairwell	0'-0"	1,634	100%	1,634	This is an access pathway. Access to all areas that are designed for personnel access of the PT Facility is assumed to be necessary.
7	Cs (Cesium) Ion Exchange (IX) Process (CXP) System	0'-0"	1,998	0%	-	Cs Nitric Acid Recovery Process (CNP) and CXP systems are not used in Alt 5.
8	CXP System	0'-0"	2,018	0%	-	CNP and CXP systems are not used in Alt 5.
9	CNP System	0'-0"	2,140	0%	-	CNP system is not used in Alt 5.
10	Empty	0'-0"	1,314	0%	-	Current design does not utilize this PA.
11	Tanks for IX column permeate	0'-0"	2,054	0%	-	CXP system is not used in Alt 5.
12	Does not exist			0%	-	
13W	Treated LAW Evaporation Process System	0'-0"	2,424	100%	2,424	Treated LAW Evaporation Process (TLP) system is required for Alt 5.
13E	Treated LAW Concentrate Liquid Storage Process System	0'-0"	2,449	100%	2,449	Treated LAW Concentrate Storage Process (TCP) system is required for Alt 5.
14	Spent Resin Handling Area	0'-0"	2,093	0%	-	CXP system is not used in Alt 5. No IX resin will need to be processed for disposal.
15	Access corridor and/or stairwell	0'-0"	1,716	100%	1,716	This is an access pathway. Access to all areas that are designed for personnel access of the PT Facility is assumed to be necessary.
16	Decon Waste Packaging Area	0'-0"	3,152	100%	3,152	Failed equipment will need to be packaged for shipment in Alt 5.

PA #	Description of PA	Level	Area of PTF-PA (sqft)	% Needed for Alt 5	Area Required for Alt 5 (sqft)	Basis for % Needed
17	No description	0'-0"	6,697	75%	5,023	This is a shielded pump corridor that includes pumps for TLP and CNX systems. Assume that 75% of the PA needs to be completed.
18	Stand-By Control Room	0'-0"	8,464	100%	8,464	Local control areas are part of the baseline design and since some of the surrounding PAs will have operating equipment installed, a local control area should be provided in PA 18.
19A	PT Facility Annex	0'-0"	8,346	0%	-	Appears to be a personnel support area given that it is located adjacent to PA-19B which was previously intended for the Control Room. Operations support areas will be required for Alternative 5.
19B	PT Facility Control Room	0'-0"	14,185	100%	14,185	Central Control Room is required for PT Facility in Alt 5.
20	Access corridor and/or stairwell	0'-0"	20,473	100%	20,473	
21	Hot Cell, Ultrafilters/Pumps/Valves	0'-0"	22,117	100%	22,117	Most of the area within the Hot Cell is needed for installation of filters, pumps, and valves for HLW pretreatment in Alt 5.
22	Vessels for LAW Vitrification Facility scrubber effluent	0'-0"	2,360	100%	2,360	TLP evaporator concentrates effluents received for LAW Vitrification Facility. These tanks supports this function.
23	Access corridor and/or stairwell	0'-0"	4,005	100%	4,005	This area allows access to the facility from outside. Access to all areas that are designed for personnel access of the PT Facility is assumed to be necessary.
24	Chilled Water Pump Room	28'-0"	3,669	50%	1,835	HLW pretreatment process operations that would require CW are limited for Alt 5. TLP and FEP evaporators require chilled water.
25	Access corridor and/or stairwell	28'-0"	1,510	100%	1,510	This is an access pathway. Access to all areas that are designed for personnel access to the PT Facility is assumed to be necessary.
26	C&I Room; Process Bulge Area; C5 Ventilation System, In-bleed	28'-0"	9,530	100%	9,530	Building and vessel ventilation systems are required for Alt 5
27	Pump and Valve Corridor		6,498	100%	6,498	Piping in this area supports TLP system and is required.
28	Electrical Room	28'-0"	2,035	75%	1,526	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
29	Maintenance Crane Reel Drum Room	28'-0"	23,528	100%	23,528	
30	Does not Exist			0%	-	
31	Filter Cave; 6T Filter Cave Crane with Manipulator	56'-0"	11,200	100%	11,200	
32	Demin Water	56'-0"	3,144	100%	3,144	Demin water is required for Alt 5.
33	Process Bulge Area	56'-0"	6,440	50%	3,220	Includes pipe racks for process air including PJMs. Vessels to be installed in PT Facility for HLW pretreatment will not use PJMs, but will require post-DBE air sparging.

PA #	Description of PA	Level	Area of PTF-PA (sqft)	% Needed for Alt 5	Area Required for Alt 5 (sqft)	Basis for % Needed
34	Evaporator Room Access (one on east side and one on west side of the building)	56'-0"	4,280	50%	2,140	East part of PA-34 provides access to TLP evaporator components via shield cover. Since TPP system is required for Alt 5, east part of PA 34 is required. West part of PA-34 provides access to CNP evaporator which is not used for Alt 5.
35	No description	56'-0"	9,243	75%	6,932	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
36	Utility Area; Control and Instrumentation (C&I) Room; HEPA (high-efficiency particulate air) Filter Room; Process Vessel Vent Thermal Oxidizing Room; Chilled Water Exchange Room	56'-0"	10,357	75%	7,768	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
37	Electrical Room; C&I Room	56'-0"	2,120	75%	1,590	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
38	Process Bulge Area	56'-0"	11,728	75%	8,796	This PA includes chilled water equipment, which is required for Alt 5, but at much lower capacity.
39	Waste Feed Evaporation Room	56'-0"	15,267	100%	15,267	FEP evaporator is required for Alt 5.
40	Access corridor and/or stairwell	56'-0"	27,332	100%	27,332	This is an access pathway. Access to all areas that are designed for personnel access of the PT Facility is assumed to be necessary.
41	Autosampling / Marshalling Area	56'-0"	1,463	50%	732	Autosampling system is required, although number of vessels to be sampled is significantly reduced from baseline case.
42	Crane Maintenance Area	98'-0"	1,453	100%	1,453	Overhead crane is required in Hot Cell for Alt 5.
43	C3 Ventilation Room; pulse jet ventilation/pretreatment vessel vent process Ventilation Room; General Filter Room	77'-0"	25,229	75%	18,922	Building and vessel vent systems are required for Alt 5 although demand is less than baseline design assumptions.
44	Utility Rack/Cabinet Area	77'-0"	4,606	75%	3,455	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
45	Heating, Ventilation, and Air Conditioning (HVAC) Plant Room	77'-0"	5,004	100%	5,004	Building and vessel vent systems are required for Alt 5 although demand is less than baseline design assumptions.
46	C&I Room	77'-0"	3,294	75%	2,471	C&I systems are less complex than baseline design due to elimination of LAW processing systems.
47	Chilled Water Room; Electrical Room	77'-0"	3,792	75%	2,844	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
48	Utility Rack/Cabinet Area; Cs Nitric Recovery Room	77'-0"	12,116	50%	6,058	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design. CNP system is not used for Alt 5.

PA #	Description of PA	Level	Area of PTF-PA (sqft)	% Needed for Alt 5	Area Required for Alt 5 (sqft)	Basis for % Needed
49	Access corridor and/or stairwell	77'-0"	6,848	100%	6,848	This is an access pathway. Access to all areas that are designed for personnel access of the PT Facility is assumed to be necessary.
50	No description		2,991	50%	1,496	
51	Utility Room; C&I Room; In-bleeds & Hydraulic Unit	77'-0"	48,067	75%	36,050	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
52	Cs (Cesium) Fresh Resin Mixing Room; Demineralized Water Storage Room; Sodium Hydroxide Reagents Area	98'-0"	2,538	75%	1,904	Demin water and NaOH (sodium hydroxide) supply will be required for Alt 5. CXP system is not used which eliminates need for resin mixing.
53	C3V Extract Fan Area; C2V Secondary HEPA Filter Room; C5V Extract Fan Area; C5 Extract Fan Room	98'-0"	19,414	75%	14,561	Building and vessel vent systems are required for Alt 5 although demand is less than baseline design assumptions.
54	Does not Exist			0%	-	
55	Does not Exist			0%	-	
56	C&I Room; Electrical Room; C2V Air Handling Supply Area	98'-0"	16,483	75%	12,362	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
57	Access Corridor and Air-Handling Equipment	98'-0"	44,338	100%	44,338	This is an access pathway. Access to all areas that are designed for personnel access to the PT Facility is assumed to be necessary.
58	Non-Radioactive Liquid Waste Disposal System	0'-0"	9,200	100%	9,200	Radioactive Liquid Waste Disposal (RLD) system is required for Alt 5.
59	Plant Service Air System, Instrument Air Service System	0'-0"	4,200	75%	3,150	
60	Does not Exist			0%	-	
61	Does not Exist			0%	-	
62	Electrical Room	98'-0"		75%	-	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
63	Unknown	98'-0"	2,099	100%	2,099	
	Electrical Room	28'-0"	471	75%	353	Utility systems are required for Alt 5, although demand is more limited than that assumed in baseline design.
	Operation & Manipulation Room	56'-0"	578	100%	578	Areas needed to support remote manipulator control are required for Alt 5.
		Total Area	**522,233**		**422,968**	
				Area of Alt 5 as % of Total PTF Area	**81%**	

For Alternative 5, new vessels and equipment will be installed in the PT Facility to perform the HLW pretreatment functions. The baseline design capabilities of the HLP, LAW Feed Receipt Process (FRP), Ultrafiltration Process (UFP), CNP, and CXP systems are not used in Alternative 5. These baseline systems would not be installed or would be abandoned in place for Alternative 5. To preserve the effluent management capabilities provided by the TLP and FEP evaporators, the process equipment and commodities for these systems would be installed. Since the baseline systems used for LAW and HLW pretreatment are not installed for Alternative 5, the process support and utility systems that are part of the baseline design could be eliminated or downsized.

The PT Facility construction effort was estimated to be 43% complete at the time that work was suspended in 2012. Many of the baseline PT Facility process vessels were already installed by this time. Considering the difficulty in sectioning and removing these vessels, the AoA Team evaluated the areas within the Hot Cell and Dark Cells that did not have equipment installed to determine where there was space available for installation of new pretreatment and filtration tanks. The other constraint on available floor space was to allow enough room for installation of the FEP and TLP evaporators and associated vessels and support systems.

The modifications required to repurpose the PT Facility to accommodate installation of the new tanks and filtration equipment for HLW pretreatment will be challenging. Although the pretreatment systems that are part of the technical baseline will not be installed for Alternative 5, the process and utility support systems will need to be installed and modified to provide services to the new HLW pretreatment equipment. New waste transfer piping will need to be installed for internal routing between the new HLW pretreatment process tanks and systems and to connect the new process tanks and systems to the FEP and PWD systems.

The process flow for HLW and LAW effluent processing in the RPT for Alternative 5 is assumed to be based on the SHSV design[kk]. The modifications to the PT Facility vessels and other SSCs as described in the referenced study are required to be completed for Alternative 5. The HLW and LAW pretreatment systems that are not used in Alternative 5 (e.g., HLW feed receipt in HLP-VSL-00022A/B/C/D, and all LAW processing systems including FRP, UFP, CXP, and CNP) are not required to be installed or modified.

It is assumed that the PT Facility engineering, construction, and commissioning work scope for Alternative 5 will be limited to:

- Installing the new HLW pretreatment systems
- Connecting the new pretreatment systems to the baseline process support and utility systems
- Completing installation of the FEP and TLP systems
- Replacing or modifying baseline vessels and associated equipment in the FEP, PWD, and RLD systems
- Completing installation of process support and utility systems
- Completing remaining civil, structural, and architectural construction

It is assumed that the RPT will not provide utility services and other support systems to serve the HLW Vitrification Facility and that new facilities must be constructed to provide these utilities and services to the HLW Vitrification Facility. These new facilities and systems include the following:

- SC air supply for purging of melter feed and feed preparation vessels
- Delivery of nitric acid and caustic solutions
- Seismic Category I Control Room with SC ventilation
- Incident Command Post with SC ventilation
- Utilities for fire water, service water, demineralized and potable water, instrument air, etc.
- SC emergency electrical power

6 HLW Feed Pretreatment and Effluent Management (HFPEM) Facility

Alternatives 2 and 14 require a new HFPEM Facility to pretreat HLW feed and to concentrate effluents and transfer line flush water from the HLW Vitrification Facility. To minimize the size and cost of the HLW pretreatment and evaporator facilities, a common facility is proposed to perform both functions. Figure 19 and Figure 20 show pre-conceptual plan and section (or elevation) views of the HFPEM Facility for Alternative 2. Figure 21 and Figure 22 show similar views of the HLW Feed Preparation and Effluent Management (HFPEM) Facility for Figure 28. Figure 23 shows a notional 'Aerial Site Diagram' with a perspective view of the proposed site of the HFPEM Facility for Alternatives 2 and 14.

The HFPEM facility receives and processes high-activity liquid wastes. Based on the MAR and the high solids concentrations in some of the process vessels in these facilities, the pre-conceptual design for these facilities assumes that the HFPEM Facility would be a Hazard Category 2 facility and that the primary and secondary containment SSCs

would be designed to Seismic Category I requirements for NPH protection. It also is assumed that the facility safety basis will require either SS or SC active vessel ventilation, vessel air sparging, and active confinement ventilation. These systems, and the associated process support and utility systems (e.g., backup electrical power, compressed air) are assumed to be housed in a ("Safety System Building") for NPH protection.

Since the WTP EMF provides similar evaporative capabilities as the HLW evaporator, the AoA Team used the WTP Effluent Management Facility (EMF) layout as the starting point for development of the HFPEM Facility. An HLW Feed Preparation (HFP) Process Vault was added to house the process vessels needed for HLW pretreatment. Once the required process and process support areas were identified, the facility configuration was revised to simplify waste transfer and utility service routing.

Process and process support areas that had safety functions for accident prevention/mitigation were located within hardened structures for NPH protection. The process areas were also configured for overhead cranes/manipulators for remote operations and maintenance (O&M).

The pre-conceptual design for the HFPEM facility is based on the following design features and configuration:

- Process vessels for HLW pretreatment and for staging pretreated HLW are in a grade-level concrete vault (HFP Process Vault).
- HLW evaporator and evaporator process equipment is in a grade-level HLW Evaporator Process Building.
- Evaporator Feed and Concentrate Vessels are in a grade-level concrete vault (HEMF Process Vault).
- The Pump and Valve Pit is partially below grade.
- Pumps and valves for internal liquid waste routing are in a partially below-grade concrete pit (Pump and Valve Pit).
- HLW Effluent Collection Vessel, Evaporator Drain Vessel, and waste transfer line jumpers/valve manifolds are in a below-grade concrete vault (Waste Transfer Pit).
- Safety systems (e.g., process vessel ventilation system, active confinement ventilation system for process areas, compressed air and process vessel air sparging systems, emergency electrical power supply and distribution systems, and essential monitoring and control system) are in a grade-level Safety System Building.
- Human-Machine Interfaces and Information Technology (IT) equipment is in a grade-level Control/IT Room.

All the process and process support areas identified above are inside of a common high hazard structure that would be designed to Seismic Category I requirements for NPH protection. Separate low hazard structures are provided to house non-safety systems. These structures include a Cold Chemical Supply Pad and a Mechanical and Electrical Building (MEB).

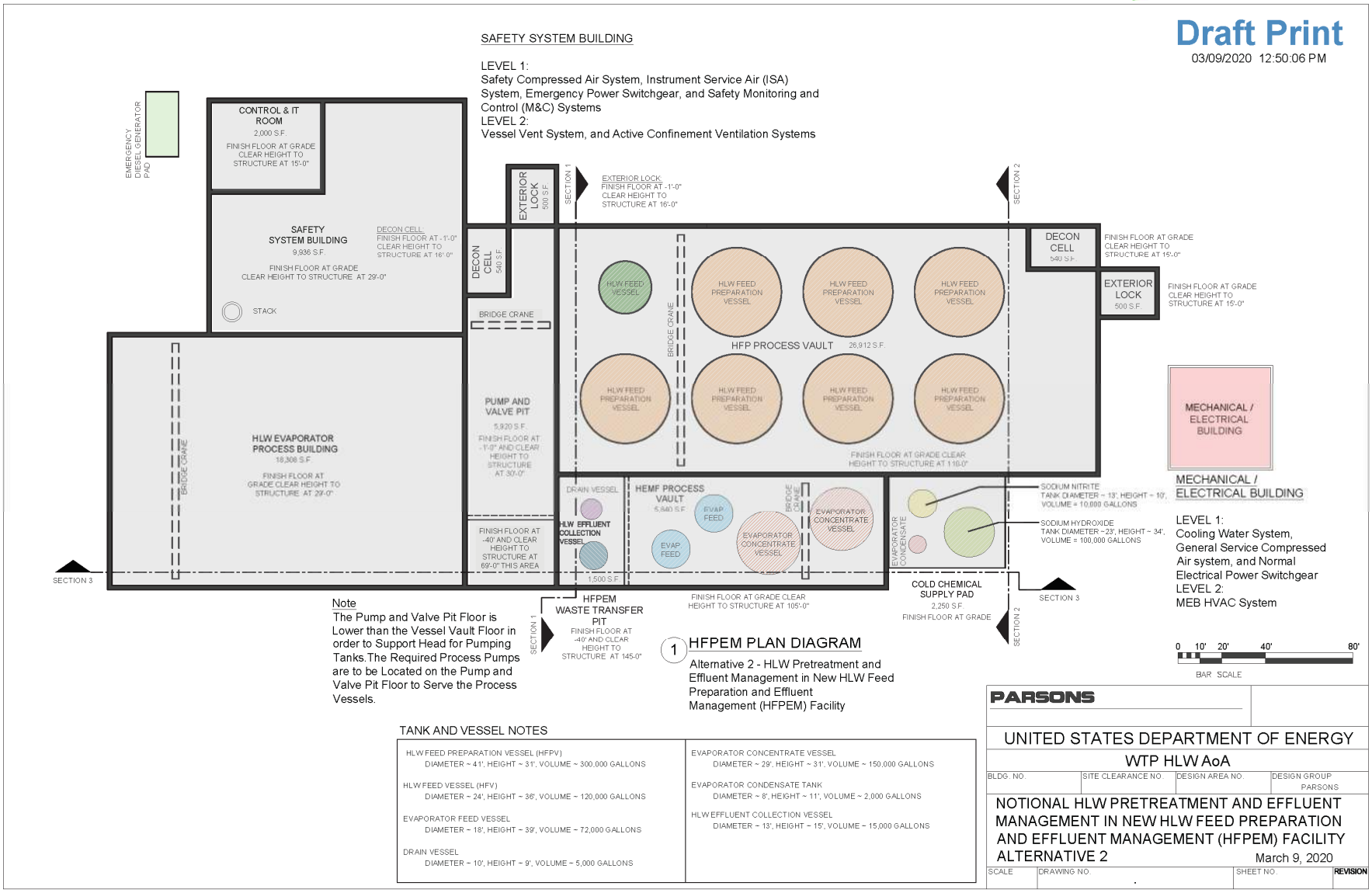

Figure 19: Alternative 2 HFPEM Facility Plan Diagram

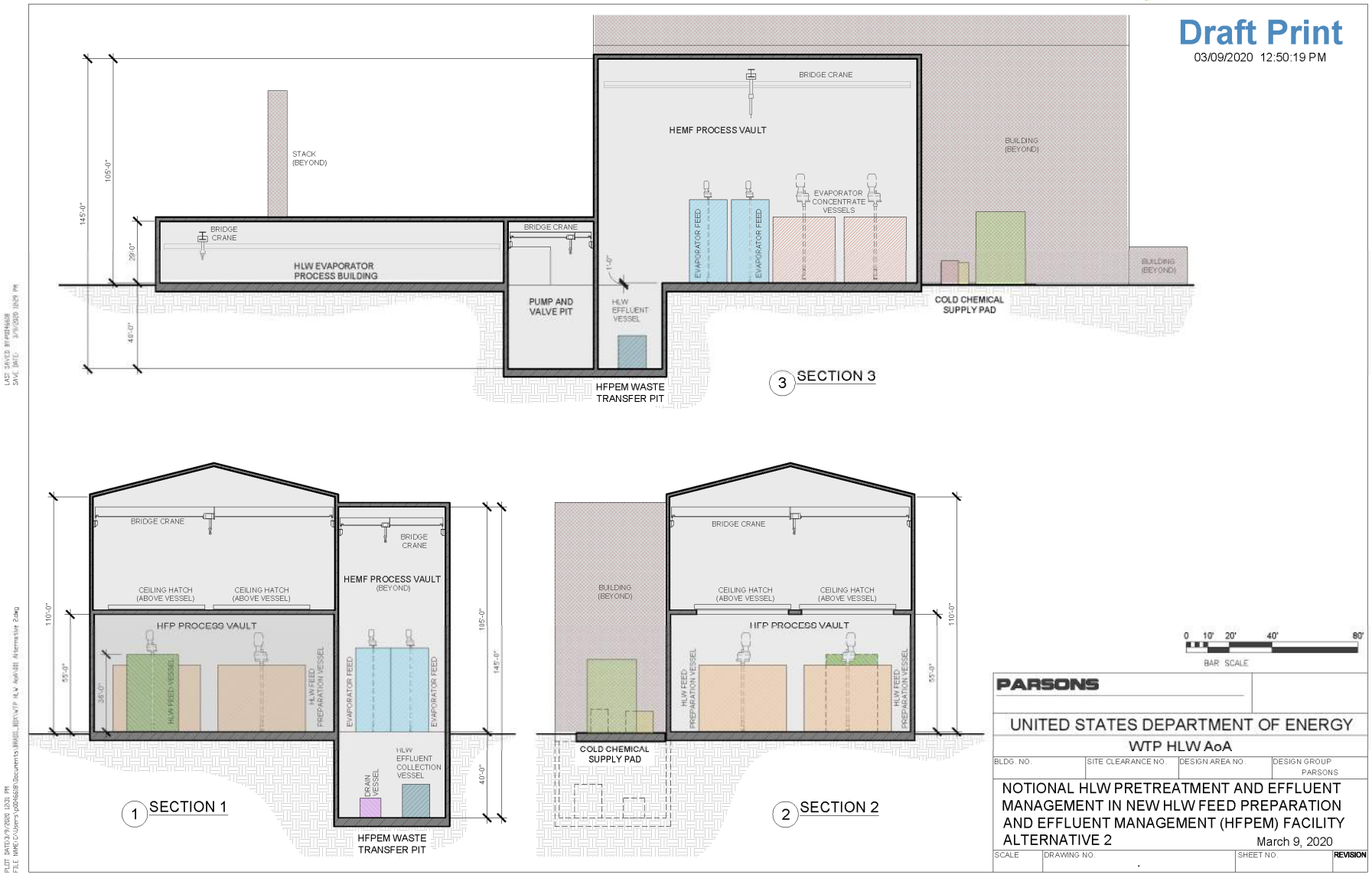

Figure 20: Alternative 2 HFPEM Facility Elevation Diagram

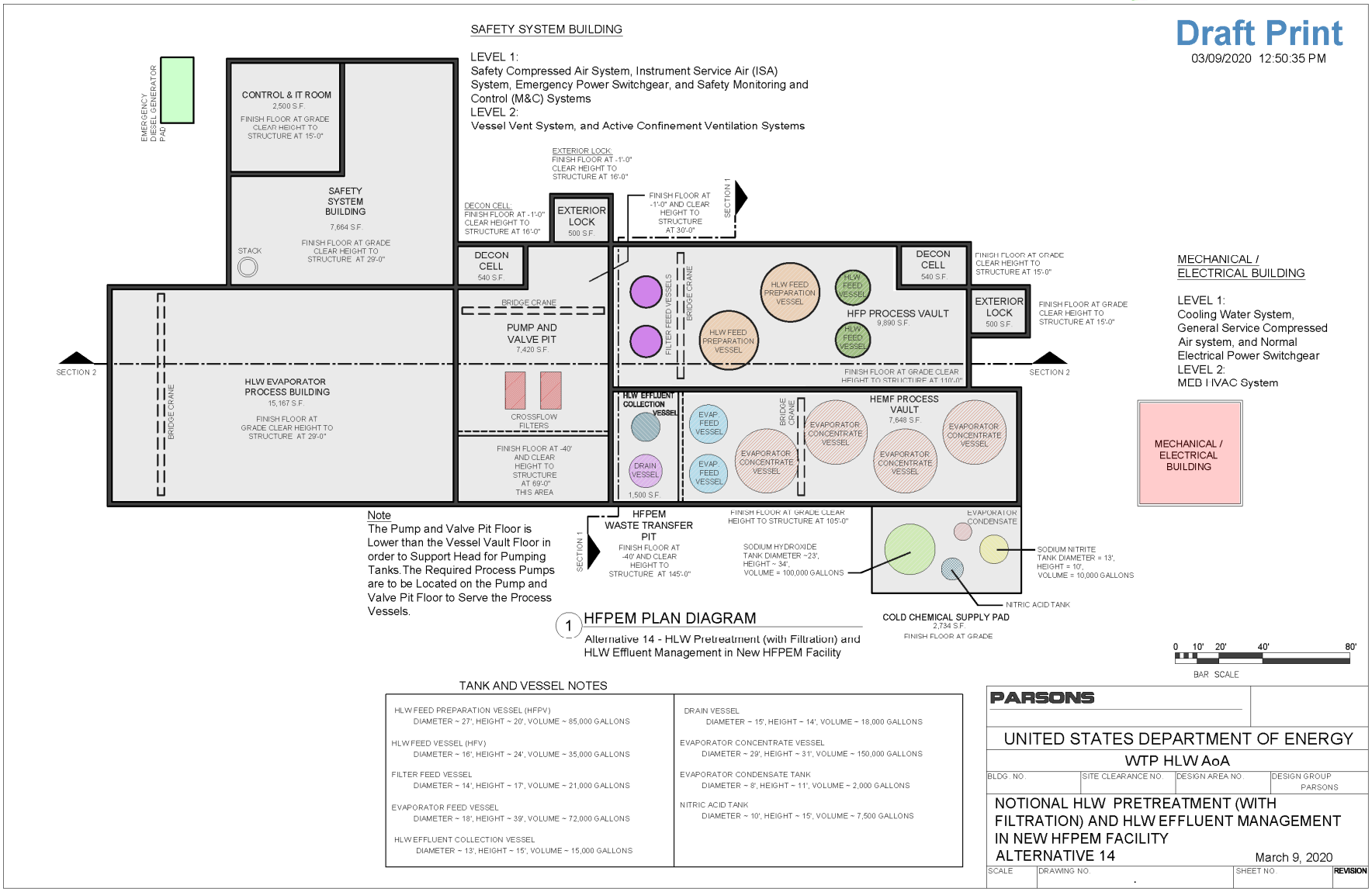

Figure 21: Alternative 14 HFPEM Facility Plan Diagram

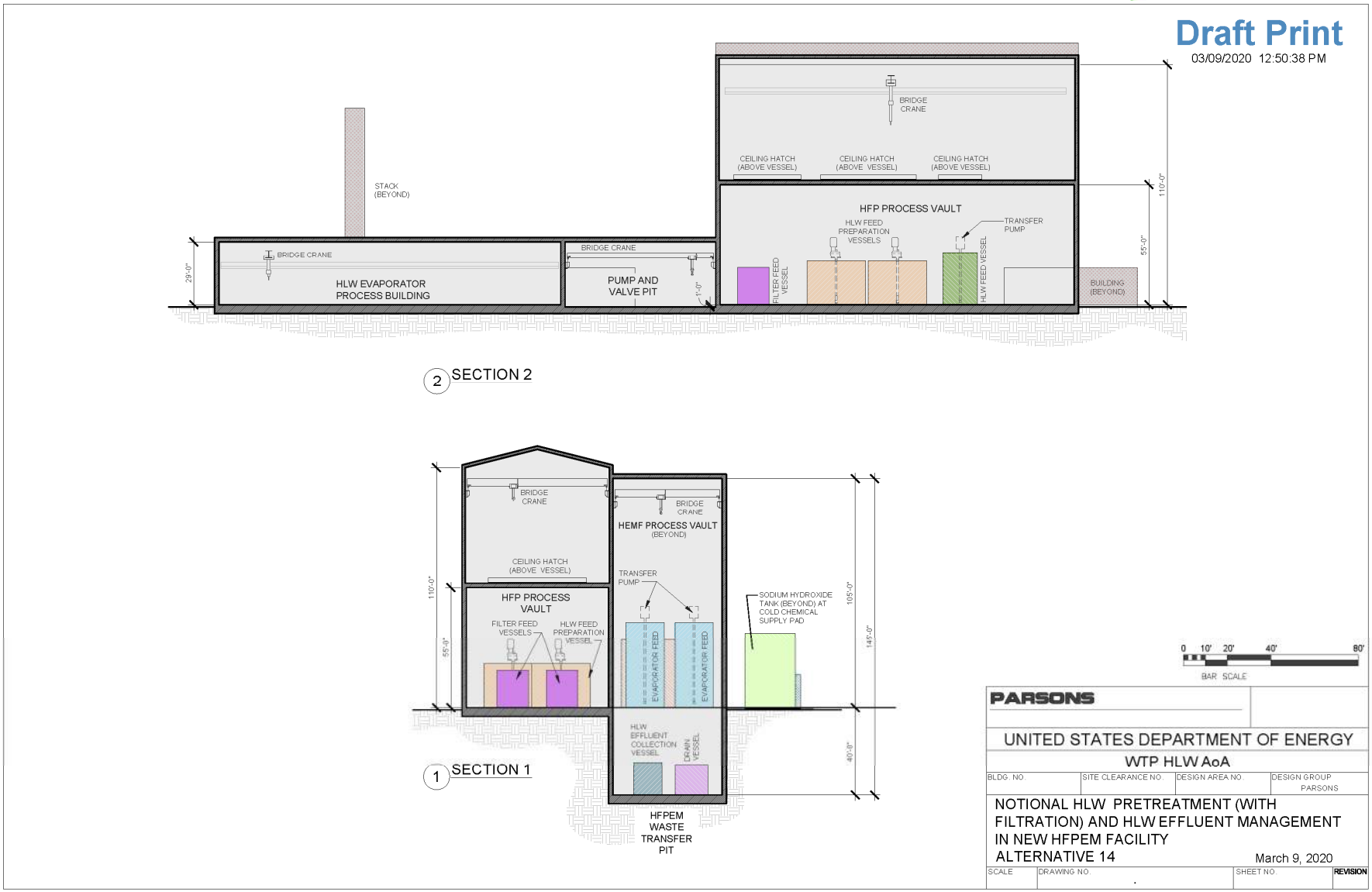

Figure 22: Alternative 14 HFPEM Facility Elevation Diagram

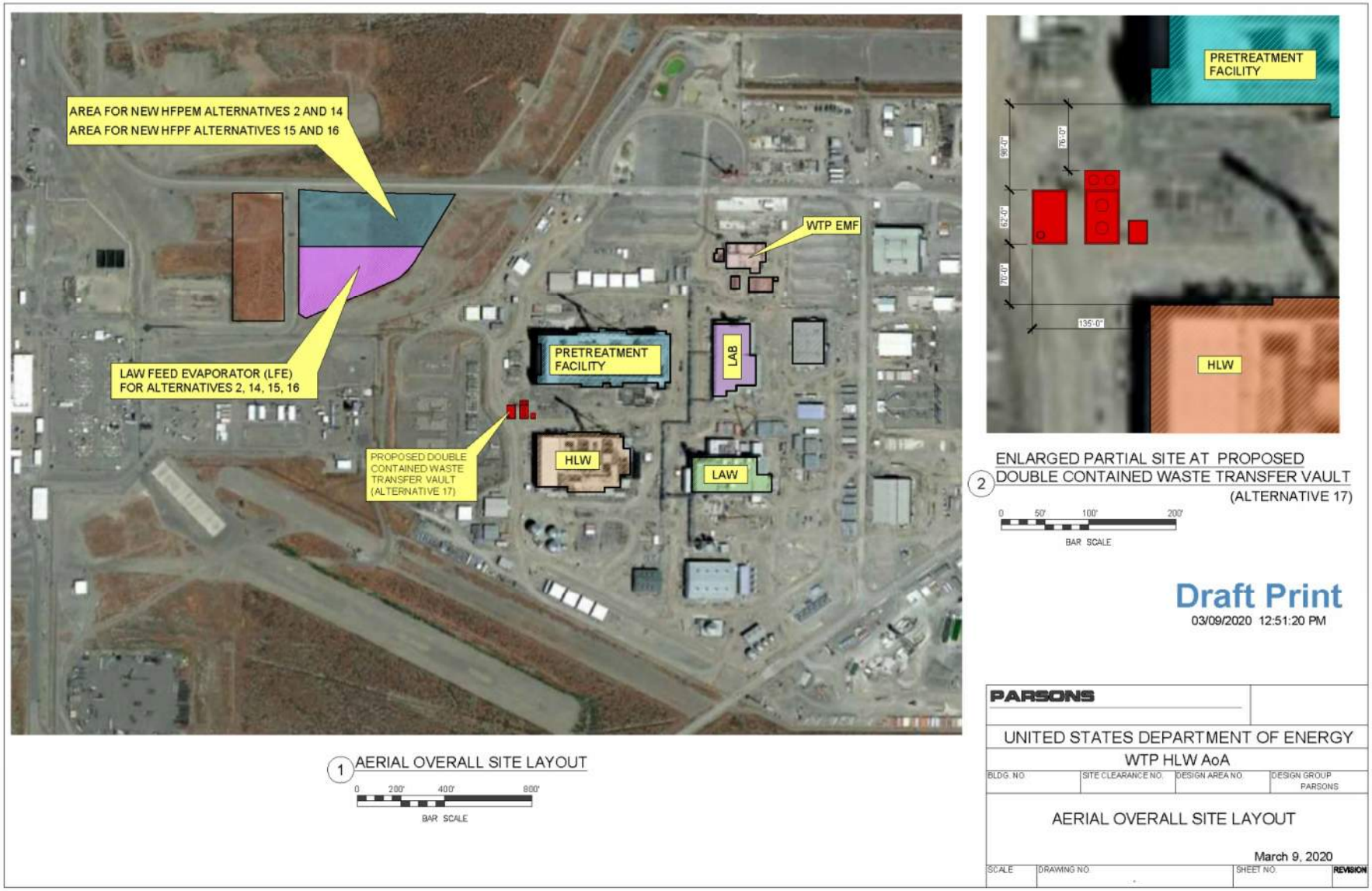

Figure 23: Proposed Site of the HFPEM Facility (Alternatives 2 and 14) and the Waste Transfer Vault Facility (Alternative 17)

6.1 Sizing the HLW Evaporator Process Building for the HFPEM Facility

The size of the HLW Evaporator Process Building for the HFPEM Facility was based on the size of the Process Area within the WTP EMF with adjustments made to account for the differences in the design capacity of the evaporators. Scaling factors for size versus design capacity were developed based on engineering judgment. The sizing inputs and results are described below.

The WTP EMF consists of a main building with a Process Area, Concentrate Tank Area, Drain Tank Area, Condensate Tank Area, Utility Building, Electrical Building, Stack, and a Truck Bay. The Process Area contains two sections, one for the Evaporator and Reboiler and one for the Condenser and process ventilation. An 'Evaporator Area' and a 'Process Area' are shown in the WTP EMF drawings. Each of these areas include space for pumps. The total Evaporator Area plus the Process Area is approximately 10,400 sq ft as determined by scaling the WTP EMF design drawings.

The HLW Evaporator Process Building was scaled for Alternatives 2 and 14 based on the ratio of the capacity (i.e., "boil-off rate") of HLW evaporator to the WTP EMF evaporator. It was assumed that the size of the area for the HLW Evaporator Process Building would increase/decrease by 50% for an increase/decrease in the boil-off rate by a factor of 2.

The calculational methodology for accounting for the differences in the boil-off rates for the WTP EMF and the HFPEM Facility are shown in Table 64.

The Process Area Scaling Factor was used to adjust the size of the WTP EMF Process Area for Alternatives 2 and 14. Table 65 shows how the size of the HLW Evaporator Process Building was determined given the differences in capacity between the HLW evaporator and the WTP EMF evaporator.

Table 64: Evaporator Boil-off Data Used to Determine the Capacity Scaling Factor for Sizing the HFPEM Facility Evaporator Process Building

Alternative	Required HLW Evap. Boil-off Rate at 40% TOE (gpm)	Adjustment Factor for 100% TOE	Required HLW Evap. Boil-off Rate at 100% TOE (gpm)	WTP EMF Design Boil-off Rate (gpm)	Difference in Boil-off Rates (gpm)	Capacity Scaling Factor for Sizing HLW Evap. Process Building
2	13.3	2.5	33.2	9	24.2	135%
14	10.4	2.5	26	9	17.0	94%

TOE – Total Operational Efficiency
gpm – gallon(s) per minute

Table 65: Scaling of WTP EMF Process Area Data to Estimate the HFPEM Facility Process Building Area

Alternative	Area of WTP EMF Process Area (sq ft)	Capacity Scaling Factor (%)	Additional Area Needed for HLW Evap. Process Building (sq ft)	Total Area for HLW Evap. Process Building (sq ft)
2	7,800	135%	10,508	18,308
14	7,800	94%	7,367	15,167

6.2 Sizing the Safety Systems Building for the HFPEM Facility

The size of the Safety Systems Building for the HFPEM Facility was developed based on the size of process support areas within the WTP EMF with adjustments to account for differences in the required capacities of the systems inside of the building. The Safety System Building is assumed to house the ventilation, compressed air, essential electrical power, and safe-shutdown monitoring and control systems. The system requiring the largest space allocation is assumed to be the facility active confinement ventilation system. The scaling factors for sizing the HFPEM Facility Safety System Building were therefore based on an analysis of the required capacity of the active confinement ventilation system.

It is assumed that the size of the areas needed to house the ventilation equipment increases at half (50%) of the rate that the ventilation system capacity increases. The active confinement ventilation capacity (i.e., exhaust flow rate) is linearly related to the size of the process areas within the facility that need to be maintained under negative pressure. The size of the Safety System Building can therefore be approximated by adjusting the size of the WTP EMF ventilation

system building (Utility Building 26) based on the difference in the sizes of the process areas within the WTP EMF and within the HFPEM facility. The details of the calculation methodology and the results are provided below.

The Safety System Building Alternatives 2 and 14 will need to service the HLW Process Vault, HFPEM Tank Vault, HFP Waste Transfer Pit, Pump & Valve Pit, and HLW Tank Vault. The area to be serviced was estimated from sizes of the areas shown in Figure 19 and Figure 20 for Alternative 2 and Figure 21 and Figure 22 for Alternative 14. The areas ventilated by the WTP EMF ventilation system include the Evaporator Process Area, the Concentrate Area, the Condensate Area, and the Drain Tank Area. The scaling factor used to adjust the size of Utility Building 26 based on the difference in the areas ventilated by the facility ventilation systems for the WTP EMF and the HFPEM Facility was 50%. This value assumes that the area required for the ventilation exhaust fans, HEPA filters, and ducting increases/decreases by 50% when the ventilation system capacity increases/decreases by a factor of 2.

Table 66 shows the calculation inputs and results data for determining the appropriate size of the Safety System Building for the HPFEM Facility.

Table 66: Safety System Building Sizing Data for the HPFEM Facility

Alternative No.	Area of HLW Evap. Process Building for HPPEM Facility (sq. ft.)	Area of Process Area for WTP EMF (sq. ft.)	Ventilation System Scaling Factor	Scaling Factor for Sizing Safety Systems Building for HFPEM Facility	Area of Utility Building 26 for WTP EMF (sq. ft.)	Total Area Required for Safety System Building for HFPEM Facility (sq. ft.)
2	59,560	14,156	50%	160%	7,632	9,936
14	42,705	14,156	50%	101%	7,732	7,664

6.3 Sizing Other Areas within the HFPEM Facility

The sizes for the Process Vaults and the Waste Transfer Pit for the HFPEM Facility were developed based solely on the size of the vessels located within them. The vessels sizes are based on the process cycle times and process rate calculations that are described in Appendix A. The sizes of the Pump and Valve Pit and the Control Room were based on engineering judgement and input from ORP assigned SMEs.

7 HLW Effluent Management Facility (HEMF)

Alternatives 15 and 16 require a new HEMF to concentrate effluents and transfer line flush water from the HLW Vitrification Facility. In addition to the HLW effluent management capability, Alternative 16 also includes the capability to concentrate the pretreated HLW feed before delivery to the HLW Vitrification Facility. Figure 24 and Figure 25 show pre-conceptual plan and section (or elevation) views of the HEMF for Alternative 15. Figure 26 and Figure 27 show similar views of the HEMF for Alternative 16. Previous Figure 23 shows a notional 'Aerial Site Diagram' with a perspective view of the proposed site of the HEMF for Alternatives 15 and 16.

Similar to the HFPEM Facility, the HEMF facility receives and processes high-activity liquid wastes. Based on the MAR and the high solids concentrations in some of the process vessels in these facilities, it is assumed that the HEMF would be Hazard Category 2 facility. It is also assumed that the primary and secondary containment SSCs would be designed to Seismic Category I requirements for NPH protection. Based on the need for SC and SS controls required for processing high-solids HLW in the WTP, it is assumed that SS or SC active vessel ventilation, vessel air sparging, and active confinement ventilation. These systems, and the associated process support and utility systems (e.g., backup electrical power, compressed air) are assumed to be housed in a Seismic Category I structure ("Safety System Building") for NPH protection.

Since the WTP EMF provides similar evaporative capabilities as the HLW evaporator, the AoA Team used the WTP EMF layout as the starting point for development of the HEMF Facility. For Alternative 16, an HFP Process Vault was added to house the process vessels needed to concentrate pretreated HLW feed. Once all the required process and process support areas had been identified, the facility configuration was revised to simplify waste transfer and utility routing.

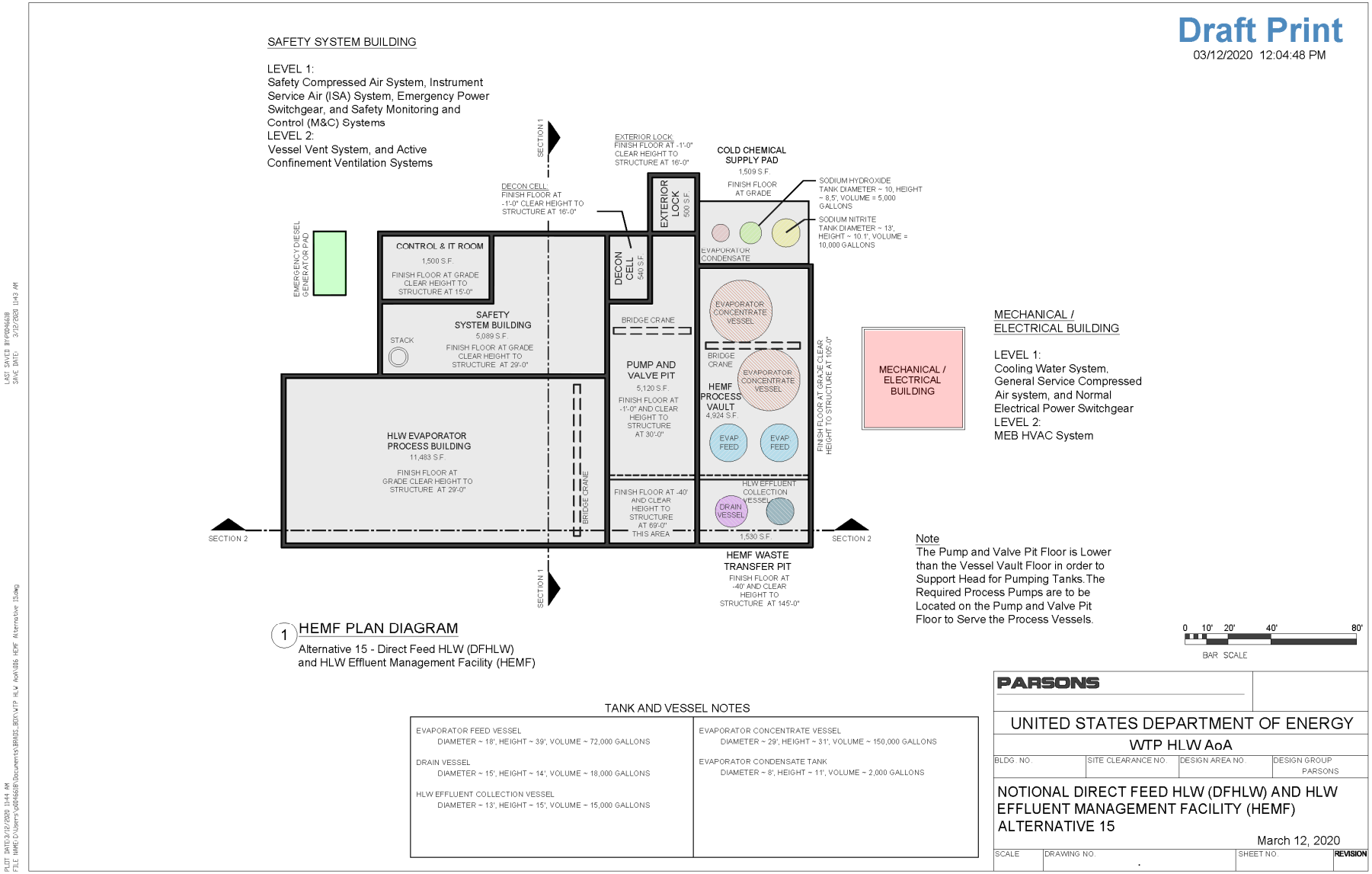

Figure 24: Alternative 15 HEMF Facility Plan Diagram

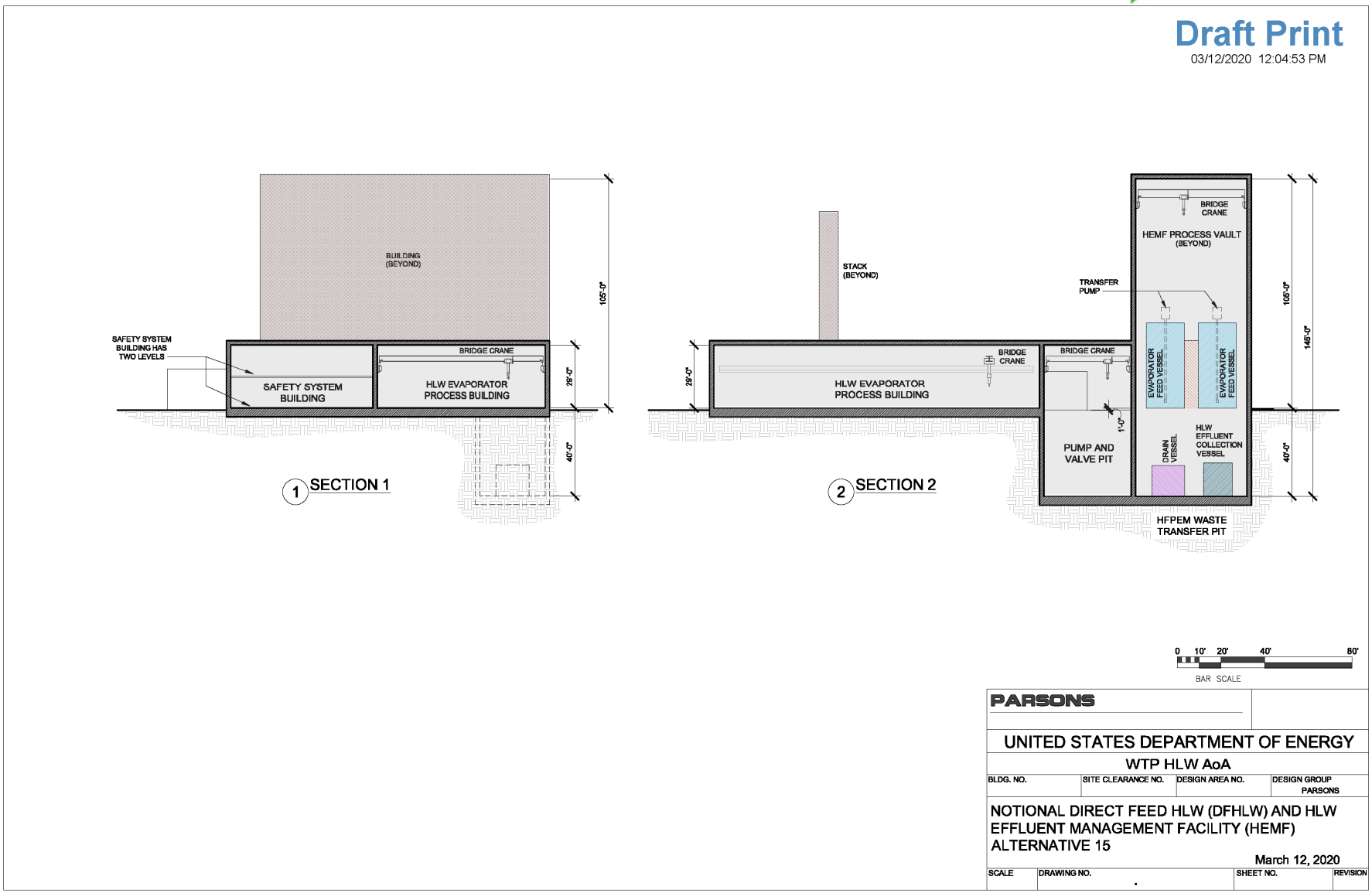

Figure 25: Alternative 15 HEMF Facility Elevation Diagram

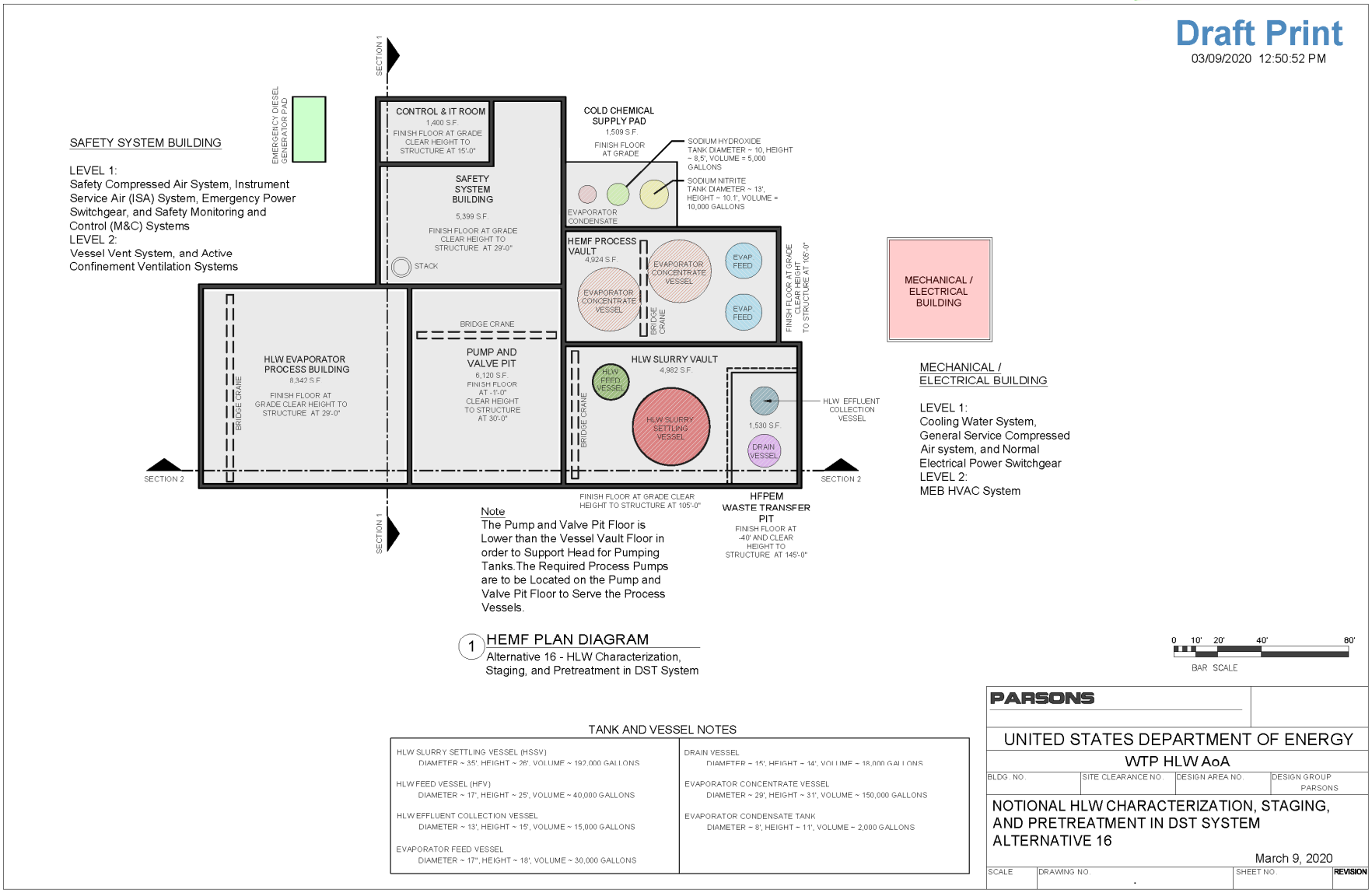

Figure 26: Alternative 16 HEMF Facility Plan Diagram

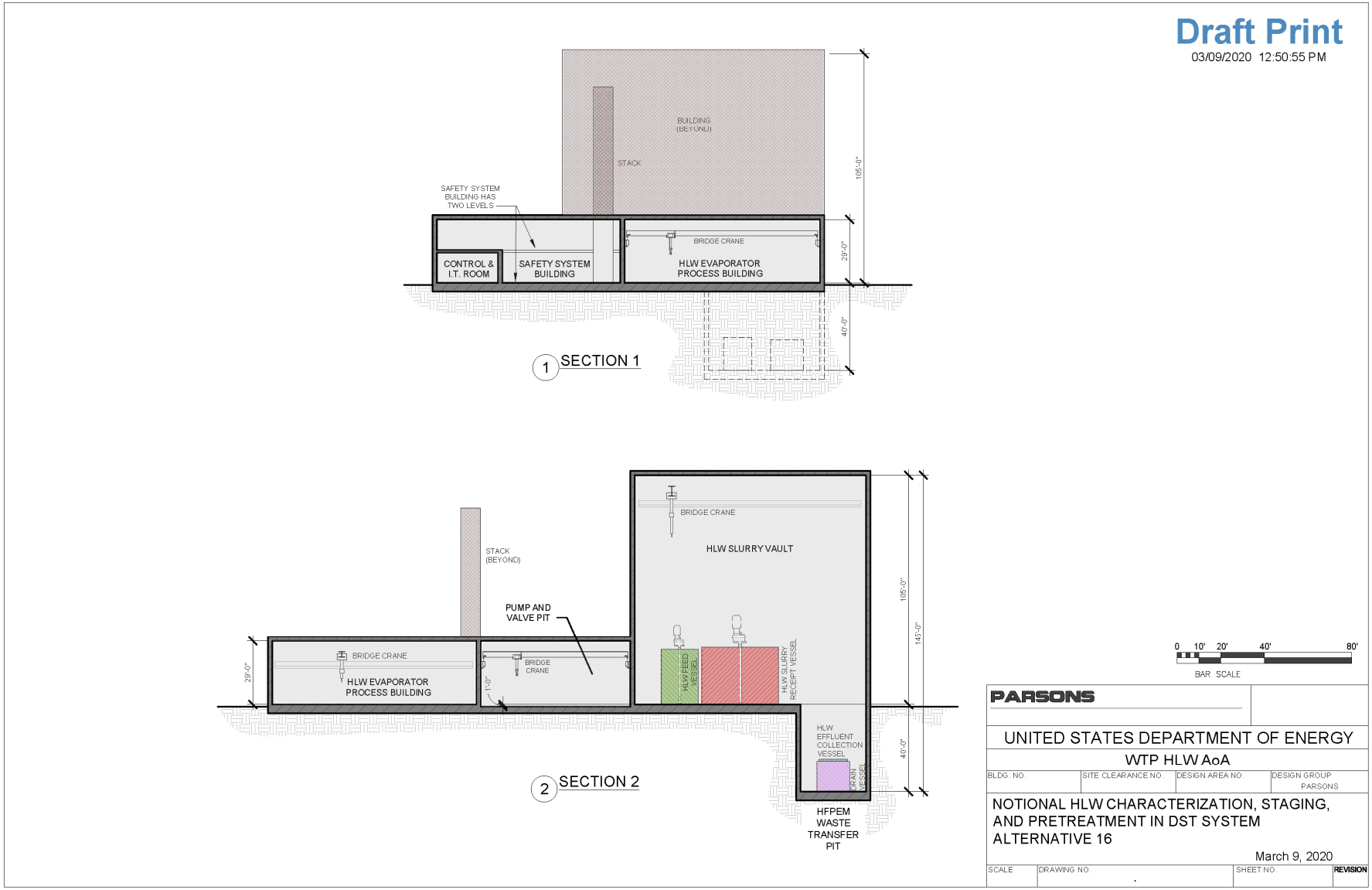

Figure 27: Alternative 16 HEMF Facility Elevation Diagram

Process and process support areas that had safety functions for accident prevention/mitigation were located within hardened structures for NPH protection. The process areas were also configured for overhead cranes/manipulators for remote O&M.

The pre-conceptual design for the HFPEM facility is based on the following design features and configuration:

- HLW Slurry Settling Vessel and HLW Feed Vessel are in a grade-level concrete vault (HFP Process Vault) (Alternative 16 only);
- HLW evaporator and evaporator process equipment is in a grade-level HLW Evaporator Process Building;
- Evaporator Feed and Concentrate Vessels are in a grade-level concrete vault (HEMF Process Vault);
- Pumps and valves for internal waste transfers are in a partially below-grade Pump and Valve Pit;
- HLW Effluent Collection Vessel, Evaporator Drain Vessel, and waste transfer line jumpers/valve manifolds are in a below-grade concrete vault (Waste Transfer Pit);
- Safety systems (e.g., process vessel ventilation system, active confinement ventilation system for process areas, compressed air and process vessel air sparging systems, emergency electrical power supply and distribution systems, and essential monitoring and control system) are in grade-level Safety System Building; and
- Human-Machine Interfaces and Information Technology equipment are in a grade-level Control/IT Room.

All the process and process support areas identified above are inside of a common high hazard structure that would be designed to Seismic Category I requirements for NPH protection. Separate low hazard structures are provided to house non-safety systems. These structures include a Cold Chemical Supply Pad and a MEB.

7.1 Sizing the HLW Evaporator Process Building for the HEMF

The capacity scaling factor for sizing the HLW Evaporator Process Building for the HEMF used in Alternatives 15 and 16 was developed in the same manner as done for the HFPEM Facility used in Alternatives 2 and 14 (see Appendix B Section 6.1). The calculational methodology for accounting for the differences in the boil-off rates for the WTP EMF and the HEMF are shown in Table 67.

Table 67: Evaporator Boil-off Data Used to Determine the Capacity Scaling Factor for Sizing the HEMF Evaporator Process Building

Alternative	Required HLW Evap. Process Boil-off Rate at 40% TOE (gpm)	Adjustment Factor for 100% TOE	Required HLW Evap. Process Boil-off Rate at 100% TOE (gpm)	WTP EMF Design Boil-off Rate (gpm)	Difference in Boil-off Rates (gpm)	Capacity Scaling Factor for HLW Evap. Process Bldg. for HEMF
15	7	0.4	17.5	9	8.50	47%
16	4.1	0.4	10.2	9	1.25	7%

The Capacity Scaling Factor was used to adjust the size of the WTP EMF Process Area to determine an appropriate HEMF HLW Evaporator Process Building size. Table 68 provides the data used to determine the sizing for the HEMF HLW Evaporator Process Building for Alternatives 15 and 16.

Table 68: Scaling of WTP EMF Process Area Data to Estimate the HEMF Process Building Area

Alternative	WTP EMF Process Area (sq ft)	Capacity Scaling Factor (%)	Additional Area Needed for Evap. Process Building(sq ft)	Total Area for HLW Evap. Process Building (sq ft)
15	7,800	47%	7,367	11,483
16	7,800	7%	542	8,342

7.2 Sizing the Safety Systems Building for the HEMF

The size of the Safety Systems Building was developed based on the size of process support areas within the WTP EMF with adjustments made to account for differences in the required capacities of the systems inside of the building. The Safety System Building is assumed to house the ventilation, compressed air, essential electrical power, and safe-shutdown monitoring and control systems. The system requiring the largest space allocation is assumed to be the facility active confinement ventilation system. The scaling factors for the HEMF Safety System Building were therefore based on an analysis of the required capacity of the active confinement ventilation system.

It is assumed that the size of the areas needed to house the ventilation equipment increases at half (50%) of the rate that the ventilation system capacity increases. The active confinement ventilation capacity (i.e., exhaust flow rate) is linearly related to the size of the process areas within the facility that need to be maintained under negative pressure. The size of the Safety System Building can therefore be approximated by adjusting the size of the WTP EMF ventilation system building (Utility Building 26) based on the difference in the sizes of the process areas within the WTP EMF and within the HEMF. The details of the calculation methodology and the results are provided below.

The Safety System Building for the Alternatives 15 and 16 will need to service the HLW Process Vault, HEMF Tank Vault, HFP Waste Transfer Pit, Pump & Valve Pit, and HLW Tank Vault. The area to be serviced was estimated from sizes of the areas shown in Figure 24 and Figure 25 for Alternative 15 and Figure 26 and Figure 27 for Alternative 16. The areas ventilated by the WTP EMF ventilation system includes the Evaporator Process Area, the Concentrate Area, the Condensate Area, and the Drain Tank Area. The scaling factor used to adjust the size of Utility Building 26 based on the difference in the areas ventilated by the facility ventilation systems for the WTP EMF and the HEMF was 50%. This value assumes that the area required for the ventilation exhaust fans, HEPA filters, and ducting increases/decreases by 50% when the ventilation system capacity increases/decreases by a factor of 2.

Table 69 shows the calculation inputs and results data for determining the appropriate size of the Safety System Building for the HEMF.

Table 69: Safety System Building Sizing Data for HEMF

Alternative No.	Area for HLW Evap. Process Building for HPPEM Facility (sq. ft.)	Area for Process Area for WTP EMF (sq. ft.)	Ventilation System Scaling Factor	Scaling Factor for Sizing Safety Systems Building for HEMF	Area of Utility Building 26 for WTP EMF (sq. ft.)	Total Area Required for Safety System Building for HEMF (sq. ft.)
15	23,597	14,156	50%	33%	7,632	5,089
16	25,898	14,156	50%	41%	7,632	5,399

7.3 Sizing Other Areas within the HEMF

The sizes for the Process Vaults and the Waste Transfer Pit for the HEMF were developed based solely on the size of the vessels located within them. The vessels sizes are based on the process cycle times and process rate calculations that are described in Appendix A. The size of the Pump and Valve Pit and the Control Room was based on engineering judgement and input from ORP assigned SMEs.

7.4 LAW Immobilization in LAW Vitrification Facility

In Alternative 2, LAW feed is pretreated in the Tank-Side Cesium Removal/Tank Farm Pretreatment (TSCR/TFPT) facilities. The pretreated LAW feed is staged in AP-106. During the DFLAW phase and before starting retrieval of the high phosphate LAW in the SSTs in B and T complexes, the pretreated LAW in AP-106 is transferred directly to the LAW Vitrification Facility. Once the B and T complex waste retrievals begin, the pretreated LAW in AP-106 is transferred to the LAW Feed Evaporator (LFE) Facility. The LFE concentrates the pretreated LAW and the concentrate is collected in an Evaporator Concentrate Vessel within the LFE. The concentrated pretreated LAW feed in the Evaporator Concentrate Vessels (two sized at 65 kgal each) is then transferred to the LAW Vitrification Facility.

8 HLW Vitrification Facility

The HLW Vitrification Facility provides the capability to immobilize pretreated HLW slurry. The facility includes two joule-heated melters, each with as dedicated feed train, an air lift system, melter pouring system, and an off-gas system. A common canister receipt system provides canisters to the melter pouring system. The melters also share a canister handling system and a secondary effluent collection system.

HLW feed is received by the HFP vessels (HFP-VSL-00001/5) in the HLW Vitrification Facility. The HLW feed is blended with glass forming chemicals and is then sent to one of the HLW Melter Feed vessels (HFP-VSL-00002/6). Feed slurry is transferred from the HLW Melter Feed vessel to the top of the melter. The melter evaporates water and volatilizes other volatile constituents present in the feed. Non-volatile constituents react to form oxides that become part of the molten glass. The air lift system transfers the molten glass to an IHLW canister. The canisters are inspected, the glass is sampled if required, and the canisters are sealed. The canisters are decontaminated and placed in temporary storage in an interim storage area within the HLW Vitrification Facility pending transfer to the IHS facility. A more detailed description of the design and operation of the HLW Vitrification Facility is provided in the WTP *Basis of Design*[ff].

As a result of the DNFSB TIs, construction and engineering and procurement work on the HLW Vitrification Facility was put on hold in 2012. Construction was estimated to be 43% complete at that time. Other than engineering work to determine the extent of the seismic analysis needed to resolve the TIs, no other work was performed to progress the procurement and construction work on the PT Facility.

Other than seismic analysis for some vessel support structures, resolution of the TIs for the HLW Vitrification Facility is not expected to require any significant changes to the baseline design. During the design and operability reviews conducted for the HLW Vitrification Facility, it was determined that the import/export capabilities were inadequate. An Engineering Study was performed in 2016[ll] to determine the scope and cost of the facility changes that were needed to resolve these import/export issues. The recommended scope of work includes construction of a MAB, equipment import/export dock, truck bay, and airlock on the north side of the HLW Vitrification Facility. It is assumed that these modifications would need to be made to make the HLW Vitrification Facility to sustain operations at its design capacity. It is assumed that for Alternatives 2, 14, 15, and 16 that these modifications would need to be completed prior to completion of hot commissioning of the HLW Vitrification Facility (Note that in the unconstrained funding case, it is assumed that hot commissioning of the HLW Vit Facility can be completed by 12/31/2033 as specified in the ACD).

For Alternative 1, it is assumed that the PT Facility will provide shared utility and support services to the HLW Vitrification Facility. Under this assumption, the only work remaining to make the HLW Vitrification Facility operational is to complete the import/export facility modifications and complete the remaining facility construction and commissioning in accordance with the baseline design. For Alternatives 2, 14, 15, and 17 it is assumed that the HLW Vitrification Facility will have to operate independent of the PT Facility. As part of the *Engineering Study for HLW Options E and F*[ll], it was determined that the new facilities and systems needed to allow the HLW Vitrification Facility to operate independent of the PT Facility included:

- SC air supply for purging of melter feed and feed preparation vessels;
- Delivery of nitric acid and caustic solutions;
- Seismic Category I Control Room with SC ventilation;
- Incident Command Post with SC ventilation;
- Utilities for fire water, service water, demineralized and potable water, instrument air, etc.; and
- SC emergency electrical power.

It is assumed for Alternatives 2, 14, 15, 16, and 17 that these new facilities/systems must be constructed and commissioned prior completion of hot commissioning of the HLW Vitrification Facility (Note that in the unconstrained funding case, It is assumed that hot commissioning of the HLW Vit Facility will be completed by 12/31/2033 as specified in the ACD).

9 Waste Transfer Vault (WTV)

Alternative 17 includes a new Waste Transfer Vault (WTV) Facility to receive and transfer pretreated DST HLW slurry to the HLW Vitrification Facility plus collect HLW Vitrification Facility effluents along with transfer line flush water and transfer these effluents to DSTs. The pre-conceptual design features for the WTV Facility include:

- HLW Effluent Collection Vessel and HLW Feed Vessel (HFV) (24 kgal each) located in a WTV for secondary containment
- SC Vessel Ventilation and Active Confinement Ventilation Systems located in a Safety Systems Building
- SC compressed air system for post-DBE air sparging of vessels also located in Safety Systems Building
- SC emergency electrical power and essential monitoring and control systems also located in Safety Systems Building
- Sodium hydroxide and sodium nitrite tanks for chemical adjustment of effluents located on a Cold Chemical Pad
- Normal utility supply systems located in a Utility Supply Building

Figure 28 shows the preconceptual design of the WTV.

It is assumed that given the MAR in the HFV within the WTV, the WTV Facility will require classification as a Hazard Category 2 facility. It also is assumed that the safety basis will require that the WTV and the Safety Systems Buildings be designed to Seismic Category I requirements for NPH protection.

The WTV is located near the HLW Vitrification Facility to facilitate waste transfer line connections. Figure 23 in Section 6 shows an 'Aerial Site Diagram' showing a perspective view of the WTV Facility location.

The HLW Feed (Receipt) Vessel transfers the slurry to the HLW Vitrification Facility in a recirculating loop. The Effluent Collection Vessel in the WTV receives liquid effluents and waste transfer line flush water drainage from the HLW Vitrification Facility. The Effluent Collection Vessel contents are transferred to the DST system.

The new WTV Facility will provide features that will facilitate the addition of new facilities and capabilities at a later date. Spare transfer line nozzles, valving, and jumpers will be provided in the WTV to facilitate routing to and from future pretreatment or effluent management facilities.

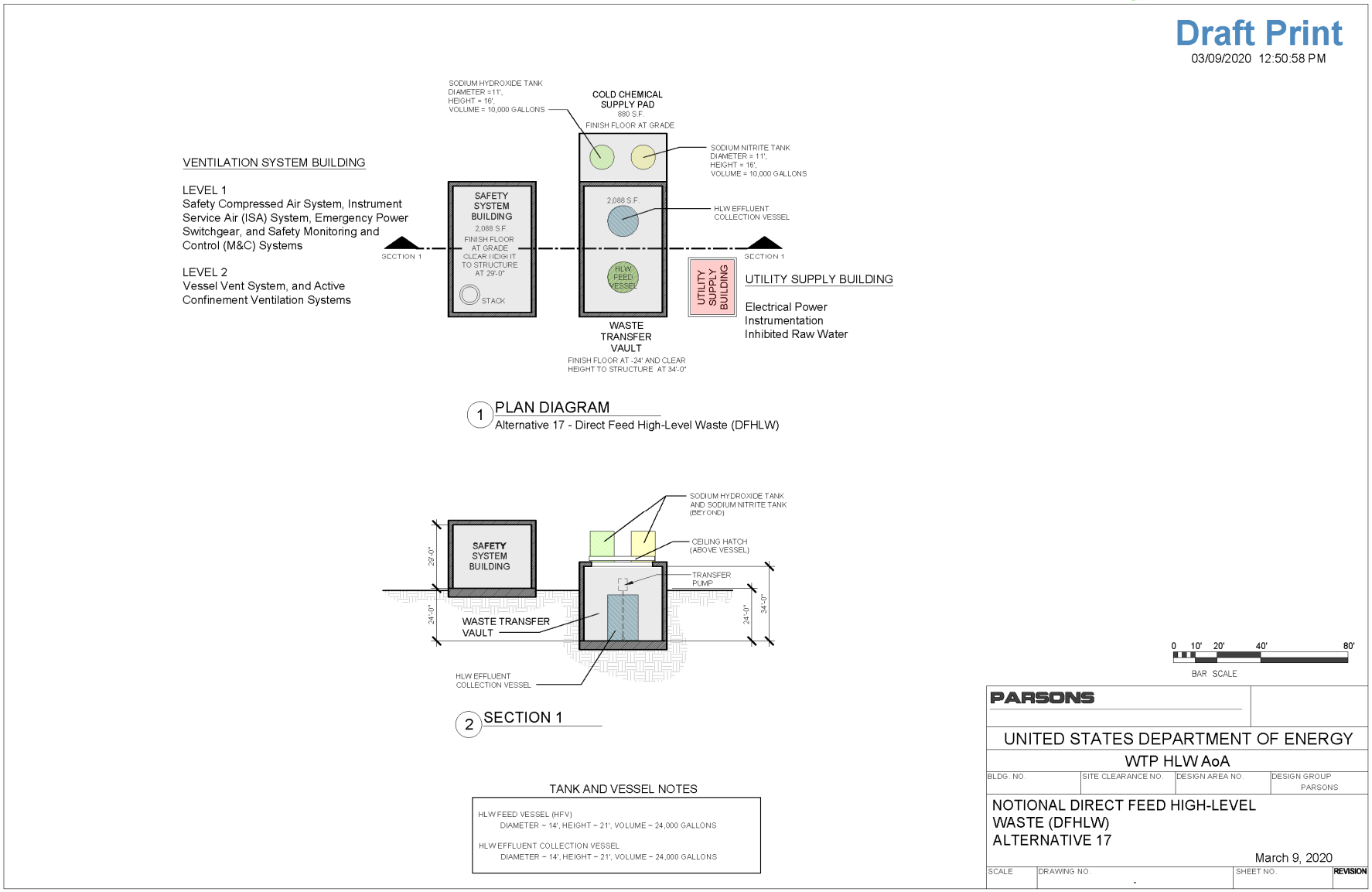

Figure 28: Alternative 17 Waste Transfer Vault Facility Plan and Elevation Diagram

10 Interim Hanford Storage (IHS) Facility and Hanford Shipping Facility (HSF)

The immobilized high-level waste (IHLW) canisters produced at the HLW Vitrification Facility will be stored on site at the Interim Hanford Storage Facility (IHS) pending availability of an offsite geological repository to receive IHLW. For purposes of the AoA, it was assumed that the Hanford IHLW canisters can be shipped to an offsite geological repository beginning in calendar year (CY) 2034. The IHS facility conceptual design provides storage space for 4,032 IHLW canisters in a crane-serviced open rack vault concept[mm].

Since HLW vitrification is planned to start immediately after completing hot commissioning of the HLW Vitrification Facility in 2033 (Note that in the unconstrained funding case, it is assumed that hot commissioning of the HLW Vit Facility will be completed by 12/31/2033 as specified in the ACD), the planned IHS will only be required to store the number of IHLW canisters that could be generated in one (1) year. Since the maximum IHLW canister production rate for any alternative is approximately 1,200 per year, the IHS design storage capacity far exceeds the minimum required capacity..

The five major IHS functional areas are shown in Figure 29[mm]. These areas include:

- **Import Bay** where the On-Site Transportation Cask (OTC) is loaded and unloaded from the On-Site Cask Transporter (OCT);
- **Transfer Tunnel** that is isolated from the Import Bay by an enclosure consisting of two roll up doors where the OTC is placed in a bogie that travels along the tunnel which runs beneath the vaults, along with a shielded bogie collar that limits radiation streaming back down the tunnel when the canister is lifted into the vault;
- Two **Storage Vaults and Racks** with a capacity to store 2,016 IHLW canisters each plus a capability to add up to six additional vaults if required, along with a 6-ton high-integrity crane in each vault;
- **Crane Maintenance Bays** that provide room to maintain and repair the vault cranes; and
- **Administration/Operations Area** that provides accommodation for facility staff, and houses the control room, HVAC room, and electrical switch room.

Once an offsite geological repository is ready to receive IHLW, the IHLW canisters will again be loaded into an OTC and transported to a separate Hanford Shipping Facility (HSF). The assumption regarding the availability date for an offsite geological repository includes the assumption that the transportation network between the Hanford Site and National Geological Repository is also available for IHLW canister transport.

Although the HSF functions and design details are not developed, it is assumed that the HSF will receive OTCs from the IHS facility, remove the canisters from the OTC, and load the canisters into off-site transportation containers approved for shipment to an offsite geological repository. The details of the transportation network for IHLW canister shipments, and for receiving and disposing of the canisters at an offsite geological repository, are outside of the scope of the WTP HLW AoA.

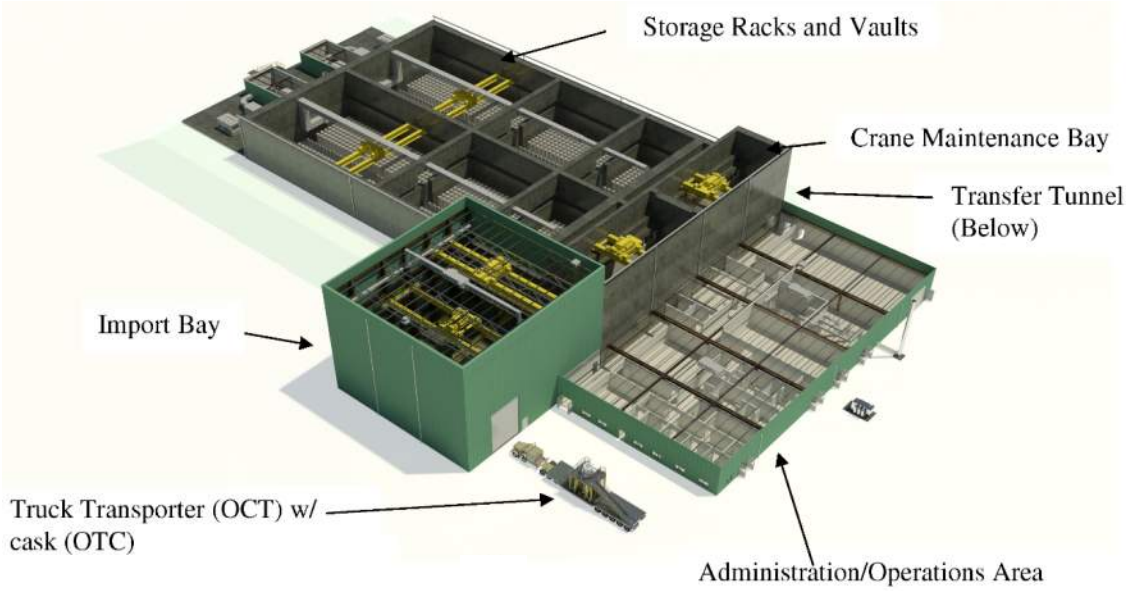

Figure 29: IHS Facility Isometric[mm]

11 LERF, ETF, and SALDS

The Liquid Effluent Retention Facility (LERF) contains retention basins that provide interim storage for staging feed for the Effluent Treatment Facility (ETF). Liquid waste is treated in the ETF to remove or destroy organics and to remove radioactive constituents. Residual radioactive solids (powder) is sent to a commercial off-site facility to be stabilized in grout. The grout is then shipped back to the Hanford site for disposal in the Integrated Disposal Facility (IDF). The treated liquid effluent from the ETF is discharged to the ground at the State-Approved Land Disposal Site (SALDS).

11.1 Liquid Effluent Retention Facility (LERF)

The LERF basins stage feed for delivery to ETF. The basins are covered double-lined surface impoundments. Each of the three basins have a capacity of 6.76 million gallons (Mgal). A fourth basin was partially constructed and abandoned. Construction on this basin is planned to resume in 2022[nn]. The LERF was designed to receive process condensate from 242-A evaporator and from plutonium and uranium extraction (PUREX).

The LERF shown is Figure 30 occupies approximately 20 acres of land northeast of the old Hanford 200 East Area site boundary[nn]. The LERF provides enclosed storage for effluents before treatment at the ETF. The LERF consists of three identical surface retention basins (Basins 42, 43, and 44) constructed with primary and secondary composite liners, a leachate collection and removal system between the liners, and a floating cover. A fourth retention basin (Basin 41) was excavated, but the construction was not completed. In addition, the LERF includes piping, a secondary containment system, a collection system, buildings, and security fencing. The LERF basin operations structure is comprised of the following:

- Retention basins (three in service);
- Primary and secondary composite liners;
- Leachate detection, collection, and removal system;
- Basin cover;
- Piping and pumps;
- Change trailer;
- Electrical power substation; and
- Security fencing.

The retention basins have a capacity to hold 6.76 Mgal each. Each basin has a double composite liner with a leachate collection system installed between the two liners. The basins receive and stage low hazard liquid waste for eventual transfer to the ETF to be treated.

Figure 30: ETF (at bottom) and LERF (at top)[oo]

11.2 Effluent Treatment Facility (ETF)

The locations of the primary buildings and structures that comprise the existing ETF are shown in Figure 30 and Figure 31. These buildings and structures include[nn]:

- Process Building, Building 2025E;
- Administration and Support Buildings, Building 2025EA, and Mobile Offices;
- Load-In Station, Building 2025ED; and
- External Tank Storage Areas.

The Process Building, 2025E, is a single building containing a control room that provides the capability of monitoring and controlling the treatment process and the treatment systems. Building 2025E also contains a chemical makeup and storage area, secondary waste treatment and storage systems, and off-gas and ventilation systems along with various support systems including fire protection, communications, sanitary and raw water, and electrical systems. Building 2025EA is a one-story Administrative Building. Several Mobile Office buildings are also present on the ETF site. The Load-In Station, Building 2025ED, provides tanker truck offload capabilities. External tank storage is provided for liquid waste awaiting treatment, process chemicals, and treated effluent awaiting analysis and/or verification. The ETF is capable of treating low-activity radioactive water containing small amounts of ammonia, inorganics, organics, and particulates.

In 2018, BNI transmitted a certified waste profile of the WTP EMF for evaluation by ETF by WRPS. The evaluation found that the WTP EMF waste profile is not acceptable for treatment and disposal at LERF/ETF under the current waste stream characterization and ETF configuration. The primary issues included the high concentration of acetonitrile and the organic loading exceeding the current ETF organic destruction capability. Additionally, the report identified issues with elevated organic concentrations including hard-to-treat species, high alkaline loading, and the shift to hard-to-detect technetium-99 and iodine-129 as the predominant isotopes in the waste stream. The evaluation concluded that other

modifications to the ETF processes, permitting, and operating practices and programs would be required to accept the WTP EMF waste stream[qq].

Figure 31: Effluent Treatment Facility[nn]

The ETF requires significant upgrades and repairs to operate reliably during the DFLAW phase. These upgrades and repairs include replacement of some of the waste processing and process support systems and components within the ETF as described in ETF Projects for FYs 18, 19, and 20[pp]. Once these upgrades and repairs are completed, the ETF will need to be modified as recommended in the *ETF Flowsheet Assessment*[qq].

11.3 Modifications to the Existing ETF and Construction of New ETF

The treatment processes within the ETF are performed in the Main Treatment System (MTS) and the Secondary Treatment System (STS). The MTS processes include feed receipt, pH adjustment, filtration, ultraviolet oxidation (UV/OX), peroxide decomposition, degasification, reverse osmosis (RO), IX polishing, effluent pH adjustment, verification sampling, evaporation, brine drying, powder handling, and off-gas treatment. The treated effluent from the MTS is collected in Verification Tanks for verification with the SALDS WAC before the Verification Tank contents are transferred to the SALDS for disposal. The concentrated liquid waste from the MTS is sent to the STS to be further concentrated and solidified.

In October 2019, an Integrated Project Team was established to "*recommend a path forward to resolve outstanding flowsheet gaps associated with the treatment of the WTP EMF material at LERF/ETF*". The Integrated Project Team issued an *ETF Flowsheet Assessment* in January 2020[qq]. This Assessment included recommendations for technology development, design of new ETF treatment processes, and installation of new systems and components to provide a more robust treatment capability. The Assessment also recommended codifying an ETF WAC and to develop inventory controls to maintain the MAR in the LERF and ETF within the limits for designation as Hazard Category 3 facilities. The specific changes in the flowsheet for the existing ETF that were recommended in the Assessment include:

- Replace current Influent Filtration technology with alternative technology.
- Add third UV/OX processing train.
- Complete testing of recently installed Peroxide Decomposition Module.
- Upgrade Vessel Off-Gas Ventilation System.

- Replace Chemical Storage and Solution Tank.
- Replace Thin Film Dryer with a new Brine Loadout System.
- Add brine cooling capability.
- Establish off-site capability to immobilize brine in a manner that would meet land disposal restrictions for disposal at the IDF.

The ETF Flowsheet Assessment also identified the need for new administrative controls for LERF/ETF for the DFLAW phase. Presumably, these same controls would also apply once HLW processing starts. These administrative controls will limit the operational flexibility of the LERF and ETF. These operational limitations are expected to reduce the sustained capacity/throughput of the LERF/ETF during the DFLAW and Balance of Mission (BoM) phases. The new administrative controls include:

- Limits on the MAR for the LERF and ETF to stay within the limits for a Hazard Category 3 facility
- Permit requirement to drain the LERF basins once each year
- Segregation of waste streams within the LERF basins

Although the recommendations from the *ETF Flowsheet Assessment* have not been accepted or approved for implementation, the AoA Team concluded that these flowsheet changes and facility modifications should be completed before starting LAW vitrification in the DFLAW phase, (Note that LAW vitrification is assumed to start immediately after completing hot commissioning of the LAW Vit Facility. This date is assumed to be 12/31/2023 as specified in the ACD). The facility modifications that are recommended in the *ETF Flowsheet Assessment*[qq] include installation of new treatment systems that use technologies that are different than those currently used. These modifications could reduce the capacity of the existing ETF. There is a risk that the modified ETF may not have a high enough process rate to treat the secondary effluents that are generated during the DFLAW phase. If the ETF cannot keep pace with the rate at which secondary effluents are generated, the LAW processing rate will need to be curtailed.

Based on process modeling results, the annual volume of process condensate generated during the DFLAW phase is approximately 6.6 Mgal for all alternatives, assuming the LAW and HLW processing facilities operate at a TOE of 40%. After adjusting to a TOE of 100%, the highest annual volume of process condensate that is expected to be generated during the DFLAW phase is 16.5 Mgal. The annual volume of leachate that is generated during the DFLAW and BoM phases is estimated to be constant at 1.8 Mgal[rr]. The total annual volume of all secondary effluents that could be produced and sent to the LERF/ETF during the DFLAW phase is 18.3 Mgal. To treat this volume of secondary effluents, the ETF would need to process these effluents at an average rate of 35 gpm over a one-year period.

The design process rate for the existing ETF will be 100 gpm once the facility is modified for processing the DFLAW process condensate (refer to Table 4-1 of the *ETF Flowsheet Assessment Report*[qq]). After adjusting for normal maintenance outages and accounting for the administrative controls that will be imposed during the DFLAW and BoM phases, the actual boil-off rate that the existing ETF will be able sustain is expected to be much less than 100 gpm. The AoA Team assumed that the capacity of the existing ETF is marginally adequate to process the secondary liquid effluents generated during the DFLAW phase.

The process modeling results for Alternative 1, 2, 5, 14, 15, and 16 show that the volume of process condensate generated annually during the BoM phase will exceed the design process rate of the existing ETF. Table 70 identifies the process condensate generation rates, leachate collection rates, and the required ETF capacity needed for each alternative during the BoM phase.

Table 70: Required ETF Capacity During BoM Phase Based on Process Condensate Generation and Leachate Collection Rates

Alternative #	Highest Annual Volume of Process Condensate Generated at 40% TOE (Mgal)	Highest Annual Volume of Process Condensate Generated at 100% TOE (Mgal)	Annual Leachate Collection from IDF and ERDF[17] (Mgal)	Highest Volume of Secondary Effluents to be Treated by ETF in any Year (Mgal)	ETF Feed Rate in Worst Case Year (gpm)
1	17.0	42.5	1.8	44.3	84
2	33.7	84.3	1.8	86.1	164
5	30.0	75.0	1.8	76.8	146
14	30.0	75.0	1.8	76.8	146
15	32.0	80.0	1.8	81.8	156
16	30.7	76.8	1.8	78.6	149
17	7.5	18.8	1.8	20.6	39

Based on the above results, the existing ETF will not have adequate capacity to treat the secondary effluents at the rate that they are generated during the BoM phase for Alternatives 2, 5, 14, 15, and 16. The AoA Team therefore assumed that a new ETF will need to be constructed and commissioned before starting BoM processing for these alternatives.

For Alternative 1, the ETF would have to sustain an average feed process rate of 84 gpm over a one-year period during the BoM phase. Although this rate is slightly below the design process rate for the ETF after the DFLAW modifications, there is a very high risk that the ETF will not be able to operate long term at or near its' design rate given the unknowns associated with the new treatment systems to be installed in the ETF for DFLAW, the recent ETF operating history, and the administrative controls that will be required for LERF/ETF.

For Alternative 17, the ETF would have to sustain an average feed process rate of 39 gpm. Although this rate is significantly below the design process rate for the ETF after the DFLAW modifications, there is a low risk that the ETF will not be able to sustain the required process rate given the unknowns associated with the new treatment systems to be installed in the ETF for DFLAW, the recent ETF operating history, and the administrative controls that will be required for the LERF/ETF.

11.4 SALDS

The Hanford SALDS is a drain field north of the 200 West Area that is permitted to receive treated effluent from the ETF. Its location was selected to avoid potential mobilization of contaminates from historical Hanford disposal practices and to give groundwater a long travel time to the Columbia River. Following is a brief description of the SALDS extracted from the Hanford site-wide risk review[ss].

> *"The State-Approved Land Disposal Site (SALDS) is one of the four primary facilities for processing and disposing of Hanford liquid waste. The other three are the ETF, LERF, and the Treated Effluent Disposal Facility (TEDF). SALDS also is known as the 616-A Crib.*
>
> *SALDS receives treated liquid discharge from the ETF with permissible levels of tritium for disposal via infiltration through the soils to the groundwater. Treated effluent is pumped to SALDS from the ETF verification tanks where the effluent is sampled prior to transfer to confirm the effluent meets delisting requirements of under 40 CFR 261, Table 2, 70 FR 44496. Treated effluent discharged at SALDS is considered a delisted waste; i.e., is no longer a listed, dangerous waste subject to the hazardous waste management requirements of RCRA. Treated effluent is discharged under Washington State Waste approved Water Discharge Permit Number ST-4500.*
>
> *Currently, the chosen alternative for handling tritium in the ETF effluent is to discharge this water to the subsurface and allow the tritium to decay into non-radioactive helium before it reaches the Columbia River.*

[17] ERDF – Environmental Restoration Disposal Facility

Although it might be desirable to have an alternative process that could actively separate tritium from water in the environment, costs would be prohibitive. Therefore, at this time, discharge to the subsurface is the only cost effective method to handle tritium in feed to the ETF.

The SALDS location was selected to avoid potential mobilization of contaminates from historical disposal practices, as well as to give groundwater a long travel time to the Columbia River. Since tritium is present in the effluent, a long travel time to the Columbia River gives the tritium time to decay before it reaches the river. SALDS employs a series of groundwater monitoring wells to keep track of the tritium plume, and annually submits a Tritium Tracking and Groundwater Monitoring Plan to the Washington State Department of Ecology as required by the monitoring plan."

11.5 LAW Feed Evaporator (LFE) Facility

The LFE Facility is a proposed new facility required for Alternatives 2, 14, 15, and 16. The functional capabilities of the LFE are described in the *Appendix A* The AoA Team developed a pre-conceptual design for the LFE Facility to be used to develop cost estimates for the AoA. Although the LFE concentrated LAW feed rather than low-activity liquid effluents, the process operations for the LFE are similar to the WTP EMF. The LFE Facility pre-conceptual drawings presented in Figure 32 and Figure 33 were developed using a configuration and orientation of buildings and areas similar to the WTP EMF.

The WTP EMF configuration was revised as necessary to reflect the need for NPH protection and remote O&M capabilities.

The pre-conceptual design for the LFE facility is based on the following configuration:

- HLW evaporator and evaporator process equipment located in a grade-level Evaporator Process Area
- Evaporator Concentrate Vessels located in a grade-level Evaporator Concentrate Area
- LAW Effluent Collection Vessel and Evaporator Drain Vessel located in a below-grade Waste Transfer Pit

All the above structures are assumed to be designed to Seismic Category II requirements and constructed of reinforced concrete. The structures share interconnecting walls and are configured to simplify waste routing. The ventilation and process support systems are assumed to be in a separate Ventilation and Process Support Building. Since the MAR is low in comparison to the HEMF, these systems are expected to be Seismic Category I. A separate non-safety MEB houses the utility systems.

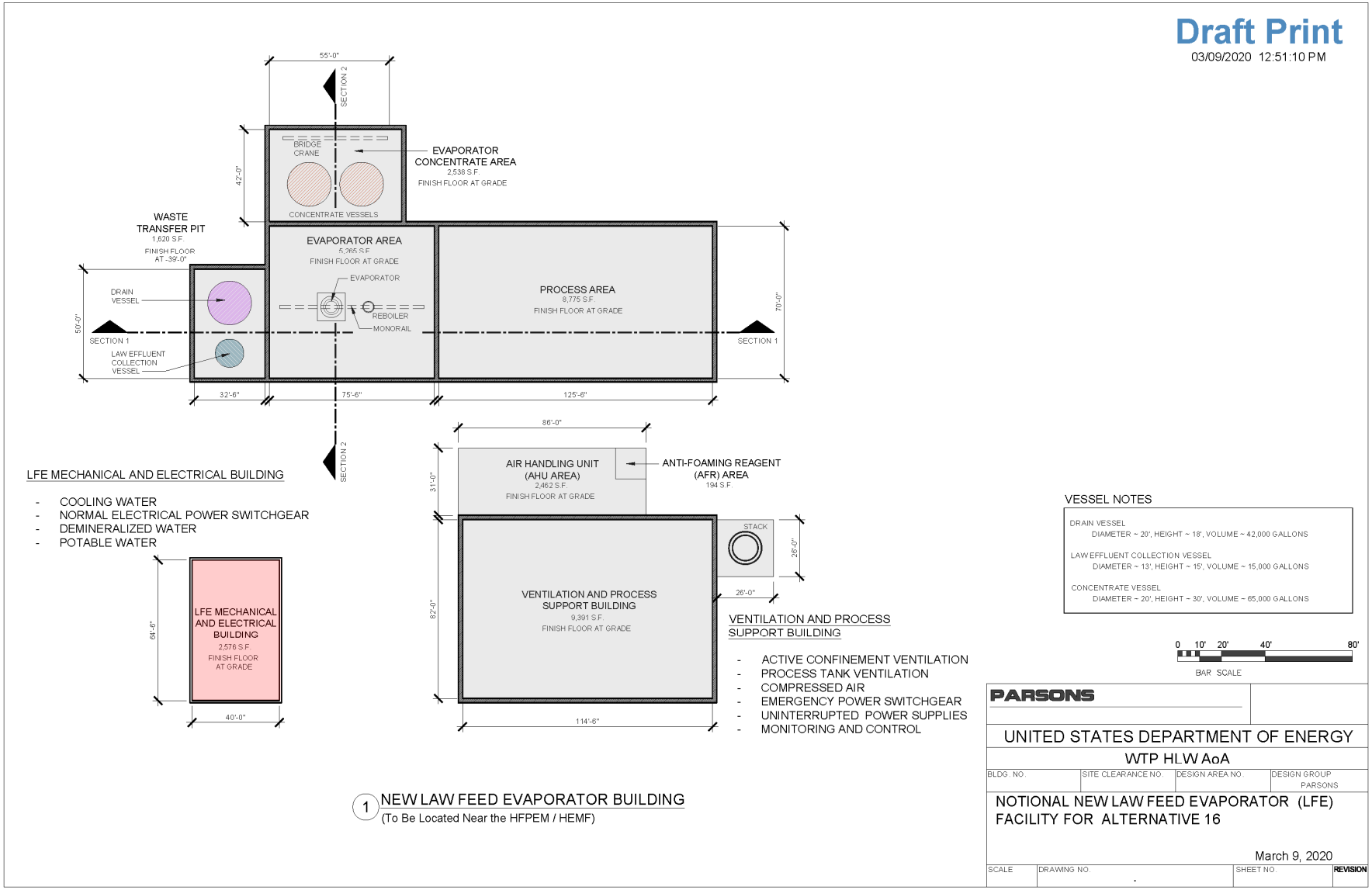

Figure 32: LFE Facility Plan Diagram (Based on Alternative 16)

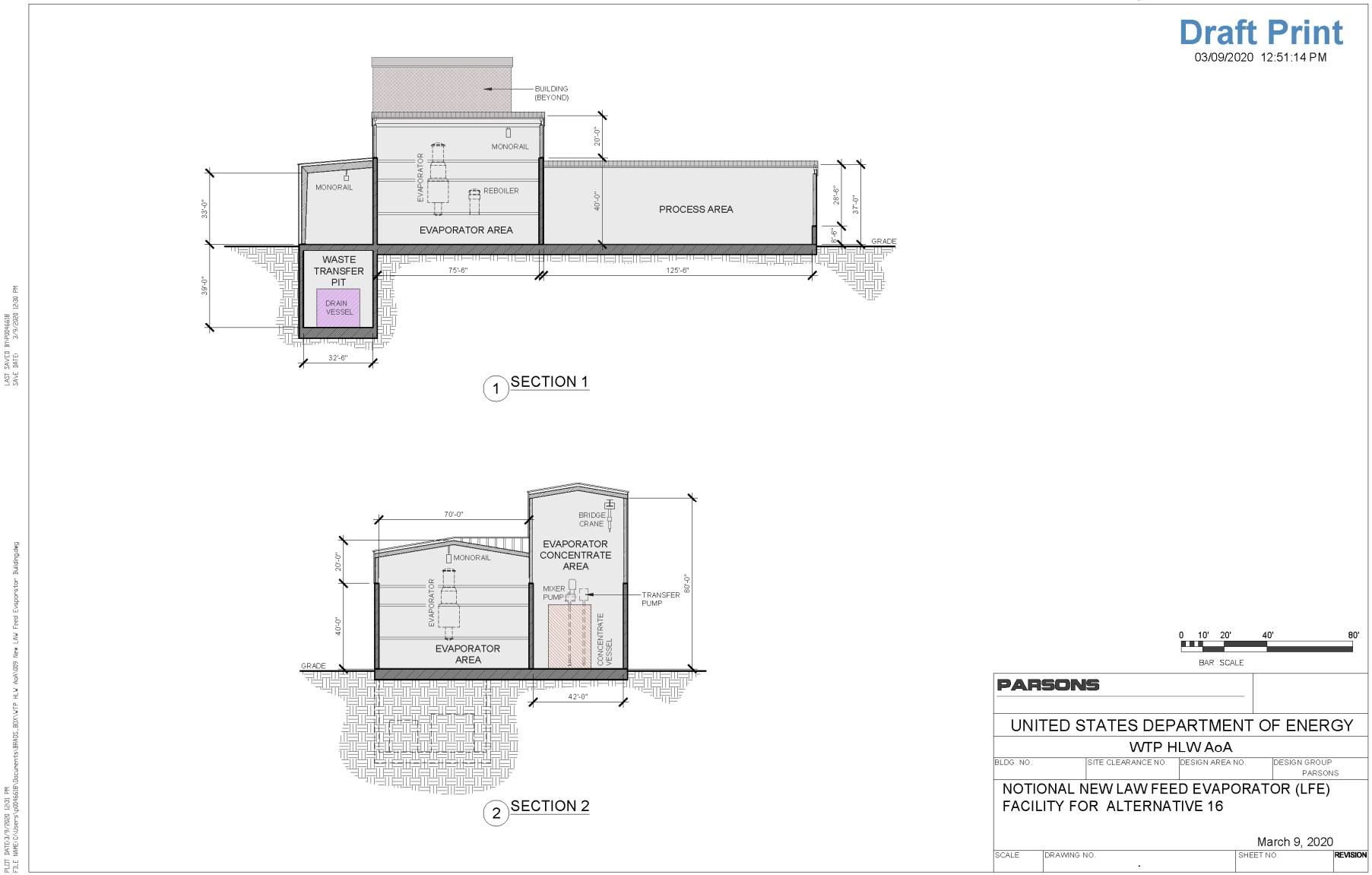

Figure 33: LFE Facility Elevation Diagram (Based on Alternative 16)

The existing WTP EMF design was used as the starting basis for developing the LFE Facility design basis. Table 71 shows the major WTP EMF areas and their approximate size estimated from design drawings. Scaling factors were developed to account for the higher processing rate for the LFE Facility. These scaling factors were multiplied with the WTP EMF area sizes to estimate the LFE area sizes shown in the Table 71.

Table 71: Sizing of LFE Facility Areas Based on WTP EMF Area Design Data

WTP-EMF Areas	WTP EMF Area Size (sq ft)	WTP Boil-off Rate (gpm)	LFE Boil-off Rate (gpm)	Scaling Factor for LFE (%)	LFE Area Size (sq ft)
Evaporator Area	3,900	42	15	50%	5,850
Process Area	6,500	42	15	50%	9,750
Evaporator Concentrate Area	1,880	42	15	25%	2,350
North Area (east of evaporator Concentrate Vessels	5,640	42	15	-100%	0
Utility Area	6,956	42	15	25%	8,695
Stack Area	676	42	15	0%	676
Air Handling Unit (AHU) Area	1,824	42	15	25%	2,280
Anti-Foaming Reagent Area	144	42	15	25%	180
Electrical Building	1,908	42	15	25%	2,385
Drain Tank / Waste transfer Pit	1,200	42	15	50%	1,800
Total Area (sq ft)	**30,628**			**Total Area (sq ft)**	**33,966**

The LFE preconceptual design is based on the following additional assumptions:

- The LFE Evaporator Area and Process Areas were sized to be 1.5 times the size of the same areas in the WTP EMF. This scaling factor was based on engineering judgment and the knowledge that, except for vessel sizing, the facility sizing is only loosely related to the process rate.
- Ventilation and Process Support Building Areas were sized to be 1.25 times the size of the same areas in the WTP EMF. This scaling factor was chosen based on engineering judgment and consideration of the fact that the ventilation, compressed air, and other process support equipment capacities and sizes are primarily dictated by the facility sizing.
- Since it is not known whether the LFE and HEMF can be collocated, the process support and utility system areas are assumed to be independent for each facility.
- The LFE Waste Transfer Pit contains an Effluent Collection Vessel and a Drain Vessel located below grade.
- The LAW Effluent Collection Vessel is intended to collect flush water drained from the waste transfer lines into and out of the LFE Facility. Since the location of the LFE Facility and the length of the waste transfer routes are unknown, the LFE Facility Effluent Collection Vessel was sized to be the same as the Effluent Collection Vessel in the HFPEM/HEMF (i.e., 15 kgal).
- The Drain Vessel in the LFE serves as a low point to allow draining the LFE process systems in the event of a planned or unplanned facility shutdown. Drain Vessel for the LFE is sized for three times the volume as for the WTP EMF (i.e., 13.8 kgal x 3 = 41.4 kgal [used 42 kgal]).
- The Caustic (sodium hydroxide [NaOH]) and Sodium Nitrite ($NaNO_2$) tanks in the WTP EMF area north of the process area are not needed for the LFE because evaporator bottoms collected in the Process Concentrate Vessels will be transferred to the LAW Vitrification Facility and will be recycled in the LAW melters. Caustic and sodium nitrite, used for corrosion control, are not needed since the supernate that was sent to the LAW Vitrification Facility would already been pretreated in the TSCR or TFPT facilities.
- The Process Condensate Vessels are not needed for the LFE because the condensate transfer to LERF is assumed to be continuous.
- The Process Concentrate Vessels are sized based on the PT Facility TLP concentrate vessel TCP-VSL-00001, which is 130 kgal maximum volume[tt]. Feed to the LAW Vitrification is batched from the concentrate vessel. The vessel

requires a mixer in case solids precipitate. Due to the height of a 130 kgal tank (approximate size would 25-foot diameter by 40-foot height), two 65 kgal tanks are used for the LFE.

- It was assumed that the LAW Vitrification Facility Control Room (FCR) will be used for monitoring and control of the LFE in the same way that the monitoring and control functions for the WTP EMF are provided for by the LAW Vitrification Facility. The WTP EMF does not contain its own control room as control of the EMF is provided through the LAW FCR. Refer to the LAW facility design description[uu], for requirements associated with control and monitoring of the EMF from the LAW FCR during operations in the DFLAW configuration[vv].

APPENDIX C: ALTERNATIVE SCHEDULES

Critical path schedules for each alternative were developed as part of the WRPS modeling efforts and modified by the AoA Team to incorporate the completion of the HLW Vitrification Facility (and PT Facility when included for an alternative), assuming unconstrained funding. The schedules are presented as summary timelines below. The assumptions and bases for the WRPS schedules can be found in a separate report[k]. The schedules for completion of the HLW Vitrification and PT Facilities are derived from the schedules that support the USACE parametric estimates for completion of those facilities, as described in the cost estimate basis discussion found in Appendix E.

A fundamental assumption of the unconstrained analysis for this AoA is that the hot commissioning of the HLW Vitrification Facility meets the current Amended Consent Decree[e] milestone of December 2033. Therefore, this is the starting point for both the WRPS modeling of the HLW processing operations and the LCCEs used for the AoA evaluations.

Timelines for the constrained case are derived from the constrained funding analysis, which is described in Appendix E.

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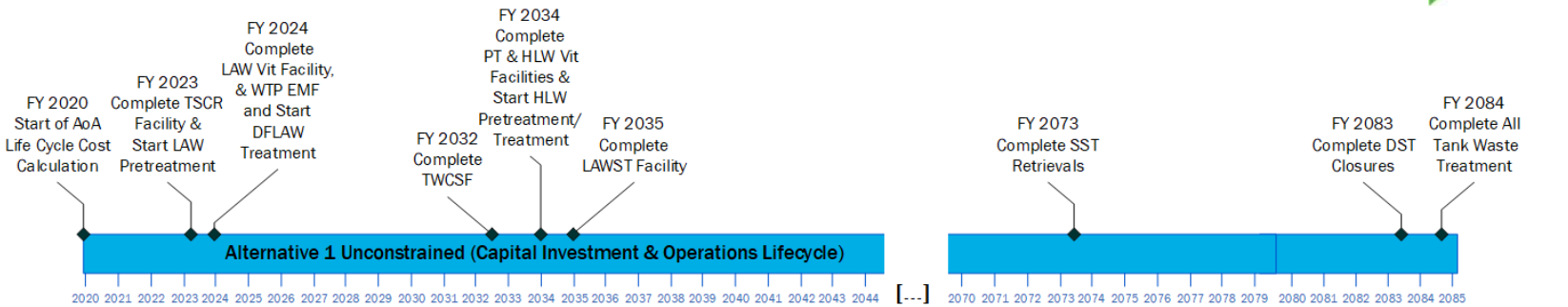
FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2032 Complete TWCSF
FY 2034 Complete PT & HLW Vit Facilities & Start HLW Pretreatment/ Treatment
FY 2035 Complete LAWST Facility
FY 2073 Complete SST Retrievals
FY 2083 Complete DST Closures
FY 2084 Complete All Tank Waste Treatment
Alternative 1 Unconstrained (Capital Investment & Operations Lifecycle)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044
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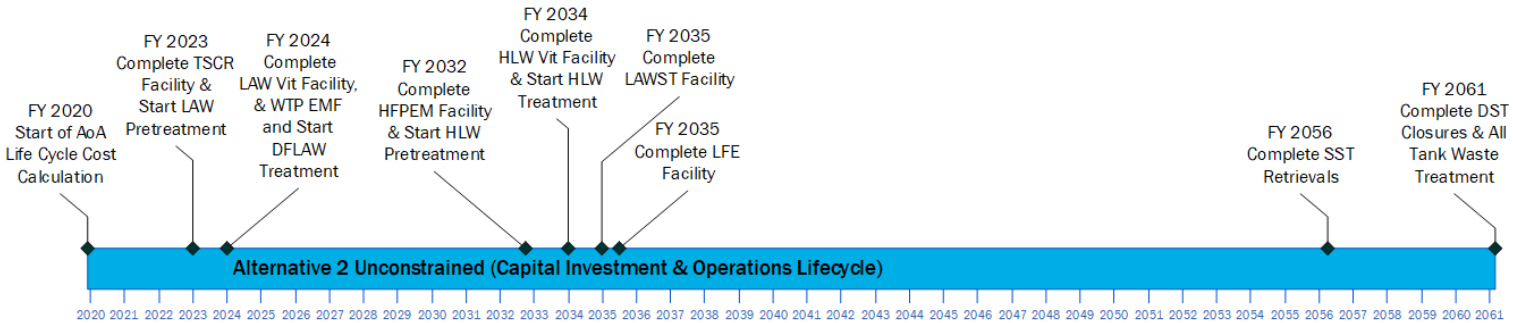
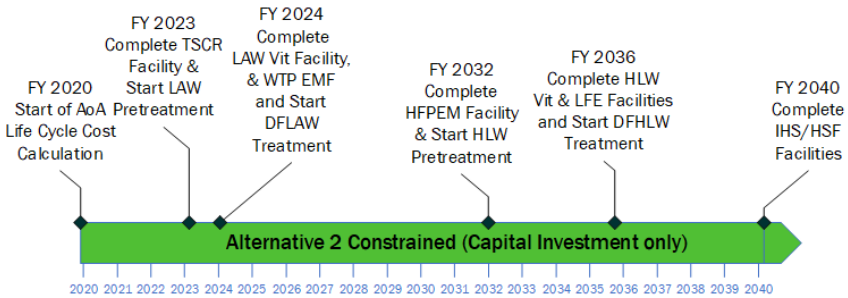
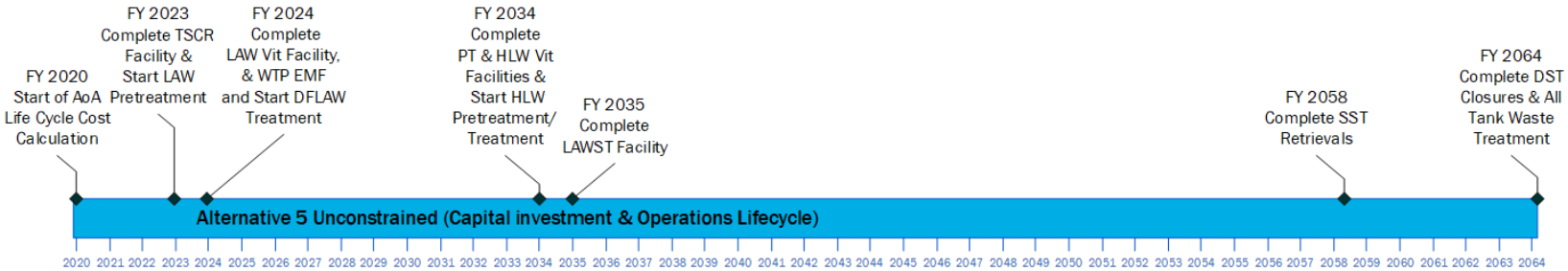
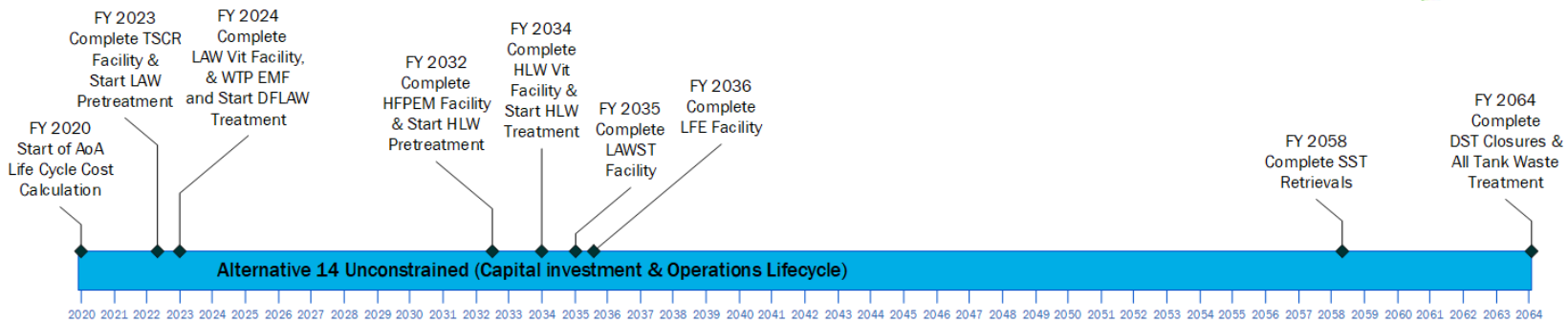
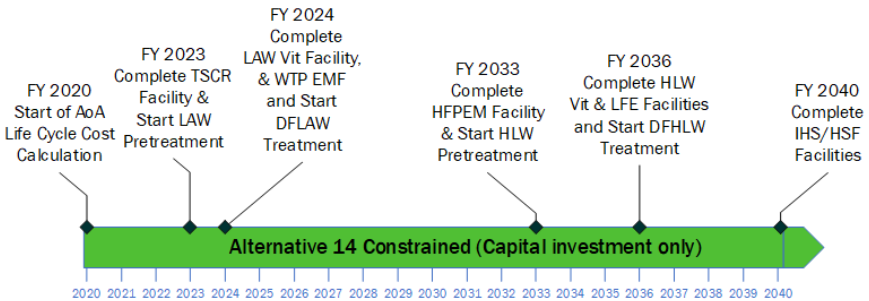
2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085

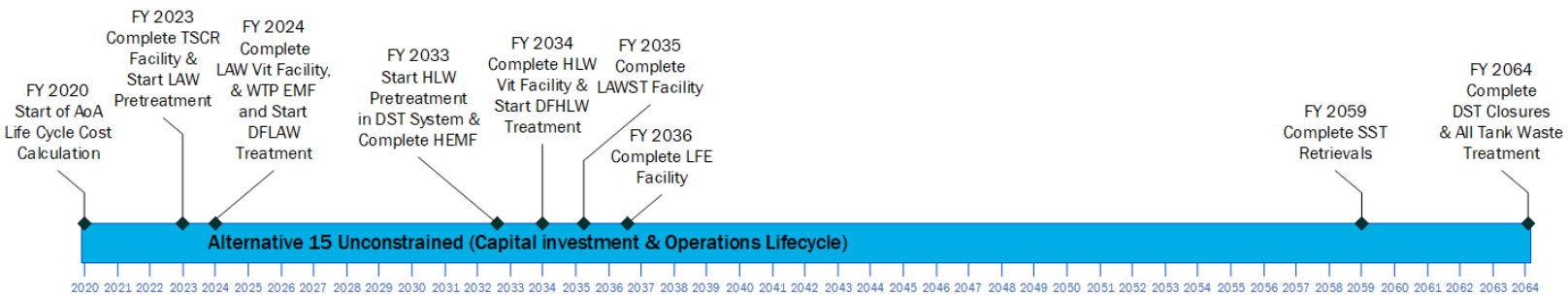

FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2032 Complete HFPEM Facility & Start HLW Pretreatment
FY 2034 Complete HLW Vit Facility & Start HLW Treatment
FY 2035 Complete LAWST Facility
FY 2035 Complete LFE Facility
FY 2056 Complete SST Retrievals
FY 2061 Complete DST Closures & All Tank Waste Treatment
Alternative 2 Unconstrained (Capital Investment & Operations Lifecycle)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061

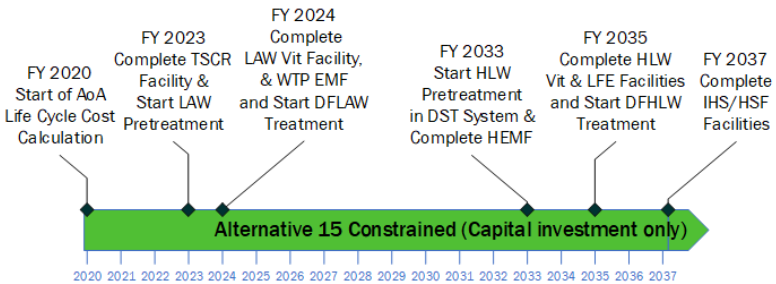

FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2032 Complete HFPEM Facility & Start HLW Pretreatment
FY 2036 Complete HLW Vit & LFE Facilities and Start DFHLW Treatment
FY 2040 Complete IHS/HSF Facilities
Alternative 2 Constrained (Capital Investment only)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040

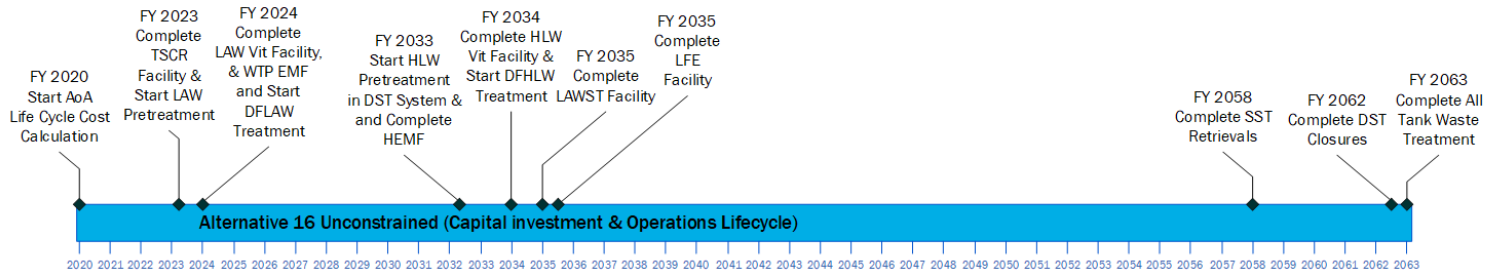

FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2034 Complete PT & HLW Vit Facilities & Start HLW Pretreatment/ Treatment
FY 2035 Complete LAWST Facility
FY 2058 Complete SST Retrievals
FY 2064 Complete DST Closures & All Tank Waste Treatment
Alternative 5 Unconstrained (Capital investment & Operations Lifecycle)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064

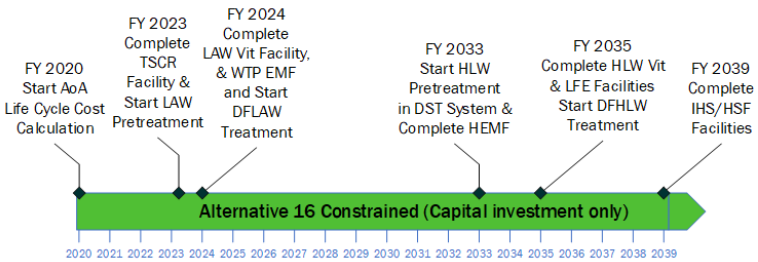

FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2032 Complete HFPEM Facility & Start HLW Pretreatment
FY 2034 Complete HLW Vit Facility & Start HLW Treatment
FY 2035 Complete LAWST Facility
FY 2036 Complete LFE Facility
FY 2058 Complete SST Retrievals
FY 2064 Complete DST Closures & All Tank Waste Treatment
Alternative 14 Unconstrained (Capital investment & Operations Lifecycle)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064

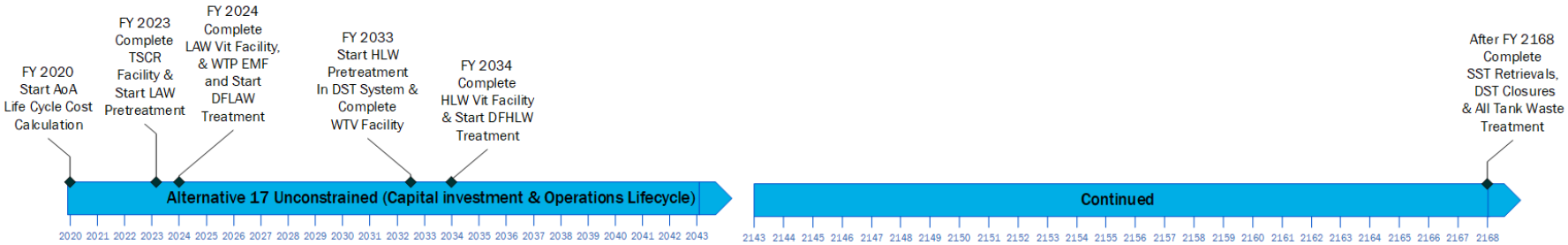

FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Complete HFPEM Facility & Start HLW Pretreatment
FY 2036 Complete HLW Vit & LFE Facilities and Start DFHLW Treatment
FY 2040 Complete IHS/HSF Facilities
Alternative 14 Constrained (Capital investment only)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040

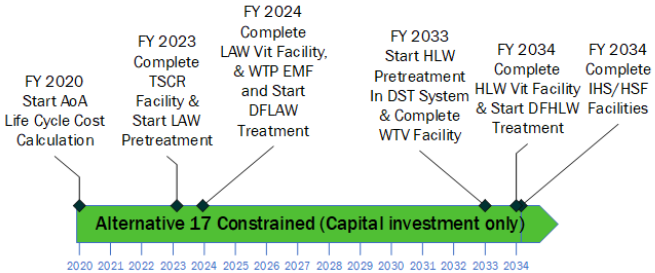

FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Start HLW Pretreatment in DST System & Complete HEMF
FY 2034 Complete HLW Vit Facility & Start DFHLW Treatment
FY 2035 Complete LAWST Facility
FY 2036 Complete LFE Facility
FY 2059 Complete SST Retrievals
FY 2064 Complete DST Closures & All Tank Waste Treatment
Alternative 15 Unconstrained (Capital investment & Operations Lifecycle)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064


FY 2020 Start of AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Start HLW Pretreatment in DST System & Complete HEMF
FY 2035 Complete HLW Vit & LFE Facilities and Start DFHLW Treatment
FY 2037 Complete IHS/HSF Facilities
Alternative 15 Constrained (Capital investment only)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037


FY 2020 Start AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Start HLW Pretreatment in DST System & and Complete HEMF
FY 2034 Complete HLW Vit Facility & Start DFHLW Treatment
FY 2035 Complete LAWST Facility
FY 2035 Complete LFE Facility
FY 2058 Complete SST Retrievals
FY 2062 Complete DST Closures
FY 2063 Complete All Tank Waste Treatment
Alternative 16 Unconstrained (Capital investment & Operations Lifecycle)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063


FY 2020 Start AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Start HLW Pretreatment in DST System & Complete HEMF
FY 2035 Complete HLW Vit & LFE Facilities Start DFHLW Treatment
FY 2039 Complete IHS/HSF Facilities
Alternative 16 Constrained (Capital investment only)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039


FY 2020 Start AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Start HLW Pretreatment In DST System & Complete WTV Facility
FY 2034 Complete HLW Vit Facility & Start DFHLW Treatment
After FY 2168 Complete SST Retrievals, DST Closures & All Tank Waste Treatment
Alternative 17 Unconstrained (Capital investment & Operations Lifecycle)
Continued
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043
2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168


FY 2020 Start AoA Life Cycle Cost Calculation
FY 2023 Complete TSCR Facility & Start LAW Pretreatment
FY 2024 Complete LAW Vit Facility, & WTP EMF and Start DFLAW Treatment
FY 2033 Start HLW Pretreatment In DST System & Complete WTV Facility
FY 2034 Complete HLW Vit Facility & Start DFHLW Treatment
FY 2034 Complete IHS/HSF Facilities
Alternative 17 Constrained (Capital investment only)
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034

APPENDIX D: ALTERNATIVE SCREENING METHODOLOGY

1 Summary

The Waste Treatment and Immobilization Plant (WTP) high-level waste (HLW) Analysis of Alternatives (AoA) team performed an initial screening of the 16 original alternatives against the three screening criteria. The screening resulted in either a rating of "Yes" (meaning that the alternative fully met a criterion) or a rating of "No" (meaning that the alternative did not fully meet a criterion). Alternative 17 was added to the viable alternative list after approval of the Study Plan, Revision 3. Table 12 summarizes the initial results of the alternatives screening. If an alternative has a single "No" score, the summary shows a "No."

Table 72: Initial Screening Results

Criterion #	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Tank waste classified as HLW shall be immobilized by vitrification.	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	The HLW processing system shall not preclude processing of LAW (either by Direct Feed LAW (DFLAW) or via the PT Facility) in parallel with HLW processing.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	HLW processing alternatives shall use proven and established technologies.	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	Y
	Summary Conclusion	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	N	Y	Y	Y	Y

2 Initial Screening Rationale

As shown above in Table 12, alternatives 6, 7, 10, 11, and 13 screened out through the initial screening process. Each of these alternatives and the rationale for failing screening are described below.

2.1 Alternative 6

Alternative 6 uses other technologies for HLW immobilization that included alternative technologies previously evaluated for low-activity waste (LAW) Supplemental Treatment (LAWST), specifically Grouting and Steam Reforming.

The Enterprise Construction Management Services (ECMS) AoA Team assumed that the technology down-select and technology development process would follow the processes proscribed by U.S. Department of Energy (DOE) O 413.3B, Program and Project Management for the Acquisition of Capital Assets and its associated Guides. In general terms, this process would include:

- Technology evaluation and alternative analysis
- Technology Readiness Assessment (TRA) and preparation of a Technology Maturation Plan.
- Bench-scale, prototype, and full-scale testing in parallel with the facility design process.

The functional requirements for the HLW feed characterization, pretreatment, and staging facilities would be developed in parallel with the technology development process for the selected HLW immobilization technology. The immobilized high-level waste (IHLW) canister storage or disposal facility design also would need to be developed and permitted in parallel with the new HLW immobilization facility.

This alternative assumes that the existing HLW Vitrification Facility would not be completed. It also assumes that the Interim Hanford Storage (his) design would be modified as required to provide interim storage of the IHLW canisters. The planned disposal pathway for IHLW also would require reexamination. If the recommended IHLW disposal pathway was on-site disposal, a new IHLW disposal facility also would require design and construction.

Screening Rationale

Alternative 6 does not satisfy Screening Criterion 1 which requires that "Tank waste classified as HLW shall be immobilized by vitrification." Vitrification is the only approved HLW treatment method identified in 40 Code of Federal Regulations (CFR) 268.42, Treatment Standards, expressed as specified technologies for Hazardous Wastes Subject to Land Disposal Restriction. By definition, treatment technologies other than vitrification as proposed by this alternative do not meet Screening Criterion 1.

2.2 Alternative 7

Alternative 7 would immobilize HLW in the existing single-shell tanks (SSTs) or double-shell tanks (DSTs). The immobilization technologies that were contemplated for in-situ HLW immobilization included:

- Vitrification
- Grouting
- Steam Reforming

The in-situ processes could involve either preparing and immobilizing the HLW sludge by equipment installed inside the tank or processing the HLW by equipment deployed external to the tank and returning the HLW to the tank prior to solidification. If the immobilization process occurs in equipment installed in the tank, the equipment would then form part of the immobilized waste matrix and be abandoned. Alternatively, a portable immobilization system could be deployed external to the tank. In this case, the HLW would be mobilized, retrieved, and then sent through the immobilization system. After adding the immobilization agents, the HLW sludge would be returned to the tank to solidify.

In all these approaches, the slurry in the tank would need to remain homogeneous as the slurry begins to solidify. It is assumed that the selected immobilization technology would need to be tested at scale to demonstrate that the entire tank contents could be solidified and that the immobilized waste form would satisfy performance assessment requirements for disposal.

Screening Rationale

Similar to Alternative 6, Alternative 7 does not satisfy Screening Criterion 1 because it uses an HLW immobilization technology other than vitrification which is the only approved HLW treatment method identified in 40 CFR 268.42.

Vitrification of the entire sludge inventory within an SST or DST represents significant and unique technology development challenges. Achieving a semi-homogenous mixture of slurry in the tank while simultaneously solidifying the slurry would be challenging. Other challenges include treatment of the off-gas during the immobilization process. The Critical Technology Elements (CTEs) for in-situ vitrification would require development and testing, including testing on real waste in an environment similar to an SST and/or DST.

Screening Criterion 3 requires that "the HLW processing alternatives use proven and established technologies." While a TRA for HLW in-situ vitrification is not available, it is the consensus opinion of the AoA Team and Government AoA Team that the CTEs for Alternative 7 are not at Technology Readiness Level 4 (TRL-4) which is the minimum level required to obtain Critical Decision (CD)-1 approval per DOE O 413.3B. The threshold for "proven and established" relative to Screening Criterion 3 was TRL-6, which is the minimum level needed to proceed with Final Design. Based on the above, Alternative 7 does not meet Screening Criterion 3.

In addition, although vitrifying the HLW in-situ technically satisfies Screening Criterion 1, use of this method effectively precludes future retrieval and subsequent treatment and disposal at the National Geological Repository. Disposal of immobilized HLW at the Hanford Site is contrary to the framework of the Tri-Party Agreement (TPA), and it is unlikely that the State of Washington Department of Ecology (Ecology) would agree to such an approach.

2.3 Alternative 10

Alternative 10 proposed to ship untreated liquid HLW to an off-site facility for pretreatment and treatment/immobilization. It is assumed that some processing would be required to adjust the HLW chemistry for corrosion control or to remove cesium to reduce the radiation levels. The liquid HLW would be shipped in rail cars or by barge to the off-site treatment facility. One of the off-site facilities that was considered for treatment of the HLW from the Hanford Tank Farms was the Defense Waste Processing Facility at the Savannah River Site (SRS).

An alternative analysis would be required to identify options for off-site treatment of HLW. Once an off-site facility was identified for further evaluation, a flowsheet assessment would be performed to determine if the Hanford HLW chemical and radionuclide concentrations would meet the feed specifications for the off-site treatment facility and to determine what pretreatment steps (if any) would be required before treatment. Assuming that there is an existing off-site treatment facility that could process the Hanford HLW, a shipment solution and disposal pathway would need development.

New technologies would be required to prepare the liquid HLW for shipment and containerize it for transport off site. An Environmental Impact Statement (EIS) would need to be developed to determine if liquid HLW could be transported off site without undue environmental risk. An EIS also would be required to identify and evaluate the disposal alternatives for the IHLW.

Screening Rationale

Liquid HLW has never been transported over the road or by rail in the U.S. The technologies required to containerize liquid HLW for transport and to prevent or mitigate transportation accidents have not been developed.

Additionally, to be cost effective, the transportation containers would need to be large and, given the curie content, heavily shielded. Although small containers of solid HLW (e.g., IHLW and spent nuclear fuel) have been transported by road, rail, and water (barges), these containers are small enough to be shielded in transportation casks. The transportation casks or other secondary container for transporting large volumes of liquid HLW could be difficult to design and difficult to approve from a nuclear safety standpoint.

Since design solutions for transportation of liquid HLW have not been developed or deployed in the U.S., the required technologies are unknown. Based on this, the ECMS and Government AoA Teams concluded that Alternative 10 was non-compliant with Screening Criterion 3 which requires that: “HLW processing alternatives shall use proven and established technologies.” Since the technologies required for transportation of liquid HLW are not yet identified or demonstrated, these technologies cannot be considered “proven and established.”

2.4 Alternative 11

Alternative 11 proposes to transport liquid HLW from the Tank Farms to the Fuels Material Examination Facility (FMEF) to be pretreated. The pretreated HLW would then be transported back to the Tank Farms and transferred via waste transfer lines to the HLW Vitrification Facility. The AoA Team considered the option to transfer the HLW between the Tank Farms and the FMEF by underground waste transfer lines and associated pumping stations. However, because the distance between the Tank Farms and the FMEF is approximately 15 miles, this option was determined to be infeasible from a capital cost perspective. Although the operating cost for transporting the waste by rail or roadways would be high, it was thought that the capital cost could be lower provided that the technology and regulatory challenges could be overcome.

The processing functions for the rail or roadway transport option are as follows:

- HLW feed is characterized in designated HLW Characterization Tanks within the DST system.
- Characterized slurry is transferred to a designated HLW Feed Tank within the DST system.
- Slurry in designated an HLW Feed Tank is transferred to a new Tank Farm HLW Loading Facility located in the Tank Farms or WTP boundary.
- Slurry is loaded into a rail tanker car or a tanker truck.
- HLW is transported by rail tanker car or tanker truck to a new FMEF HLW Loading Facility.
- HLW is pretreated and staged in new processing vessels to be installed in the FMEF.

- Pretreated HLW is transferred from the HLW Feed Vessel within the FEMF via the HLW Loading Facility to a rail tanker car or tanker truck.
- Pretreated HLW feed is transported by rail tanker car or tanker truck to the Tank Farm HLW Loading Facility.
- Pretreated HLW is received at the Tank Farm HLW Loading Facility and transferred (via waste transfer lines) to the HLW Vitrification Facility.

The HLW pretreatment and staging functions within the FMEF are assumed to be the same as described for Alternative 2. Construction of the FMEF was completed in the late 1980 timeframe. Much of the installed process equipment would need to be removed to allow installation of the new process vessels required for HLW pretreatment and staging.

The FMEF is a Hazard Category 2 facility and was previously designed to meet Performance Category 3 (PC-3) NPH requirements. The new Tank Farm and FMEF HLW Loading Facilities would be new capital projects. These facilities also would be Hazard Category 2 facilities. The required Seismic Category and safety functions would be determined as part of the safety basis development process.

In addition to repurposing the FMEF and constructing new Tank Farm and FMEF HLW Loading Facilities, Alternative 11 also requires construction of new rail lines or road(s). The new rail line or road(s) would run between the HLW Loading Facilities.

Screening Rationale

Similar to Alternative 10, design solutions for transportation of liquid HLW have not been developed or deployed in the U.S., and the required transportation technologies are therefore unknown. The ECMS and Government AoA Teams concluded that Alternative 11 was non-compliant with Screening Criterion 3 which requires that: “HLW processing alternatives shall use proven and established technologies.” Since the technologies required for transportation of liquid HLW are not yet identified or demonstrated, these technologies cannot be considered “proven and established.”

2.5 Alternative 13

Bulk vitrification was previously evaluated for treatment of Hanford tank waste classified as contact-handled transuranic. The proposed design solution involved retrieval of liquid waste and vitrifying the waste inside an engineered container approved for disposal. Alternative 13 assumed that a similar approach could be used for tank waste classified as HLW.

The technical solution for vitrifying HLW in bulk inside of an engineered container is expected to be complex and may require new technologies. Design solutions for containment, confinement, and off-gas treatment for bulk vitrification of HLW are expected to be more complex than those required for contact handled transuranic.

Alternative 13 also requires development of an alternative disposal pathway for the IHLW that would be generated by bulk vitrification of HLW. “Bulk vitrification” in the context of Alternative 13 assumed that the waste is vitrified inside a bulk container that is suitable for disposal. The River Protection Project (RPP) mission is based in part on the assumption that HLW would be vitrified inside a container suitable for disposal in an offsite geological repository. Bulk containers, presumably larger than the IHLW canisters produced by the HLW Vitrification Facility, would require an alternate disposal strategy.

Screening Rationale

Previous studies evaluated the bulk vitrification technology for treatment of tank waste at the Hanford Site that is classified as contact handled transuranic. Technical issues related to the immobilization technology, together with the uncertainties on the disposal pathway led to abandonment of this approach. Retrieval of sludge from the SSTs or DSTs and vitrification in an engineered container has not been evaluated from a technical viability or technology readiness perspective.

Screening Criterion 2 requires that “the HLW processing alternatives use proven and established technologies.” Although a TRA has not been done for bulk vitrification of HLW, it is the consensus opinion of the ECMS and the Government AoA Teams that the CTEs for Alternative 7 are not at TRL-4, the minimum level required to obtain CD-1 approval per DOE O

413.3B. The threshold for "proven and established" in the context of the HLW AoA was TRL-6, the minimum for Final design. Based on the above, Alternative 13 does not meet Screening Criterion 2.

In addition, although vitrifying the HLW in-situ technically satisfies Screening Criterion 1, use of this method effectively precludes future retrieval and subsequent treatment and disposal at an offsite geological repository. Disposal of immobilized HLW at the Hanford Site is contrary to the framework of the TPA and is likely to be challenged by Ecology.

3 Subsequent Screening

As the AoA progressed, new information from a variety of sources was discovered by the AoA Team which was presented to the Steering Committee for their consideration. Following best practices, the decision to not fully evaluate an alternative that passed initial screening was made by the Steering Committee at the recommendation of the AoA Team. Alternatives 3, 4, 8, 9, and 12 were screened out by Steering Committee decision. Descriptions of these alternatives and the rationale for not fully evaluating them, despite passing initial screening, are described below.

3.1 Alternative 3

In Alternative 3, HLW sludge is characterized and staged in the DST system and transferred to a new HLW Feed Preparation Facility (HFPF) for pretreatment. The slurry is settled and decanted in HLW Feed Preparation Vessels (HFPVs) in the HFPF. If the concentration of aluminum in the solids exceeds a specified threshold, the concentrated slurry is leached.

The leaching steps include adding concentrated caustic (19 moles per liter [M] sodium hydroxide [NaOH]) and water, heating the slurry by operating the mixer pumps, allowing time for aluminum to go into solution, cooling the slurry and settling the solids, and decanting the supernate. These steps are repeated as required to reduce the aluminum concentration of the solids below the specified threshold.

After leaching, the slurry is washed if the supernate sodium concentration exceeds 1 M. The leaching steps include adding a mixture of water and concentrated caustic, allowing the solids to settle, and decanting the supernate. These steps are repeated until the supernate sodium concentration is < 1 M.

After the pretreatment steps are completed, the pretreated slurry in the HFPV is sent to an HLW Feed Vessel (HFV). The pretreated slurry in the HFV is transferred in batches to one of the Meter Feed Preparation (MFP) Vessels in the HLW Vitrification Facility.

Decanted supernate from the HFPVs and the liquid effluents from the HLW Vitrification Facility are transferred to a new HLW Evaporator for concentration. The HLW Evaporator concentrate is either transferred to an HFV in the HFPF or transferred directly to one of the MFP Vessels in the HLW Vitrification Facility. The HLW Evaporator condensate is transferred to the Liquid Effluent Retention Facility/Effluent Treatment Facility (LERF/ETF) for treatment.

Alterative 3 assumes that DFLAW process operations are the same as described for Alternative 1. The Tank-Side Cesium Removal/Tank Farm Pretreatment (TSCR/TFPT) Facility is required to operate for the duration of the mission to provide pretreated LAW feed to the LAW Vitrification Facility and to the LAWST Facility.

Screening Rationale

When Alternative 3 was formulated, it was expected that characterizing the HLW Feed in the DST system would allow a significant reduction of the size of the HFPVs and the HFVs, thereby reducing the size (and cost) of the HFPF. This assumed that the time required for characterization (sampling, sample analysis, and evaluation of sample results) took significantly longer than the cycle time for HLW pretreatment.

An analysis of the HLW pretreatment cycle time showed that the time required for pretreatment was nearly the same as the time required for characterization (112 days versus 120 days). The change in vessel sizing would therefore be insignificant. From a cost perspective, this alternative is undistinguishable from Alternative 2.

Alternative 3 is functionally equivalent to Alternative 2 aside from characterizing HLW feed in the DST system. Since assigning the HLW characterization function to the DST system did not provide any benefit, Alternative 3 was determined to be indistinguishable from Alternative 2 from a technical standpoint.

Alternative 3 also reduces the operational flexibility of the DST system. To characterize HLW feed in the DST system, DSTs would need to be dedicated for characterization and for staging feed for the HFPF. Dedication of these DSTs reduces the DST space available for SST retrieval and for preparing HLW and LAW feed.

3.2 Alternative 4

In Alternative 4, the HLW characterization, pretreatment, and staging functions are performed in a new HFPF. The only functional difference between this alternative and Alternative 2 is that the HFPF pretreatment capability would include high-temperature caustic leaching and concentration of the pretreated feed by evaporation. Heating the HLW slurry during the leaching operations improves the effectiveness of the caustic leaching process. The more robust leaching capability reduces the required amount of water added to the slurry to keep aluminum compounds in solution which increases the efficiency and throughput of the HLW melters.

After sampling, characterization, and staging in the DST system, slurry is transferred to one of two HFPF Slurry Receipt Vessels where the slurry is concentrated by allowing the solids to settle and decanting the supernate. The concentrated slurry is treated by caustic leaching if the aluminum concentration in the solids exceeds an established threshold. After adding concentrated caustic and water, the slurry in the Slurry Receipt Vessel is heated by mixer pump operation. After allowing time for the aluminum to go into solution, the slurry is cooled, solids are allowed to settle, and supernate is decanted. The leaching steps are repeated as required until the aluminum concentration in the solids is below the leaching threshold. The slurry is then washed by adding water and caustic, allowing the solids to settle again, and decanting the supernate.

Alter caustic leaching and washing, the slurry is sent to one of two HFPF Primary Sludge Vessels (PSVs). The slurry is concentrated by heating the slurry by steam heating coils inside the PSV. The concentrated pretreated slurry in the PSV is transferred to one of the MFP Vessels in the HLW Vitrification Facility. The condensate from the PSV is collected in a HFPF Condensate Receipt Vessel.

The dilute supernate from the solids/liquid separation and caustic leaching process is blended with the liquid effluents from the HLW Vitrification Facility and the condensate from the PSV slurry concentration process. These dilute secondary effluents are sent to the HLW evaporator to be concentrated. The HLW evaporator concentrate (bottoms) is returned to the DST system and the condensate sent to the LERF/ETF.

To reduce the waste transfer distances it is assumed that the HLW pretreatment process vessels and the HLW evaporator are located between the Tank Farms (AP Tank Farm) and the HLW Vitrification Facility. To simplify waste routing and to allow use of shared process support and utility systems, the HLW pretreatment process vessels and the HLW evaporator are assumed to be housed within a common facility (i.e., the HFPF).

With one exception, the DFLAW processing operations remain the same as for Alternative 1. The TSCR or TFPT Facility must provide the full capacity needed to maintain feed to the LAW Vitrification Facility and the LAWST Facility.

The assumed schedule for startup of the Tank Farm and WTP facilities needed for the Alternative 3 LAW and HLW treatment mission are as follows:

- HLW pretreatment begins once the new HFPF is constructed and commissioned (scheduled for 6/30/2032, 18 months before starting HLW treatment/vitrification).
- HLW treatment/vitrification begins once the HFPF has started HLW feed pretreatment and the HLW Vitrification Facility is constructed and hot commissioned (scheduled for 12/31/2033 as specified in the Amended Consent Decree [ACD]).
- LAW pretreatment begins once the TSCR Demonstration Facility is constructed and commissioned (scheduled for 3/24/2023, 9 months before starting LAW treatment operations).

- LAW vitrification begins once the TSCR Demonstration Facility is operational and the LAW Vitrification Facility is constructed and hot commissioned (scheduled for 12/31/2023 as specified in the ACD).
- Additional TSCR facilities are constructed and commissioned as required to provide feed to the LAW Vitrification Facility and to the LAWST Facility.
- LAWST Facility operations begin one year after LAW treatment operations start (scheduled for 12/31/2034).

Screening Rationale

Alternative 4 was developed to improve the efficiency of the HLW melters by using a more robust (i.e., higher temperature) leaching process for the HLW feed. Further evaluation by Washington River Protection Solutions (WRPS) determined that increasing the leaching temperature from 60°C (140°F) (temperature used for HLW leaching in Alternatives 1 and 2) to 82°C (180°F), as proposed for Alternative 4, had minimal effect on melter efficiency. Additionally, the PT Facility Standard High-Solids Vessel (SHSV) Concept Design Alternative Study determined that leaching temperatures should be limited to 60°C (140°F) to reduce the hydrogen generation rate, risk of stress corrosion cracking, and thermal stresses on the vessels and equipment. Considering the risks involved in high temperature leaching and the fact that using this process did not appreciably improve HLW melter performance, Alternative 4 was eliminated.

3.3 Alternative 8

In Alternative 8, sludge from the DSTs in the 200 West Area (SY Tank Farm) is sampled, characterized, staged, and pretreated in a new West Area HFPF, and the pretreated slurry is vitrified in a new West Area HLW Vitrification Facility. Supernate from HLW pretreatment and the liquid effluents from the West Area HLW Vitrification Facility are concentrated in a new West Area HLW Effluent Management Facility (HEMF).

The smaller volume of sludge in the West Area Tank Farms and the complexities involved in transferring supernate from the West Area tanks to the 200 East Area DSTs preclude providing continuous feed to the new West Area HLW Vitrification Facility. As a result, the new West Area HLW Vitrification Facility will be required to use a vitrification technology that allows operation in a batch processing mode.

Since a 'batch-wise mode' vitrification technology is not been successfully demonstrated for defense waste, the HLW feed pretreatment requirements for this new vitrification capability are unknown. It is assumed that the new batch-wise vitrification process would require pretreatment, and that a new West Area HFPF would be needed.

Waste retrieved from the S, SX, T, TX, TY, and U Tank Farms would be collected in a West Area Waste Retrieval Facility (WRF) to be constructed near the T Tank Farm complex. The HLW fraction from the West Area WRF would either be sent directly to the West Area HFPF or to a DST in the SY Tank Farm to be staged for delivery to the West Area HFPF. The SY Tank Farm infrastructure (e.g., transfer lines, pump and valve pits, diversion boxes) would require upgrades to support routing of HLW between the T Farm WRF, SY Tank Farm, West Area HFPF, West Area HEMF, and West Area HLW Vitrification Facility.

Although the specific HLW pretreatment requirements for this new vitrification capability are not known, it is assumed that the functional capability of the new West Area HFPF process vessels would be the same as Alternative 2 for the purpose of defining the Alternative 8 scope of facilities. The capacity of the West Area HFPF would be less than the East Area HFPF since the volume of HLW that would be pretreated in the West Area would be less than that planned for the other alternatives that were intended to pretreat the full volume of HLW from both the East and West Area tanks.

Given the volume of HLW that is in the DST and SST Tank Farms in the West Area, and the duration of the SST retrieval schedule, it is assumed that the new West Area HLW Vitrification Facility would operate in a batch-wise mode at a process rate necessary to sustain sludge retrieval rates from the West Area SSTs and DSTs. Because the West Area HLW Vitrification Facility would have to operate in a batch mode, the technologies that were considered for Alternative 8 include "in-can melter" developed by AREVA, CAE, and ECM Technologies, and "transportable vitrification system" developed by the Savannah River Technology Center.

To limit the volume of supernate that would need to be returned to the East Area DST system via the supernate line in the Cross-Site Transfer System, a new West Area HLW evaporator also would be required. The West Area HLW evaporator would concentrate the liquid effluents from the West Area HLW Vitrification Facility and the dilute decants from the West Area HFPF. The concentrated evaporator bottoms would be returned either to an HFPV in the West Area HFPF or to a designated DST in the SY Tank Farm. Since there is no transfer line in West Area that connects to the LERF, the evaporator condensate would need to be transferred to the LERF by a new transfer line to be installed between the West Area HLW evaporator and the LERF.

HLW vitrification in the 200 West Area would reduce the volume of HLW to be pretreated in the East Area HFPF and vitrified in the WTP HLW Vitrification Facility. The volume of LAW to be processed by the TSCR or TFPT Facility and the LAW Vitrification Facility is not expected to change appreciably. The number and the circuitous routing of transfers within the West Area and between the West Area and East Area via the supernate line in the Cross-Site Transfer System could affect the LAW processing rates in the East Area.

Some of the relevant schedule assumptions for Alternative 8 include:

- Technology evaluation and selection for the new West Area HLW Vitrification Facility is completed by 12/2021.
- Pilot-scale testing of West Area HLW melter and support systems is completed by 12/2025.
- Full-scale testing of melter and support systems is completed by 12/2030.
- Final design of the new West Area HLW Vitrification Facility is completed by 12/2032.
- West Area HFPF and HEMF construction and commissioning is completed by 12/2035.
- West Area HLW Vitrification Facility is constructed and commissioned by 12/2043.
- West Area HLW Vitrification Facility availability is assumed to be 40%.

Screening Rationale

The “in-can melter” and “transportable vitrification system” technologies were tested at pilot-scale on surrogate materials selected to be representative of waste remediation and decontamination and decommissioning (D&D) solid and liquid wastes. The pilot-scale testing did not achieve all test objectives. Also, since the pilot-scale tests only used surrogates for mixed waste and low-activity D&D waste, the results were not considered to be directly relevant to HLW in the Hanford Tank Farms.

Based on the lack of any relevant technology demonstration test data, the ECMS and Government AoA Teams determined that Alternative 8 did not meet Screening Criterion 3 which requires that “the HLW processing alternatives use proven and established technologies.” Since none of the vitrification technologies were tested with surrogates that were representative of HLW from the Hanford Tank Farms, the technologies cannot be considered “proven and established.”

3.4 Alternative 9

In Alternative 9, HLW sampling, characterization, and pretreatment occurs in a new HFPF. The new HFPF system capacities and functional capabilities for HLW pretreatment are the same as Alternative 2.

The major difference between Alternative 9 and Alternative 2 is in the facilities used for LAW pretreatment. In Alternative 9, the PT Facility is repurposed to only provide pretreatment of LAW feed. Similar to Alternatives 1 and 5, the Repurposed PT Facility also provides all HLW and LAW liquid effluent processing capabilities.

Since the Repurposed PT Facility would not need to process HLW feed, the LAW pretreatment capacity would be significantly higher than for Alternative 1. The Repurposed PT Facility would be able to feed the LAW Vitrification Facility and the LAWST Facility at full capacity without reliance on the TSCR or TFPT Facility.

Screening Rationale

The Alternative 9 evaluation process relies on the results of the process modeling performed by WRPS. To complete the AoA evaluation per Study Plan schedule, the Alternative 9 modeling results were needed in January 2020. WRPS could not complete modeling of all HLW processing alternatives being considered in this timeframe. The ECMS and

Government AoA Teams reviewed the alternatives under consideration in late 2019 to reassess their viability based on technical or cost considerations.

During this review, Alternative 9 was determined to be non-viable from a cost perspective since it would require completing the PT Facility and construction of a new HFPF in parallel. Given the cost constraints on the Office of River Protection (ORP) budget, completion of both projects would significantly delay the start of HLW treatment.

3.5 Alternative 12

In Alternative 12, the PT Facility is repurposed to provide HLW pretreatment and treatment (i.e., vitrification). New HLW pretreatment vessels and equipment would be installed in the Hot Cell or the Dark Cells within the Repurposed PT Facility along with two HLW melters would be installed in the Hot Cell. The HLW Vitrification Facility would not be used.

After evaluating the available space in the PT Facility Hot Cell, the AoA Team concluded that the vessels required for HLW pretreatment are too large to fit through the maintenance airlock on the east side of the PT Facility. Even if the maintenance access opening was enlarged, or if the new vessels were fabricated in the Hot Cell, there would be insufficient room remaining for installation of one or more HLW melters.

The AoA Team also evaluated the option of installing the HLW pretreatment vessels in the PT Facility Dark Cells. Most of the Dark Cells have vessels already installed. The Dark Cells within Planning Areas 3 and 4 do not have any large vessels installed and could be used for installation of new HFPVs and the HFV(s) that would be needed for HLW pretreatment and staging.

The concrete roof above most of the Dark Cells was already poured and would need to be removed to allow access for installation of the new HFPVs and HFVs. Removable Cover Blocks would be used to seal the roof after the new vessels and piping systems were installed. The Cover Blocks could be removed by an external crane to allow removal and replacement of the mixer pumps or other internal equipment within the new vessels.

In addition to installation of new HLW pretreatment vessels, Alternative 12 also included installation of two HLW melters within the PT Facility. These melters were assumed to be of the same design as the melters within the HLW Vitrification Facility. The only area within the PT Facility that is large enough for an HLW melter is the Hot Cell. The AoA Team evaluated the area required to fit a melter and the melter support systems.

Much of the area within the Hot Cell is taken up by the Feed Evaporation Process (FEP) evaporators and support systems. Since Alternative 12 assumes that the HLW liquid effluents are concentrated by the FEP evaporators, the area allocated to the evaporator support equipment would need to be preserved. Part of the Hot Cell also would be needed for installation of support equipment for the new vessels for HLW pretreatment and staging. After considering the size of the areas required for the support equipment for the FEP evaporators and the new pretreatment and staging vessels, insufficient space remains within the Hot Cell to fit one or more HLW melters.

If the HLW melters could be redesigned to be significantly smaller, and both melters were then installed in the PT Facility Hot Cell, removal and replacement of spent melters would be problematic without significant structural redesign. In the existing design, maintenance access to the Hot Cell is limited to the air lock on the east side. Unless a new maintenance opening was cut out on the west side of the Hot Cell, replacement of the HLW melter on the west side of the Hot Cell would require removal of both melters. New cut-outs for the Cover Blocks in the roof of the Dark Cells, together with a larger opening for system maintenance on the west side of the Hot Cell could significantly decrease the seismic design capacity of the PT Facility confinement structure.

Screening Rationale

Based on the limited PT Facility space available to house the new HLW pretreatment vessels and the HLW melters, and the limited maintenance access to the Hot Cell, the AoA Team concluded that this alternative was not viable due to the space/fit issues. Additionally, since construction of the HLW Vitrification Facility is 43% complete, the cost to complete the remaining construction was judged to be less than the cost to install HLW melters in the PT Facility.

APPENDIX E: COST ESTIMATES

1 Introduction and General Assumptions

The life cycle cost estimates (LCCEs) used to evaluate the high-level waste (HLW) alternatives are based on and derived from the Washington River Protection Solutions (WRPS) modeling results and resultant cost and schedule estimates. The Enterprise Construction Management Services (ECMS) Analysis of Alternatives (AoA) Team used those results, added appropriate scope elements not included in the WRPS models (in particular, the completion of the engineering/design, procurement, construction, and commissioning activities for all Waste Treatment and Immobilization Plant [WTP] project facilities), and adjusted estimates where appropriate. The bases and assumptions used for the WRPS modeling are described in WRPS modeling report[k].

The AoA Team generally accepted the cost estimates by year (Budgeted Cost of Work Scheduled [BCWS]) generated by the WRPS modeling effort and provided to the AoA Team in a spreadsheet format in base Fiscal Year (FY) 2018 dollars. The bases for key elements were reviewed, to the extent such bases were available. When it appeared the WRPS generated estimates were not appropriate and fully consistent with AoA parameters and assumptions, appropriate estimate adjustments were made. All such estimate adjustments and deviations from the WRPS cost model results are described in Sections 2.2 and 2.3 of this appendix. In addition, there were relatively minor discrepancies noted in the BCWS profile at the lowest work breakdown structure (WBS) level of the WRPS profile when comparing like elements across alternatives. However, these minor discrepancies (which can be seen in a few of the summary level WBS elements used for the AoA) were not significant relative to alternative evaluation and comparison, especially when considered from a cost range perspective (as described in Section 4 of this appendix). For this reason, the AoA Team has not attempted to modify or change the WRPS results to eliminate those variations in order to preserve the traceability of all estimate values used for the AoA.

Key Parameters used for AoA LCCEs

- Escalation Rate for Project Costs (both capital and expense funded) — 4% per year
- Escalation Rate for Operations Activities/Costs — 2.4% per year
- Discount Rate per OMB Circular A-94 Nominal Rate (30 year), November 2019 — 2.4% per year
- Discount Rate per OMB Circular A-94 Real Rate (30 year), November 2019 — 0.4% per year
- Fee applied to all estimated Tank Farm Operations Contractor costs — 5%

2 Bases of Estimates

Direct-feed low activity waste (DFLAW) completion costs were added by the AoA Team based on the current approved project baseline, including expenditure of all Management Reserve (MR) and U.S. Department of Energy (DOE) Contingency allowances in accordance with the baseline schedule and funding plan. Other additions and adjustments made by the AoA Team are described below.

2.1 Cost to Complete HLW Vitrification and PT Facilities

The AoA Team determined the most valid starting point to assess the estimated costs for completion of the HLW and pretreatment (PT) facilities was the parametric analysis completed by the U.S. Army Corps of Engineers[f] (USACE) and the review of that effort completed by the DOE Office of Project Management[ww] (PM) in 2018. In general, the DOE assessment found the USACE results to be credible, although some deficiencies and recommended additions or areas of concern were identified. For purposes of this AoA, the resulting parametric estimate was determined to provide a reasonable basis for the estimation of HLW Vitrification and PT Facilities completion, as currently planned and required to meet existing baseline project completion criteria.

The USACE parametric estimate Case 1A assumed completion of both the HLW Vitrification and PT facilities, as well as additional work scope needed for Balance of Facilities (BOF) and the Analytical Laboratory (LAB), on a schedule that complies with the current Amended Consent Decree[xx] (ACD) milestones of HLW Substantial Completion by 12/31/2030 and PT Substantial Completion by 12/31/2031, leading to Hot Start of WTP by the end of 12/31/2033. These assumptions are consistent with Alternative 1 under an unconstrained funding scenario.

To accommodate the possible deficiencies identified by the PM review of the USACE parametric analysis, the AoA estimate includes slightly higher allowances for MR and DOE Contingency than those used by USACE. The adders included by the AoA Team are 40% (compared to 36.3% by USACE) and 15% (compared to 13.4% by USACE), respectively, for MR and DOE Contingency. The AoA Team also escalated all capital project costs at 4% per year in accordance with current DOE guidance for capital asset projects, as compared to the 3% annual escalation rate used by USACE.

The estimated costs and annual funding requirements for the WTP facilities needed to support HLW treatment for Alternative 1, using the above described basis, are shown in Table 73.

Alternatives that do not use PT Facility

The PT Facility cost estimate included work scope elements that were needed to support operation of the HLW Vitrification Facility. Since the PT Facility is not completed for Alternatives 2, 14, 15, and 16, the AoA Team adjusted the cost to complete the HLW Vitrification Facility upwards to include those work scope elements that were considered to be necessary to operate the facility independent of the PT Facility. The estimate for completion of the HLW Vitrification Facility for these alternatives is derived from the same starting point as described for Alternative 1 – the USACE parametric estimate, as adjusted by the AoA Team. The Alternative 1 estimate was modified, based on the following assumptions, to derive the estimated cost for completion of the HLW Vitrification Facility for these alternatives.

- No additional preventive maintenance costs will be incurred for the PT Facility.
- Completion of the existing HLW Vitrification Facility will be the same as estimated by USACE and used for the Alternative 1 estimate.
- Only 90% of the BOF completion costs will be required since utility tie-ins and capacity to support the PT Facility will not be required.
- Only 90% of the LAB completion costs will be required since tie-ins and capacity to support the PT Facility will not be required.
- Some of the additional work scope elements needed to operate the HLW Vitrification Facility independent of the PT Facility were previously estimated by WTP project personnel. The rough order of magnitude (ROM) estimate of approximately $325M (escalated to FY18 $'s) that was developed for that effort is assumed to be applicable for this AoA.
- In addition to the work scope identified in that earlier estimate, the AoA Team also identified the need to add the following work scope elements and costs to support HLW Vitrification Facility operation without a PT Facility. The appropriate ROM estimates for these elements (all cost estimates considered to be in FY18$s for consistency in escalating with the base USACE values) are included.
    - Safe Haven Control Room – assumed to require equipment only because it can be collocated in the Melter Assembly Building. ROM estimate is $5M.
    - Safety Instrument Air Supply – assumed to be included in an approximate 5000 square foot sq ft) Hazard Category 2 (HC2) addition to the HLW Vitrification Facility. ROM estimate is $75M (based on $15k/sq ft).
    - Emergency Power -- assumed to be included in an approximate 5000 sq ft (HC2) addition to the HLW Vitrification Facility. ROM estimate is $75M (based on $15k/sq ft).

The estimated costs and annual funding requirements for completion of the HLW Vitrification Facility for Alternatives 2, 13, 14, and 16, based on the above assumptions and the same schedule and spend plan as used for the USACE analysis and Alternative 1, are shown on Table 74.

HLW Vitrification Facility and Re-Purposed PT Facility (Alternative 5)

The estimated cost to complete the HLW Vitrification Facility and a repurposed PT Facility for Alternative 5 is also based on the USACE and Alternative 1 estimate, with the following adjustments:

- The estimated costs to complete the HLW Vitrification Facility, BOF and LAB are the same as for Alternative 1, including the Melter Assembly Building.
- All costs associated with completing the repurposed PT Facility are included based on the estimated percentage of space to be used for the repurposed capabilities and systems. The percentage of the PT Facility Planning Areas that need to be completed for Alternative 5 are based on the analysis described in Appendix B. The AoA Team analysis indicates that approximately 81% of the PT Facility will need to be completed. Thus, the estimated cost for PT completion is 81% of the cost included for Alternative 1.

The estimated costs and annual funding requirements needed to complete the HLW Vitrification and Repurposed PT Facilities, based on the above assumptions and the same schedule and spend plan as used for the USACE analysis and Alternative 1, are shown in Table 75.

Minimal Direct Feed HLW Completion

The estimated cost for completion of HLW Vitrification Facility for Alternative 17 is essentially the same as for the other alternatives that do not use the PT Facility, with the following exceptions:

- The cost for the WTP facility modifications needed for direct-feed HLW (DFHLW) are reduced by 50% based on the assumption that some modifications could be deferred until sometime after start of HLW treatment operations.
- Cost for the Melter Assembly Building is deleted since construction of the MAB is not immediately needed to support single melter operations and could be deferred until sometime after start of HLW treatment operations.

The estimated costs and annual funding requirements for completion of the HLW Vitrification Facility for Alternative 17, based on the above assumptions and the same schedule and spend plan as used for the USACE analysis and Alternative 1, are shown in Table 76.

Table 73: Alternative 1 – Estimated Annual Spend Plan to Complete HLW Vitrification and PT Facilities Required for HLW Treatment

Base Case -- HLW and PT Completion															
Basis: USACE Parametric Estimate, with slightly higher MR and Contingency allowances															
	See USACE Case 1A														
Costs in Millions															
Element	**Total**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**FY2025**	**FY2026**	**FY2027**	**FY2028**	**FY2029**	**FY2030**	**FY2031**	**FY2032**	**FY2033**
PT Engineering	962.09	0.00	0.00	0.00	20.80	35.65	158.06	216.05	216.05	216.05	93.50	5.94	0.00	0.00	0.00
PT Procurement	700.19	0.00	0.00	0.00	0.00	17.78	280.08	280.08	122.26	0.00	0.00	0.00	0.00	0.00	0.00
PT Construction	747.10	0.00	0.00	0.00	0.00	0.00	0.00	147.26	181.03	181.03	180.31	57.47	0.00	0.00	0.00
PT Preventive Maintenance	70.97	14.95	14.89	14.89	14.83	11.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PT Commissioning	1,088.32	0.00	0.00	0.00	24.99	42.84	42.84	42.84	82.39	107.14	106.71	187.92	214.28	215.13	21.26
HLW Engineering	242.39	0.00	0.00	0.00	57.61	66.59	66.59	19.99	12.73	12.73	6.16	0.00	0.00	0.00	0.00
HLW Procurement	281.94	0.00	0.00	0.00	18.67	48.01	48.01	48.01	48.01	48.01	23.24	0.00	0.00	0.00	0.00
HLW Construction	537.93	0.00	0.00	0.00	0.00	54.00	105.49	105.49	105.49	105.49	61.96	0.00	0.00	0.00	0.00
HLW Preventive Maintenance	40.76	10.84	10.80	10.80	8.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLW Commissioning	725.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.03	176.31	96.66	120.92	220.60	45.02
Melter Assembly Building	68.18	0.00	0.00	0.00	4.64	5.37	7.09	7.27	14.32	14.32	12.39	2.78	0.00	0.00	0.00
BOF Mods Engineering	44.91	0.00	0.00	0.00	6.60	7.63	11.09	14.82	4.76	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Procurement	19.76	0.00	0.00	0.00	2.40	3.83	3.76	7.44	2.33	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Construction	82.63	0.00	0.00	0.00	0.00	12.15	14.05	20.40	27.27	8.77	0.00	0.00	0.00	0.00	0.00
BOF Mods Commissioning	32.34	0.00	0.00	0.00	0.00	0.00	0.00	2.03	5.50	5.42	10.63	8.77	0.00	0.00	0.00
LAB Mods Engineering	25.91	0.00	0.00	0.00	3.81	4.41	6.40	8.55	2.75	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Procurement	17.94	0.00	0.00	0.00	2.18	3.48	3.42	6.75	2.12	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Construction	46.84	0.00	0.00	0.00	0.00	0.00	6.95	7.96	11.62	15.46	4.85	0.00	0.00	0.00	0.00
LAB Mods Commissioning	8.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.83	1.92	2.28	1.61	1.61	0.00
Project Services + Facility Services	2,422.19	0.00	0.00	0.00	60.93	129.75	324.14	402.03	360.91	335.94	291.53	155.58	144.83	188.06	28.50
ORP Direct Support	330.00				30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Base Costs (FY 18 M$'s)	8,496.92	25.79	25.69	25.69	255.79	472.90	1,107.96	1,366.97	1,230.25	1,147.19	999.49	547.40	511.63	655.40	124.78
Escalation (From FY 18 $'s)	3,904.07	2.10	3.21	4.36	55.42	125.47	350.04	503.82	520.78	550.93	539.18	329.01	340.27	479.54	99.94
Escalated Base Cost	12,401.00	27.90	28.90	30.05	311.20	598.37	1,458.00	1,870.79	1,751.02	1,698.12	1,538.67	876.41	851.91	1,134.94	224.72
MR	4,960.40	11.16	11.56	12.02	124.48	239.35	583.20	748.32	700.41	679.25	615.47	350.56	340.76	453.98	89.89
Fee	729.18	1.64	1.70	1.77	18.30	35.18	85.73	110.00	102.96	99.85	90.47	51.53	50.09	66.73	13.21
DOE Contingency	1,860.15	4.18	4.33	4.51	46.68	89.76	218.70	280.62	262.65	254.72	230.80	131.46	127.79	170.24	33.71
Total Project Cost	**19,950.72**	**44.88**	**46.49**	**48.35**	**500.66**	**962.66**	**2,345.63**	**3,009.73**	**2,817.05**	**2,731.93**	**2,475.42**	**1,409.96**	**1,370.55**	**1,825.89**	**361.53**

Table 74: Estimated[18] Annual Spend Plan to Complete HLW Vitrification Facility Required for HLW Treatment without PT Facility

HLW Completion Only (no PT)															
Costs in Millions															
Element	**Total**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**FY2025**	**FY2026**	**FY2027**	**FY2028**	**FY2029**	**FY2030**	**FY2031**	**FY2032**	**FY2033**
HLW Engineering	242.39	0.00	0.00	0.00	57.61	66.59	66.59	19.99	12.73	12.73	6.16	0.00	0.00	0.00	0.00
HLW Procurement	281.94	0.00	0.00	0.00	18.67	48.01	48.01	48.01	48.01	48.01	23.24	0.00	0.00	0.00	0.00
HLW Construction	537.93	0.00	0.00	0.00	0.00	54.00	105.49	105.49	105.49	105.49	61.96	0.00	0.00	0.00	0.00
HLW Preventive Maintenance	40.76	10.84	10.80	10.80	8.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLW Commissioning	725.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.03	176.31	96.66	120.92	220.60	45.02
Melter Assembly Building	68.18	0.00	0.00	0.00	4.64	5.37	7.09	7.27	14.32	14.32	12.39	2.78	0.00	0.00	0.00
BOF Mods Engineering	40.42	0.00	0.00	0.00	5.94	6.87	9.98	13.34	4.29	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Procurement	17.78	0.00	0.00	0.00	2.16	3.45	3.39	6.69	2.10	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Construction	74.37	0.00	0.00	0.00	0.00	10.94	12.64	18.36	24.54	7.89	0.00	0.00	0.00	0.00	0.00
BOF Mods Commissioning	29.10	0.00	0.00	0.00	0.00	0.00	0.00	1.83	4.95	4.87	9.57	7.89	0.00	0.00	0.00
LAB Mods Engineering	23.32	0.00	0.00	0.00	3.43	3.96	5.76	7.70	2.47	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Procurement	16.15	0.00	0.00	0.00	1.96	3.13	3.07	6.08	1.90	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Construction	42.16	0.00	0.00	0.00	0.00	0.00	6.26	7.17	10.46	13.91	4.36	0.00	0.00	0.00	0.00
LAB Mods Commissioning	8.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.74	1.73	2.05	1.45	1.45	0.00
Added Scope - DFHLW	480.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	96.00	96.00	96.00	96.00	0.00	0.00	0.00
Project Services + Facility Services	1,116.14	0.00	0.00	0.00	44.17	87.00	115.36	145.31	141.00	159.10	168.44	88.32	52.62	95.48	19.36
ORP Direct Support	330.00				30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Base Costs	4,074.28	10.84	10.80	10.80	176.91	319.32	413.63	513.23	498.91	559.09	590.14	323.70	204.99	347.54	94.38
Escalation	1,905.77	0.88	1.35	1.83	38.33	84.72	130.68	189.16	211.19	268.50	318.36	194.56	136.33	254.29	75.59
Escalated Base Cost	5,980.05	11.73	12.15	12.63	215.23	404.04	544.31	702.38	710.10	827.59	908.50	518.26	341.32	601.82	169.97
MR	2,392.02	4.69	4.86	5.05	86.09	161.61	217.72	280.95	284.04	331.03	363.40	207.30	136.53	240.73	67.99
Fee	351.63	0.69	0.71	0.74	12.66	23.76	32.01	41.30	41.75	48.66	53.42	30.47	20.07	35.39	9.99
DOE Contingency	897.01	1.76	1.82	1.90	32.29	60.61	81.65	105.36	106.52	124.14	136.28	77.74	51.20	90.27	25.50
Total Project Cost	**9,620.70**	**18.87**	**19.54**	**20.33**	**346.27**	**650.01**	**875.68**	**1,130.00**	**1,142.41**	**1,331.42**	**1,461.60**	**833.78**	**549.12**	**968.22**	**273.45**

[18] Used for Alternatives 2, 13, 14, and 16

Table 75: Alternative 5 Estimated Annual Spend Plan to Complete HLW Vitrification Facility and Re-Purposed PT Facility Required for HLW Treatment

HLW and Re-Purposed PT															
Costs in Millions															
Element	**Total**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**FY2025**	**FY2026**	**FY2027**	**FY2028**	**FY2029**	**FY2030**	**FY2031**	**FY2032**	**FY2033**
PT Engineering	779.22	0.00	0.00	0.00	16.84	28.88	128.02	174.98	174.98	174.98	75.72	4.81	0.00	0.00	0.00
PT Procurement	567.10	0.00	0.00	0.00	0.00	14.40	226.84	226.84	99.02	0.00	0.00	0.00	0.00	0.00	0.00
PT Construction	605.09	0.00	0.00	0.00	0.00	0.00	0.00	119.27	146.62	146.62	146.04	46.55	0.00	0.00	0.00
PT Preventive Maintenance	70.97	14.95	14.89	14.89	14.83	11.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PT Commissioning	881.46	0.00	0.00	0.00	20.24	34.70	34.70	34.70	66.73	86.77	86.43	152.20	173.55	174.24	17.22
HLW Engineering	242.39	0.00	0.00	0.00	57.61	66.59	66.59	19.99	12.73	12.73	6.16	0.00	0.00	0.00	0.00
HLW Procurement	281.94	0.00	0.00	0.00	18.67	48.01	48.01	48.01	48.01	48.01	23.24	0.00	0.00	0.00	0.00
HLW Construction	537.93	0.00	0.00	0.00	0.00	54.00	105.49	105.49	105.49	105.49	61.96	0.00	0.00	0.00	0.00
HLW Preventive Maintenance	40.76	10.84	10.80	10.80	8.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLW Commissioning	725.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.03	176.31	96.66	120.92	220.60	45.02
Melter Assembly Building	68.18	0.00	0.00	0.00	4.64	5.37	7.09	7.27	14.32	14.32	12.39	2.78	0.00	0.00	0.00
BOF Mods Engineering	44.91	0.00	0.00	0.00	6.60	7.63	11.09	14.82	4.76	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Procurement	19.76	0.00	0.00	0.00	2.40	3.83	3.76	7.44	2.33	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Construction	82.63	0.00	0.00	0.00	0.00	12.15	14.05	20.40	27.27	8.77	0.00	0.00	0.00	0.00	0.00
BOF Mods Commissioning	32.34	0.00	0.00	0.00	0.00	0.00	0.00	2.03	5.50	5.42	10.63	8.77	0.00	0.00	0.00
LAB Mods Engineering	25.91	0.00	0.00	0.00	3.81	4.41	6.40	8.55	2.75	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Procurement	17.94	0.00	0.00	0.00	2.18	3.48	3.42	6.75	2.12	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Construction	46.84	0.00	0.00	0.00	0.00	0.00	6.95	7.96	11.62	15.46	4.85	0.00	0.00	0.00	0.00
LAB Mods Commissioning	8.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.83	1.92	2.28	1.61	1.61	0.00
Project Services + Facility Services	2,151.17	0.00	0.00	0.00	67.14	126.79	284.83	345.94	311.73	294.73	260.42	135.04	127.31	170.47	26.76
ORP Direct Support	330.00				30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Base Costs	7,561.07	25.79	25.69	25.69	253.29	451.64	977.22	1,180.44	1,066.69	1,010.14	896.06	479.09	453.39	596.93	119.00
Escalation	3,469.79	2.10	3.21	4.36	54.88	119.83	308.74	435.07	451.54	485.11	483.38	287.95	301.54	436.76	95.31
Escalated Base Cost	11,030.85	27.90	28.90	30.05	308.17	571.46	1,285.96	1,615.52	1,518.23	1,495.25	1,379.45	767.04	754.93	1,033.68	214.31
MR	4,412.34	11.16	11.56	12.02	123.27	228.59	514.38	646.21	607.29	598.10	551.78	306.81	301.97	413.47	85.73
Fee	648.61	1.64	1.70	1.77	18.12	33.60	75.61	94.99	89.27	87.92	81.11	45.10	44.39	60.78	12.60
DOE Contingency	1,654.63	4.18	4.33	4.51	46.23	85.72	192.89	242.33	227.74	224.29	206.92	115.06	113.24	155.05	32.15
Total Project Cost	**17,746.43**	**44.88**	**46.49**	**48.35**	**495.78**	**919.37**	**2,068.85**	**2,599.05**	**2,442.54**	**2,405.56**	**2,219.26**	**1,234.01**	**1,214.53**	**1,662.99**	**344.79**

Table 76: Estimated Annual Spend Plan to Complete HLW Vitrification Facility Required for Direct Feed HLW Treatment

Alternative 17 -- Minimal Direct Feed HLW Completion Only (no PT)															
Costs in Millions															
Element	**Total**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**FY2025**	**FY2026**	**FY2027**	**FY2028**	**FY2029**	**FY2030**	**FY2031**	**FY2032**	**FY2033**
HLW Engineering	242.39	0.00	0.00	0.00	57.61	66.59	66.59	19.99	12.73	12.73	6.16	0.00	0.00	0.00	0.00
HLW Procurement	281.94	0.00	0.00	0.00	18.67	48.01	48.01	48.01	48.01	48.01	23.24	0.00	0.00	0.00	0.00
HLW Construction	537.93	0.00	0.00	0.00	0.00	54.00	105.49	105.49	105.49	105.49	61.96	0.00	0.00	0.00	0.00
HLW Preventive Maintenance	40.76	10.84	10.80	10.80	8.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLW Commissioning	725.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.03	176.31	96.66	120.92	220.60	45.02
Melter Assembly Building	0.00														
BOF Mods Engineering	36.38	0.00	0.00	0.00	5.35	6.18	8.98	12.00	3.86	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Procurement	16.01	0.00	0.00	0.00	1.95	3.10	3.05	6.02	1.89	0.00	0.00	0.00	0.00	0.00	0.00
BOF Mods Construction	66.93	0.00	0.00	0.00	0.00	9.84	11.38	16.52	22.09	7.10	0.00	0.00	0.00	0.00	0.00
BOF Mods Commissioning	26.19	0.00	0.00	0.00	0.00	0.00	0.00	1.64	4.45	4.39	8.61	7.10	0.00	0.00	0.00
LAB Mods Engineering	20.99	0.00	0.00	0.00	3.09	3.57	5.18	6.93	2.23	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Procurement	14.53	0.00	0.00	0.00	1.77	2.82	2.77	5.47	1.71	0.00	0.00	0.00	0.00	0.00	0.00
LAB Mods Construction	37.94	0.00	0.00	0.00	0.00	0.00	5.63	6.45	9.42	12.52	3.93	0.00	0.00	0.00	0.00
LAB Mods Commissioning	7.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.67	1.56	1.85	1.30	1.31	0.00
Added Scope - DFHLW	317.50	0.00	0.00	0.00	0.00	0.00	0.00	63.50	63.50	63.50	63.50	63.50	0.00	0.00	0.00
Project Services + Facility Services	1,006.14	0.00	0.00	0.00	41.60	83.47	110.54	125.57	118.66	137.79	148.46	72.72	52.56	95.42	19.36
ORP Direct Support	330.00				30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Base Costs	3,708.46	10.84	10.80	10.80	168.33	307.58	397.62	447.61	424.61	488.22	523.72	271.83	204.78	347.33	94.38
Escalation	1,738.77	0.88	1.35	1.83	36.47	81.61	125.62	164.97	179.74	234.46	282.52	163.38	136.20	254.13	75.59
Escalated Base Cost	5,447.22	11.73	12.15	12.63	204.80	389.19	523.24	612.58	604.36	722.68	806.24	435.20	340.98	601.47	169.97
MR	2,178.89	4.69	4.86	5.05	81.92	155.68	209.29	245.03	241.74	289.07	322.50	174.08	136.39	240.59	67.99
Fee	320.30	0.69	0.71	0.74	12.04	22.88	30.77	36.02	35.54	42.49	47.41	25.59	20.05	35.37	9.99
DOE Contingency	817.08	1.76	1.82	1.90	30.72	58.38	78.49	91.89	90.65	108.40	120.94	65.28	51.15	90.22	25.50
Total Project Cost	**8,763.49**	**18.87**	**19.54**	**20.33**	**329.49**	**626.13**	**841.78**	**985.52**	**972.29**	**1,162.65**	**1,297.08**	**700.15**	**548.57**	**967.64**	**273.45**

2.2 Estimate Adjustments

The AoA LCCEs started with the unescalated (FY 2018 $'s) BCWS generated for each alternative from the WRPS modeling effort. When appropriate, the AoA Team made various adjustments and additions to the WRPS LCCEs for each alternative. These adjustments or additions are described below.

WTP Operations Costs

The estimated annual operating costs for the WTP facilities that were used in the WRPS modeling are derived from an estimate developed by Bechtel National Inc. (BNI) in support of the AoA effort. The only adjustment made by the AoA Team was to lower the estimated annual cost for Alternative 5 operations. In Alternative 5, approximately 80% of the PT Facility will be completed and operated. Accordingly, the annual operations cost for the PT Facility was assumed to be 80% of the full PT operations cost used for Alternative 1. These WTP operating costs are summarized in Table 77 for a typical full year of operations in FY 2018 $'s (the base year used for the WRPS cost model).

Table 77: WTP Operations Annual Costs ($M)

#	Alternative Name	LAW	LAB	BOF	HLW	PT	Total
1	HLW Pretreatment in PT Facility (Baseline Case)	159	52	85	99	57	452
2	HLW Pretreatment in HLW Feed Preparation Facility (HFPF)	159	52	85	99		395
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management Facility (HEMF)	159	52	85	99	46	441
14	New HFPF (with Filtration) and New HEMF	159	52	85	99		395
15	DFHLW and HLW Effluent Processing in New HEMF	159	52	85	99		395
16	HLW Pretreatment in Double-Shell Tanks (DSTs) and in Feed Preparation Tanks in New HEMF	159	52	85	99		395
17	DFHLW Single Melter HLW Without Evaporators or Low-Activity Waste (LAW) Supplemental Treatment (LAWST)	159	52	85	99		395

Melter Replacement Costs

The estimated costs for WTP operations described above do not include the cost of melter replacements over the operating life of both the LAW and HLW Vitrification Facilities. Office of River Protection (ORP) staff provided a ROM estimate of $30M for each melter replacement (for estimating purposes, this estimate is assumed to cover both procurement and installation costs in FY 2018 $'s). There two 2 melters in both the LAW and HLW Vitrification Facilities, and it is assumed there will be a need to replace melters every five years over the operating life. Therefore, to approximate the cost for LCC estimating purposes, $12 million per year was added to the annual operating cost for both LAW and HLW Vitrification Facilities (two melters at $30M each averaged over five years).

For Alternative 17, in which a single HLW melter is operating, the added cost was reduced to $6 million per year.

For the LAWST Facility, the annual operating costs were adjusted to include melter replacements based on the number of assumed melters needed for each alternative, using the same 5-year averaging concept. These added costs are shown in Table 78.

Table 78: Supplemental LAW Melter Replacement Costs ($M)

#	Alternative Name	Number of Melters	Additional Annual Operations ($M/year)
1	HLW Pretreatment in PT Facility (Baseline Case)	7	42
2	HLW Pretreatment in HFPF	12	72
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	12	72
14	New HFPF (with Filtration) and New HEMF	9	54
15	DFHLW and HLW Effluent Processing in New HEMF	10	60

#	Alternative Name	Number of Melters	Additional Annual Operations ($M/year)
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	10	60

TWCSF Estimate Adjustment

WRPS developed a cost estimate for the Tank Waste Characterization and Staging Facility (TWCSF) based on a total capacity of 3.6 million gallons (Mgal) (six vessels with a capacity of 600 kilogallons [kgal] each). As described in Appendix B, the AoA Team believes that the vessel capacity (at overflow level) should be 500 kgal each, based on available information. For that reason, the WRPS cost estimate was scaled accordingly, using an exponential scaling factor of 0.7, consistent with published cost estimating parameters for industrial tankage facilities. The resultant estimate is 88% of the WRPS cost estimate, and the BCWS generated by the WRPS model was adjusted accordingly.

WRF Estimate Adjustment

To determine an appropriate estimate for the East and West Area Waste Retrieval Facilities (WRFs) needed for each alternative, the AoA Team determined it would be appropriate to use the WRPS developed estimate for the proposed TWCSF as a basis for scaling and parametrically estimating the WRF capital cost. That TWCSF estimated cost is $1,183 million (FY 2020 $'s) and is based on six vessels of 600 kgal capacity each for a total capacity of 3.6 Mgal. As discussed in Appendix B, the AoA Team determined that each WRF would consist of four 180 kgal vessels, for a total facility capacity of 720 kgal. The TWCSF estimate was scaled based on the ratio of capacities using an exponential scaling factor of 0.7, consistent with published cost estimating parameters for industrial tankage facilities. The resultant estimated cost for each WRF of $383 million is approximately 2.13 times the approximated average cost estimate included in the WRPS model for the two WRFs (approximately $180 million), both in FY 2020 $'s. This factor was applied to the BCWS values produced by the WRPS model for both the East and West Areas WRFs to derive the AoA Team's cost estimate.

LFE Estimate Adjustments

WRPS estimated the capital cost estimate for a LAW Feed Evaporator (LFE) facility to be approximately $382 M, based on an initial size estimate of 33,454 square feet. The AoA Team used that estimate to scale the cost of the LFE needed for each alternative based on facility footprint reflected in the pre-conceptual drawings developed by the AoA Team. The drawings and facility sizing information developed by the AoA Team on a square foot basis are provided in Appendix B. The resultant estimated capital costs for the LFE Facilities for each alternative are as shown in Table 79, and the factor shown was applied to the WRPS BCWS for each facility.

Table 79: LAW Feed Evaporator Estimate Adjustments

#	Alternative Name	Square Feet	Factor	Revised Estimate ($M)
2	HLW Pretreatment in HFPF	32,646	0.98	373
14	New HFPF (with Filtration) and New HEMF	30,337	0.91	346
15	DFHLW and HLW Effluent Processing in New HEMF	32,525	0.97	371
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	33,497	1.00	382

HFPEM/HEMF Estimate Adjustments

WRPS developed capital cost estimates for the specific HLW feed preparation and processing support facilities needed for each alternative, as described in Appendix B, based on initial facility sizing assumptions. In general, the AoA Team found those estimates for the HLW Feed Preparation and Effluent Management HFPEM) Facility (Alternatives 2 and 14) and HEMF (Alternatives 15 and 16) to be reasonable, given the pre-conceptual stage of those facilities and the uncertainties in facility sizing and equipment density. However, the estimated cost of the HFPEM for Alternative 2 appeared too low when compared to the other facility estimates on a cost per square foot basis, even allowing for its larger footprint. Accordingly, the AoA Team chose to add 10% to the WRPS estimated cost for the Alternative 2 HFPEM to ensure the estimate more fully reflects the impact of additional safety systems and complexities and compares more

appropriately (in terms of relative total cost as well as cost per square foot) to the estimated costs for the facilities needed for the other alternatives. The ECMS Team developed revised cost estimates for each alternative using the WRPS estimated cost per square foot (with the added allowance tor Alternative 2) and the facility sizes developed by the AoA Team (see Appendix B). These combined adjustments, and resultant capital cost estimate used for the analyses, are shown in Table 80. The factor shown represents the ratio between the AoA Team's revised estimate and the initial WRPS estimate and was applied to the WRPS model generated BCWS for the respective alternative.

Table 80: HFPEM/HEMF Estimate Adjustments

	WRPS Est (FY 20$'s)				ECMS Size		SS/Compl Factor	**Factor**	Rev Est		$/sf
Alternative 2	$1,634	M	79,792	sf	71,496	sf	10%	**0.99**	$1,611	M	22,526
Alternative 14	$1,342	M	46,255	sf	52,869	sf	0%	**1.14**	$1,534	M	29,013
Alternative 15	$836	M	29,100	sf	30,186	sf	0%	**1.04**	$867	M	28,729
Alternative 16	$980	M	29,432	sf	32,697	sf	0%	**1.11**	$1,089	M	33,297

WTV Facility Estimate Adjustment

WRPS developed a capital cost estimate for the Waste Transfer Vault (WTV) Facility used for Alternative 17. The AoA Team added 10% to that cost estimate to account for the need for additional safety systems and complexities, as described in Appendix B.

242-A Evaporator Upgrades Estimate Adjustment

The WRPS modeling effort includes an annual estimated cost for ongoing upgrades to the 242-A Evaporator that continue for the operational life for each alternative. The AoA Team chose to stop those annual expenditures with approximately 15 years of mission remaining for all alternatives except for Alternative 17 (for which the model results end before the mission life would end).

Cross-Site Waste Transfer Line Estimates Adjustment

The AoA Team determined the estimated costs included in the WRPS modeling appeared to be too low for both the Cross-Site Slurry Line (WBS 5.01.04.01.07) and the Cross-Site Supernate Transfer Line (WBS 5.01.04.01.30). The BCWS included by WRPS for these WBS elements appears to assume that the slurry and supernate lines can be tested and reactivated without the need for significant repair or replacement of structures, systems, and components (SSCs).

The AoA Team believes it is likely that decades of disuse and the lack of preventive and corrective maintenance could have resulted in corrosion of the slurry and supernate transfer lines and damage to the associated SSCs. Even if it is assumed that the waste transfer line containment boundaries are intact, it is likely that the support SSCs will require significant refurbishment or replacement.

For the Slurry Line, the WRPS model included approximately $19 million (FY 2018 $'s) for activation of the line. The AoA Team believes a ROM estimate for refurbishment and replacement of the support SSCs for the slurry line is on the order of $50-60 million. This estimate is a factor of three times the WRPS BCWS for that WBS element, and the AoA Team adjusted the BCWS accordingly. The BCWS for the Slurry Line varied slightly for the alternatives in the WRPS BCWS output at lower levels of the WBS. Because those variations were very minor, the AoA Team did not attempt to normalize them, but rather applied the factor of 3 to the BCWS for each alternative.

For the Supernate Transfer Line, a recent report (RPP-RPT-60825) provided an estimate of $35 million for refurbishment and replacement of the support SSCs. This is approximately twice as much as was included in the WRPS cost modeling for this WBS element. The AoA Team adjusted the WRPS generated BCWS for each alternative accordingly, and, as with the Slurry Line, ignored very minor differences at the lower levels of the WBS for the various alternatives.

New Effluent Treatment Facility

As described in Appendices A and B, the current Effluent Treatment Facility (ETF) capacity will not be adequate to support treatment of the process condensate generated by the LAW and HLW processing mission. Accordingly, the AoA Team has included the cost to construct an additional new, higher capacity ETF for each alternative, sized to accommodate the expected process condensate generation and leachate collection rate for each alternative.

As a basis for the estimated cost for this ETF, the AoA Team relied on a recent estimate for a replacement ETF (documented in Appendix C of RPP-RPT-61547). The $310M estimate for a replacement ETF was escalated to FY 2020 $'s. The AoA Team added 25% to account for the fact that new technologies and processing systems will be required to properly treat the process condensate from LAW and HLW processing (refer to Appendix B). The resulting estimated cost for a new ETF of the same capacity as the existing ETF is approximately $400M. This cost for a nominal 100 gallons per minute (gpm) design capacity treatment rate was scaled accordingly to the treatment rate required for each HLW alternative using a 0.7 exponential scaling factor as used by industry for evaporator facilities. The resultant estimates are shown in Table 81. These costs were used to replace the costs already included in the WRPS cost model for Secondary Liquid Waste Treatment (WBS 5.03.10), using the same percent per year spread for the project costs.

Operational costs for the ETF were factored accordingly, adding an additional ETF (at an appropriate size) to the current ETF estimate costs.

Table 81: New ETF Facility Estimate

#	Alternative Name	Design Capacity (gpm)	New ETF Estimate (FY20 $M)	Operations Cost Factor
1	HLW Pretreatment in PT Facility (Baseline Case)	120	450	2.1
2	HLW Pretreatment in HFPF	234	730	2.8
5	Repurpose PT Facility for HLW Pretreatment and HLW Effluent Management	209	670	2.7
14	New HFPF (with Filtration) and New HEMF	209	670	2.7
15	DFHLW and HLW Effluent Processing in New HEMF	222	700	2.7
16	HLW Pretreatment in DSTs and in Feed Preparation Tanks in New HEMF	213	680	2.7
17	DFHLW Single Melter HLW Without Evaporators or LAWST	No New ETF Assumed to be Needed		

Allowance for Additional ETF Mods to support DFLAW

Because it is believed that the existing ETF will require additional, currently unplanned modifications to accommodate DFLAW operations, the AoA Team added an allowance of $100 million (approximately 25% of the cost of a replacement ETF as described above), spread evenly over a four-year period (FY2021 through FY 2024). The scope of the required modifications to the existing ETF are described in Appendix B.

Replacement Facilities – Alternative 17

Due to the very extended mission life needed for Alternative 17, the AoA Team has assumed that the major facilities needed for the tank waste treatment mission will exceed their design life and require replacement over the duration of the mission life. Accordingly, the AoA Team added the following allowances to the LCCE for Alternative 17:

- Assumed design, construction, and commissioning of new WTP facilities, including LAW and HLW Vitrification Facilities, as well as appropriate pre-treatment and feed staging facilities along with BOF and LAB elements, will be needed every 60 years, or twice over the mission life.
  - Assumed the TPC for each set of replacement WTP facilities would be approximately $20B (FY 2020 $'s) and would be accomplished over a 20-year schedule with flat funding of $1B per year.
  - Operation of new WTP facilities would begin in 2094 and again in 2154.
- Assumed that it will be necessary to replace all DSTs every 50 years on a rolling schedule. The AoA Team developed the allowance for replacement DSTs as follows:

- The DST system includes 29 DSTs with individual tank capacities that range from 1,018 kgal to 1,257 kga. The total storage capacity for all DSTs is approximately 33 Mgal. The DSTs were constructed from 1970 through 1986. The design life that is ascribed to these DSTs is 50 years, although it is generally assumed that most of the existing DSTs will be serviceable (i.e., no leaks) well beyond their design life.
- The planning for the tank waste treatment mission assumes that the DST space availability is not significantly affected by DST leaks that would occur over the mission duration. Except for Alternative 17, all the alternatives that were considered viable under the constrained funding case would complete tank waste treatment between the years 2061 and 2064. The WRPS process modeling did not assume that any of the DSTs would be replaced prior to completion of tank waste treatment.
- The AoA Team has assumed that for Alternative 17, new DSTs (or other liquid HLW and LAW storage facilities) will be constructed beginning in 2055. This would ensure that new storage space would be available in the 2065 timeframe, assuming a 10-year duration for design, construction, and commissioning. For cost estimating purposes it is assumed that tank waste treatment will be approximately 30% complete by 2085, and the DST storage space requirement would also be 30% less than is provided by the existing DSTs (23 Mgal). It is assumed that the new DSTs will be similar in design to that assumed for the TWCSF for Alternative 1, and that the new DSTs will be built on a rolling schedule such that 23 Mgal of new storage space is available by 2085. This construction schedule ensures that none of the existing DSTs would need to remain in service for more than 100 years. Since each TWCSF provides 3 Mgal of storage capacity, and the capital cost of each TWCSF is approximately $1B (in FY 2020 $'s), the required capital expenditure would be approximately $270M per year from 2055 to 2085.
- The AoA Team also assumed that for Alternative 17, the new DSTs that are completed by 2085 would have to be replaced again beginning in 2115 (50 years after completion of the first new DSTs) and completing 30 years later (2145). The tank waste treatment mission should be approximately 70% complete by 2045, and the DST storage space requirement would then be approximately 10 Mgal. The required capital expenditure would then be approximately $100M per year (in FY 2020 $) from 2115 to 2145.

2.3 End of Life (D&D)

The AoA Team assessed the end-of-life decontamination and decommissioning (D&D) costs for major facilities included in the WRPS cost model, not including the tank farm closures already included in the model results. The assessment results and resulting adjustments are discussed below. The D&D cost estimates are included with the appropriate WBS element within the "Operations Activities/Costs" portion of the LCCE summaries.

A primary reference point used for DOE AoAs is a Cost Estimating Relationship (CER) developed as part of the Cost Estimating and Scheduling Initiative (CESI) for the DOE PM. That CER, based on historical DOE D&D project costs, found that the TPC of a D&D project could be parametrically estimated based on a building footprint.

WTP D&D (WBS 5.05.02.04.01)

The WRPS model cost estimate includes approximately $650 million (FY 2018 $'s) for D&D of the full WTP. The basis for that estimate could not be found and verified. The AoA Team found that estimate is higher than would be generated using the CESI CER. However, because that estimate does appear to be more in line with nuclear power plant decommissioning costs, and it is likely the challenges of D&D for the WTP at the end of its operations is likely more extreme than the projects considered for the CESI CER, that value was maintained for the purposes of the AoA for Alternatives 1 and 5. For all alternatives without an operating PT Facility, that value was reduced by 25%. The AoA Team assumed that D&D would be accomplished over a 4-year period beginning 2 years after operations end, with a flat funding profile.

LAWST Facility D&D (WBS 5.04.01.08.03)

The AoA Team assumed D&D of the LAWST Facility would be approximately 25% of the full WTP D&D cost, adjusted for size (based on number of melters). As for the WTP D&D, it was assumed that D&D would be accomplished over a 4-year period beginning 2 years after operations end, with a flat funding profile.

D&D of Other Major Facilities (WBS 5.03.02.19.03)

The AoA Team used the CESI CER to estimate the cost of D&D of the other major facilities included for each alternative, with the resulting cost estimates shown in Table 82 in FY 2018 $'s. For these facilities, the effort was assumed to be completed over 2 years, beginning 2 years after operations end. For the new ETF Facility, it was assumed D&D could be completed at 50% of the last year's operating cost over a 2-year period.

Table 82: Facility D&D Estimates

#	Facilities	Size (sq ft)	D&D Estimate ($M)
1	TWCSF	75,000	19
2	HFPEM and LFE	104,000	22
14	HFPEM and LFE	83,000	20
15	HEMF and LFE	67,000	18
16	HEMF and LFE	66,000	18
17	WTV	6,000	6

3 Alternative LCCE Summaries – Unconstrained Funding

The following pages provide summary comparisons of the LCCEs for each alternative, assuming unconstrained annual funding levels[19].

Table 83 shows a comparison of LCC in FY 2020 dollars. These values are useful for comparison across the alternatives on a total cost basis without the influence of disparate schedules, since all costs are in constant dollars. The base estimates used were in FY 2018 $'s for the most part, consistent with the WRPS modeling results, and have been escalated to FY 2020 using the escalation rates shown at the beginning of Appendix E.

Table 84 compares the as-spent (escalated) LCC for each alternative. Escalation has been included to the time of expected expenditure based on the schedule for each alternative, using the appropriate escalation rate. Because schedules may be different for the various alternatives, these comparisons are indicative of the combined effect of both base estimated cost differences as well as the schedules for each specific alternative.

Table 85 presents the Present Value (PV) of the LCC for each alternative. This comparison provides the most useful method for alternative comparison as it considers the time-value of money spent, in accordance with OMB guidance.

[19] For Alternative 17, LCCs are only calculated through FY 2168 due to modeling limitations. Mission is not complete at that time.

Table 83: Comparison of WTP HLW AoA LCCEs in FY 2020 Dollars from FY 2020 through Completion

			Alternative 1	Alternative 2	Alternative 5	Alternative 14	Alternative 15	Alternative 16	Alternative 17
			Total FY 2020 M$	Total FY 2020 M$	Total FY 2020 M$	Total FY 2020 M$	Total FY 2020 M$	Total FY 2020 M$	Total FY 2020 M$
Operations Activites/Costs			**$113,461**	**$85,746**	**$84,913**	**$84,913**	**$85,890**	**$85,477**	**$155,720**
	5.01.01	Base Operations	$12,213	$8,096	$8,548	$8,548	$8,442	$8,165	$27,165
	5.01.02	DST Space Management	$1,771	$1,471	$1,471	$1,471	$1,651	$1,661	$1,851
	5.01.03	TOC Facility Operations	$3,324	$2,138	$2,326	$2,326	$2,328	$2,225	$9,267
	5.01.05	Project Support	$7,062	$4,586	$4,827	$4,827	$4,780	$4,622	$14,784
	5.01	**Base Operations**	**$24,370**	**$16,291**	**$17,172**	**$17,172**	**$17,201**	**$16,673**	**$53,067**
	5.02.01	Retrieval/Closure Program	$2,187	$1,687	$1,687	$1,687	$1,698	$1,687	$5,245
	5.02.02	SST Retrieval East Area	$1,840	$1,812	$1,819	$1,819	$1,813	$1,809	$1,953
	5.02.03	SST Retrieval West Area	$3,085	$3,077	$3,081	$3,081	$3,071	$3,070	$3,213
	5.02.04	Closure Program	$212	$147	$152	$152	$151	$148	$473
	5.02.05	SST Closure	$2,192	$2,192	$2,192	$2,192	$2,192	$2,192	$2,193
	5.02.07	AX-Farm Retrieval	$114	$129	$129	$129	$129	$129	$129
	5.02.08	A/AX Retrieval Common Upgrades & Design	$0	$0	$0	$0	$0	$0	$0
	5.02	**Retrieve and Close SSTs**	**$9,630**	**$9,045**	**$9,061**	**$9,061**	**$9,055**	**$9,036**	**$13,206**
	5.03.01	WTP Feed Delivery Program	$2,516	$1,505	$1,632	$1,632	$1,608	$1,547	$5,641
	5.03.02.19	TWCSF/HFPEM/HEMF/WTV/LFE Operations	$864	$1,437	$1,598	$1,598	$937	$1,099	$684
	5.03.04	DST Retrieval/Closure East Area	$771	$756	$756	$756	$756	$756	$281
	5.03.05	DST Retrieval/Closure West Area	$93	$93	$93	$93	$93	$93	$93
	5.03.06	Immobilization Program	$2,687	$1,315	$1,381	$1,381	$1,347	$1,333	$6,275
	5.03.07	WTP Operational Readiness	$82	$80	$80	$80	$80	$80	$80
	5.03.10	Secondary Waste Treatment/ETF	$4,229	$3,209	$3,363	$3,363	$3,347	$3,215	$5,049
	5.03.11	Next Generation Projects	$43	$43	$43	$43	$43	$43	$43
	5.03.12	Strategic Planning and Technology	$207	$186	$186	$186	$186	$186	$186
	5.03	**WFD/Treatment Planning / DST Retrieval/Closure**	**$11,492**	**$8,623**	**$9,130**	**$9,130**	**$8,396**	**$8,351**	**$18,332**
	5.04	**Supplemental Treatment**	**$32,629**	**$28,253**	**$24,988**	**$24,988**	**$26,901**	**$26,642**	**$639**
	5.05.40	Tank Side Cesium Removal (TSCR) System Ops	$1,461	$3,377	$3,294	$3,294	$2,882	$3,736	$3,912
	5.05.02	Remaining Treat Waste (WTP Operations)	$29,349	$15,332	$16,649	$16,649	$16,619	$16,189	$63,000
	5.05	**Treat Waste**	**$30,810**	**$18,710**	**$19,943**	**$19,943**	**$19,500**	**$19,925**	**$66,911**
	5.06	**Facility Closures**	**$313**	**$313**	**$313**	**$313**	**$313**	**$313**	**$184**
	5.12	**TOC - ORP Project Support**	**$4,668**	**$2,955**	**$3,117**	**$3,117**	**$3,061**	**$2,980**	**$10,256**
		Ramp-Down	**($5,855)**	**($2,527)**	**($2,847)**	**($2,847)**	**($2,628)**	**($2,487)**	**($14,290)**
		Fee	**$5,403**	**$4,083**	**$4,035**	**$4,035**	**$4,090**	**$4,044**	**$7,415**

			Alternative 1	Alternative 2	Alternative 5	Alternative 14	Alternative 15	Alternative 16	Alternative 17
Capital and Expense Funded Projects			$33,732	$34,488	$34,443	$30,255	$32,070	$32,666	$68,791
	5.01.04.01.01	242-A Evaporator Upgrades	$507	$328	$346	$346	$364	$355	$1,202
	5.01.04.01.07	Cross-Site Slurry Line	$66	$65	$65	$65	$66	$66	$64
	5.01.04.01.30	Cross-Site Supernate Transfer Line	$36	$36	$36	$36	$36	$36	$35
	5.01.04	Other Tank Farm Upgrade Projects	$1,542	$984	$1,069	$1,069	$1,062	$1,015	$3,365
	5.02.01.06.01	B-Complex Waste Receiver Facility (WRF)	$385	$385	$385	$385	$385	$385	$373
	5.02.01.06.02	T-Complex Waste Receiver Facility (WRF)	$395	$395	$395	$395	$395	$395	$383
	5.03.02	Construct DST Systems	$1,241	$1,273	$1,265	$1,265	$1,287	$1,287	$1,266
	5.03.02.19.01	TWCSF/HFPEM/HEMF/WTV	$1,041	$1,611	$0	$1,534	$867	$1,089	$156
	5.03.02.19.04	LAW Feed Evaporator (LFE)	$0	$373	$0	$346	$371	$382	$0
	5.03.06.04	Hanford Shipping Facility (HSF)	$170	$170	$170	$170	$170	$170	$165
	5.03.06.06	Interim Hanford Storage (IHS)	$204	$203	$202	$202	$203	$203	$197
	5.03.10.01	Secondary Liquid Waste Treatment	$450	$730	$670	$670	$700	$680	$0
	5.04.01.08.01	LAWST Facility	$9,728	$16,677	$12,508	$12,508	$15,032	$15,032	$0
	5.05.40	Tank Side Cesium Removal (TSCR) System	$565	$1,553	$1,559	$1,559	$1,428	$1,866	$1,426
	5.05.02.02	Start-up and Commissioning/Transition - TOC	$258	$258	$258	$258	$258	$258	$250
	5.05	LBL/DFLAW Completion	$2,261	$2,261	$2,261	$2,261	$2,261	$2,261	$2,261
		Additional ETF Modifications	$96	$96	$96	$96	$96	$96	$96
	5.05	HLW/PT Completion	$14,785	$7,090	$13,157	$7,090	$7,090	$7,090	$6,453
	Replacement Facilities (Alternative 17)								
		WTP (LAW, HLW, BOF, LAB)							$40,000
		Allowance for DSTs and Other Infrastructure							$11,100

* *For Alternative 17, life cycle costs only calculated through FY 2168 but mission not yet complete at that time*

Table 84: Comparison of WTP HLW AoA LCCEs in As-Spent Dollars from FY 2020 through Completion

		Alternative 1	Alternative 2	Alternative 5	Alternative 14	Alternative 15	Alternative 16	Alternative 17
		Escalated Costs	Escalated Costs	Escalated Costs	Escalated Costs	Escalated Costs	Escalated Costs	Escalated Costs
	Total Life Cycle Costs	$ 340,862	$ 214,929	$ 217,352	$ 211,886	$ 214,242	$ 212,858	$ 5,098,657
Operations Activites/Costs		$ 285,552	$ 160,172	$ 163,657	$ 163,657	$ 164,790	$ 162,175	$ 1,426,809
5.01.01	Base Operations	$ 30,389	$ 14,376	$ 15,734	$ 15,734	$ 15,399	$ 14,570	$ 251,339
5.01.02	DST Space Management	$ 3,961	$ 2,528	$ 2,637	$ 2,637	$ 2,999	$ 2,948	$ 17,549
5.01.03	TOC Facility Operations	$ 7,621	$ 3,547	$ 4,057	$ 4,057	$ 4,062	$ 3,775	$ 89,343
5.01.05	Project Support	$ 18,516	$ 8,326	$ 9,074	$ 9,074	$ 8,924	$ 8,433	$ 138,455
5.01	**Base Operations**	$ 60,488	$ 28,776	$ 31,503	$ 31,503	$ 31,385	$ 29,726	$ 496,686
5.02.01	Retrieval/Closure Program	$ 4,422	$ 2,852	$ 2,852	$ 2,852	$ 2,881	$ 2,852	$ 41,522
5.02.02	SST Retrieval East Area	$ 4,068	$ 3,066	$ 3,475	$ 3,475	$ 3,330	$ 3,119	$ 12,007
5.02.03	SST Retrieval West Area	$ 6,140	$ 5,713	$ 5,751	$ 5,751	$ 5,906	$ 5,880	$ 27,335
5.02.04	Closure Program	$ 514	$ 262	$ 275	$ 275	$ 273	$ 263	$ 4,253
5.02.05	SST Closure	$ 4,760	$ 4,070	$ 4,195	$ 4,195	$ 4,227	$ 4,153	$ 15,649
5.02.07	AX-Farm Retrieval	$ 117	$ 134	$ 134	$ 134	$ 134	$ 134	$ 134
5.02.08	A/AX Retrieval Common Upgrades & Design	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5.02	**Retrieve and Close SSTs**	$ 20,022	$ 16,097	$ 16,683	$ 16,683	$ 16,752	$ 16,402	$ 100,900
5.03.01	WTP Feed Delivery Program	$ 5,972	$ 2,592	$ 2,925	$ 2,925	$ 2,849	$ 2,702	$ 52,612
5.03.02.19	TWCSF/HFPEM/HEMF/WTV/LFE Operations	$ 2,309	$ 2,759	$ 3,227	$ 3,227	$ 1,849	$ 2,172	$ 6,931
5.03.04	DST Retrieval/Closure East Area	$ 3,069	$ 1,940	$ 2,100	$ 2,100	$ 2,066	$ 1,981	$ 8,576
5.03.05	DST Retrieval/Closure West Area	$ 310	$ 226	$ 232	$ 232	$ 243	$ 235	$ 2,616
5.03.06	Immobilization Program	$ 7,216	$ 2,450	$ 2,639	$ 2,639	$ 2,544	$ 2,502	$ 61,859
5.03.07	WTP Operational Readiness	$ 97	$ 94	$ 94	$ 94	$ 94	$ 94	$ 94
5.03.10	Secondary Waste Treatment/ETF	$ 10,926	$ 6,026	$ 6,588	$ 6,588	$ 6,471	$ 6,134	$ 47,393
5.03.11	Next Generation Projects	$ 62	$ 62	$ 62	$ 62	$ 62	$ 62	$ 62
5.03.12	Strategic Planning and Technology	$ 244	$ 214	$ 214	$ 214	$ 214	$ 214	$ 214
5.03	**WFD/Treatment Planning / DST Retrieval/Closure**	$ 30,204	$ 16,363	$ 18,082	$ 18,082	$ 16,392	$ 16,096	$ 180,357
5.04	**Supplemental Treatment**	$ 89,790	$ 56,893	$ 52,127	$ 52,127	$ 55,449	$ 54,741	$ 5,826
5.05.40	Tank Side Cesium Removal (TSCR) System Ops	$ 2,887	$ 6,320	$ 6,265	$ 6,265	$ 5,355	$ 6,969	$ 36,241
5.05.02	Remaining Treat Waste (WTP Operations)	$ 76,127	$ 27,951	$ 31,618	$ 31,618	$ 31,532	$ 30,307	$ 616,406
5.05	**Treat Waste**	$ 79,013	$ 34,271	$ 37,883	$ 37,883	$ 36,887	$ 37,276	$ 652,647
5.06	**Facility Closures**	$ 977	$ 679	$ 708	$ 708	$ 708	$ 694	$ 1,170
5.12	**TOC - ORP Project Support**	$ 11,887	$ 5,242	$ 5,716	$ 5,716	$ 5,552	$ 5,313	$ 96,710
	Ramp-Down	$ (20,427)	$ (5,776)	$ (6,810)	$ (6,810)	$ (6,181)	$ (5,715)	$ (175,430)
	Fee	$ 13,598	$ 7,627	$ 7,765	$ 7,765	$ 7,847	$ 7,641	$ 67,943

			Alternative 1	Alternative 2	Alternative 5	Alternative 14	Alternative 15	Alternative 16	Alternative 17
Capital and Expense Funded Projects			$ 55,311	$ 54,757	$ 53,695	$ 48,230	$ 49,451	$ 50,683	$ 3,671,847
	5.01.04.01.01	242-A Evaporator Upgrades	$ 1,660	$ 646	$ 715	$ 715	$ 789	$ 751	$ 43,628
	5.01.04.01.07	Cross-Site Slurry Line	$ 95	$ 97	$ 82	$ 82	$ 125	$ 129	$ 126
	5.01.04.01.30	Cross-Site Supernate Transfer Line	$ 51	$ 53	$ 44	$ 44	$ 67	$ 69	$ 67
	5.01.04	Other Tank Farm Upgrade Projects	$ 6,100	$ 2,198	$ 2,601	$ 2,601	$ 2,563	$ 2,339	$ 123,978
	5.02.01.06.01	B-Complex Waste Receiver Facility (WRF)	$ 629	$ 625	$ 625	$ 625	$ 703	$ 703	$ 629
	5.02.01.06.02	T-Complex Waste Receiver Facility (WRF)	$ 853	$ 876	$ 871	$ 871	$ 919	$ 918	$ 3,083
	5.03.02	Construct DST Systems	$ 2,751	$ 2,159	$ 2,248	$ 2,248	$ 2,296	$ 2,221	$ 15,257
	5.03.02.19.01	TWCSF/HFPEM/HEMF/WTV	$ 1,418	$ 2,214	$ -	$ 2,118	$ 1,196	$ 1,501	$ 222
	5.03.02.19.04	LAW Feed Evaporator (LFE)	$ -	$ 583	$ -	$ 542	$ 443	$ 598	$ -
	5.03.06.04	Hanford Shipping Facility (HSF)	$ 247	$ 247	$ 247	$ 247	$ 247	$ 247	$ 247
	5.03.06.06	Interim Hanford Storage (IHS)	$ 318	$ 317	$ 315	$ 315	$ 317	$ 317	$ 318
	5.03.10.01	Secondary Liquid Waste Treatment	$ 670	$ 1,087	$ 997	$ 997	$ 1,042	$ 1,012	$ -
	5.04.01.08.01	LAWST Facility	$ 16,009	$ 27,454	$ 20,590	$ 20,590	$ 22,878	$ 22,878	$ -
	5.05.40	Tank Side Cesium Removal (TSCR) System	$ 1,751	$ 3,776	$ 3,806	$ 3,806	$ 3,440	$ 4,573	$ 71,652
	5.05.02.02	Start-up and Commissioning/Transition - TOC	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348
	5.05	LBL/DFLAW Completion	$ 2,358	$ 2,358	$ 2,358	$ 2,358	$ 2,358	$ 2,358	$ 2,358
		Additional ETF Modifications	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100
	5.05	HLW/PT Completion	$ 19,951	$ 9,621	$ 17,746	$ 9,621	$ 9,621	$ 9,621	$ 8,765
	Replacement Facilities (Alternative 17)								
		WTP (LAW, HLW, BOF, LAB)							$ 3,084,623
		Allowance for DSTs and Other Infrastructure							$ 316,446

* *For Alternative 17, life cycle costs only calculated through FY 2168 but mission not yet complete at that time*

Table 85: WTP HLW AoA Present Value of LCCE from FY 2020 through Completion

		Alternative 1	Alternative 2	Alternative 5	Alternative 14	Alternative 15	Alternative 16	Alternative 17
	Total Life Cycle Costs	$150,592	$124,835	$123,379	$118,840	$120,766	$121,092	$423,267
Operations Activites/Costs		$110,802	$83,736	$82,922	$82,922	$83,877	$83,474	$152,070
5.01.01	Base Operations	$11,927	$7,906	$8,347	$8,347	$8,244	$7,974	$26,529
5.01.02	DST Space Management	$1,730	$1,437	$1,436	$1,436	$1,612	$1,622	$1,807
5.01.03	TOC Facility Operations	$3,246	$2,088	$2,272	$2,272	$2,274	$2,172	$9,050
5.01.05	Project Support	$6,897	$4,478	$4,714	$4,714	$4,668	$4,514	$14,437
5.01	**Base Operations**	$23,799	$15,909	$16,769	$16,769	$16,798	$16,282	$51,823
5.02.01	Retrieval/Closure Program	$2,136	$1,648	$1,648	$1,648	$1,658	$1,648	$5,122
5.02.02	SST Retrieval East Area	$1,797	$1,769	$1,776	$1,776	$1,771	$1,767	$1,907
5.02.03	SST Retrieval West Area	$3,013	$3,005	$3,009	$3,009	$2,999	$2,998	$3,138
5.02.04	Closure Program	$207	$144	$148	$148	$148	$144	$462
5.02.05	SST Closure	$2,141	$2,141	$2,141	$2,141	$2,141	$2,141	$2,141
5.02.07	AX-Farm Retrieval	$111	$126	$126	$126	$126	$126	$126
5.02.08	A/AX Retrieval Common Upgrades & Design	$0	$0	$0	$0	$0	$0	$0
5.02	**Retrieve and Close SSTs**	$9,405	$8,833	$8,848	$8,848	$8,843	$8,824	$12,896
5.03.01	WTP Feed Delivery Program	$2,457	$1,470	$1,593	$1,593	$1,570	$1,510	$5,508
5.03.02.19	TWCSF/HFPEM/HEMF/WTV/LFE Operations	$844	$1,403	$1,561	$1,561	$915	$1,074	$668
5.03.04	DST Retrieval/Closure East Area	$753	$738	$738	$738	$738	$738	$275
5.03.05	DST Retrieval/Closure West Area	$91	$91	$91	$91	$91	$91	$91
5.03.06	Immobilization Program	$2,624	$1,284	$1,348	$1,348	$1,316	$1,302	$6,128
5.03.07	WTP Operational Readiness	$80	$78	$78	$78	$78	$78	$78
5.03.10	Secondary Waste Treatment/ETF	$4,129	$3,134	$3,284	$3,284	$3,268	$3,140	$4,931
5.03.11	Next Generation Projects	$42	$42	$42	$42	$42	$42	$42
5.03.12	Strategic Planning and Technology	$203	$181	$181	$181	$181	$181	$181
5.03	**WFD/Treatment Planning / DST Retrieval/Closure**	$11,222	$8,421	$8,916	$8,916	$8,199	$8,155	$17,902
5.04	**Supplemental Treatment**	$31,864	$27,591	$24,403	$24,403	$26,270	$26,017	$624
5.05.40	Tank Side Cesium Removal (TSCR) System Ops	$1,427	$3,298	$3,217	$3,217	$2,814	$3,649	$3,820
5.05.02	Remaining Treat Waste (WTP Operations)	$28,661	$14,973	$16,259	$16,259	$16,229	$15,809	$61,523
5.05	**Treat Waste**	$30,088	$18,271	$19,475	$19,475	$19,043	$19,458	$65,343
5.06	**Facility Closures**	$306	$306	$306	$306	$306	$306	$180
5.12	**TOC - ORP Project Support**	$4,559	$2,885	$3,044	$3,044	$2,990	$2,911	$10,015
	Ramp-Down	($5,718)	($2,468)	($2,780)	($2,780)	($2,566)	($2,429)	($13,956)
	Fee	$5,276	$3,987	$3,940	$3,940	$3,994	$3,950	$7,241

			Alternative 1	Alternative 2	Alternative 5	Alternative 14	Alternative 15	Alternative 16	Alternative 17
Capital and Expense Funded Projects			$39,790	$41,099	$40,457	$35,918	$36,889	$37,618	$271,197
	5.01.04.01.01	242-A Evaporator Upgrades	$756	$411	$440	$440	$471	$456	$4,003
	5.01.04.01.07	Cross-Site Slurry Line	$75	$74	$70	$70	$83	$84	$83
	5.01.04.01.30	Cross-Site Supernate Transfer Line	$40	$41	$38	$38	$45	$45	$45
	5.01.04	Other Tank Farm Upgrade Projects	$2,458	$1,291	$1,445	$1,445	$1,431	$1,346	$11,329
	5.02.01.06.01	B-Complex Waste Receiver Facility (WRF)	$457	$455	$455	$455	$477	$477	$457
	5.02.01.06.02	T-Complex Waste Receiver Facility (WRF)	$523	$528	$527	$527	$539	$538	$869
	5.03.02	Construct DST Systems	$1,591	$1,500	$1,513	$1,513	$1,545	$1,526	$2,156
	5.03.02.19.01	TWCSF/HFPEM/HEMF/WTV	$1,148	$1,782	$0	$1,700	$961	$1,206	$178
	5.03.02.19.04	LAW Feed Evaporator (LFE)	$0	$434	$0	$403	$432	$445	$0
	5.03.06.04	Hanford Shipping Facility (HSF)	$192	$192	$192	$192	$192	$192	$192
	5.03.06.06	Interim Hanford Storage (IHS)	$237	$236	$235	$235	$236	$236	$236
	5.03.10.01	Secondary Liquid Waste Treatment	$514	$834	$765	$765	$799	$777	$0
	5.04.01.08.01	LAWST Facility	$12,124	$20,787	$15,590	$15,590	$17,322	$17,322	$0
	5.05.40	Tank Side Cesium Removal (TSCR) System	$821	$2,112	$2,122	$2,122	$1,934	$2,546	$5,183
	5.05.02.02	Start-up and Commissioning/Transition - TOC	$282	$282	$282	$282	$282	$282	$282
	5.05	LBL/DFLAW Completion	$2,245	$2,245	$2,245	$2,245	$2,245	$2,245	$2,245
		Additional ETF Modifications	$92	$92	$92	$92	$92	$92	$92
	5.05	HLW/PT Completion	$16,235	$7,801	$14,444	$7,801	$7,801	$7,801	$7,104
	Replacement Facilities (Alternative 17)								
		WTP (LAW, HLW, BOF, LAB)							$200,682
		Allowance for DSTs and Other Infrastructure							$36,060

* *For Alternative 17, life cycle costs only calculated through FY 2168 but mission not yet complete at that time*

4 LCCE Cost Ranges

The estimates used for the HLW alternative LCCEs are all considered AACE International Class 5 estimates. Such estimates have an expected uncertainty range of from -30%/-50% to +50%/100%.

For the purposes of the AoA, it is assumed that the operational activities have a somewhat narrower uncertainty range as a result of those activities generally being staff-based and level of effort in terms of the annual expenditures expected. There is still a great deal of uncertainty as to overall duration that is dependent on a wide set of factors, including Total Operational Efficiency (TOE) achieved/experienced for the vitrification facilities over their operational life. Because the WRPS modeling is based on an assumed 40% TOE, the overall duration is not considered overly optimistic. For these reasons, the operational period elements of the LCC for each alternative are assumed to have an uncertainty range of from -30% to +50%.

The project related costs, consisting of both expense funded projects and the various capital projects needed for each alternative, are expected to have much broader ranges of uncertainty, consistent with DOE experience. These estimates are based on pre-conceptual design information and are primarily parametric-based estimate. Thus, a range of from -50% to +100% has been assumed for the estimated costs of these elements of the LCC for each alternative.

Table 86 presents the PV of the LCC for each alternative in terms of a range. Table 87 shows the as-spent (escalated) range of the LCCE for each alternative.

Table 86: WTP HLW AoA Alternative LCCE PV Range

PV (millions of $'s)			
Alt 1	**Low**	**Point**	**High**
Projects Cost (TPC)	20,000	39,790	80,000
Operation Period Cost	78,000	110,802	166,000
Total	98,000	150,592	246,000
Alt 2	**Low**	**Point**	**High**
Projects Cost (TPC)	21,000	41,099	82,000
Operation Period Cost	59,000	83,736	126,000
Total	80,000	124,835	208,000
Alt 5	**Low**	**Point**	**High**
Projects Cost (TPC)	20,000	40,457	81,000
Operation Period Cost	58,000	82,922	124,000
Total	78,000	123,379	205,000
Alt 14	**Low**	**Point**	**High**
Projects Cost (TPC)	18,000	35,918	72,000
Operation Period Cost	58,000	82,922	124,000
Total	76,000	118,840	196,000
Alt 15	**Low**	**Point**	**High**
Projects Cost (TPC)	18,000	36,889	74,000
Operation Period Cost	59,000	83,877	126,000
Total	77,000	120,766	200,000
Alt 16	**Low**	**Point**	**High**
Projects Cost (TPC)	19,000	37,618	75,000
Operation Period Cost	58,000	83,474	125,000
Total	77,000	121,092	200,000
Alt 17	**Low**	**Point**	**High**
Projects Cost (TPC)	136,000	271,197	542,000
Operation Period Cost	106,000	152,070	228,000
Total	242,000	423,267	770,000

Table 87: WTP HLW AoA Alternative As-Spent LCCE Range

As-Spent (millions of $'s)			
Alt 1	**Low**	**Point**	**High**
Projects Cost (TPC)	28,000	55,311	111,000
Operation Period Cost	200,000	285,552	428,000
Total	228,000	340,862	539,000
Alt 2	**Low**	**Point**	**High**
Projects Cost (TPC)	27,000	54,757	110,000
Operation Period Cost	112,000	160,172	240,000
Total	139,000	214,929	350,000
Alt 5	**Low**	**Point**	**High**
Projects Cost (TPC)	27,000	53,695	107,000
Operation Period Cost	115,000	163,657	245,000
Total	142,000	217,352	352,000
Alt 14	**Low**	**Point**	**High**
Projects Cost (TPC)	24,000	48,230	96,000
Operation Period Cost	115,000	163,657	245,000
Total	139,000	211,886	341,000
Alt 15	**Low**	**Point**	**High**
Projects Cost (TPC)	25,000	49,451	99,000
Operation Period Cost	115,000	164,790	247,000
Total	140,000	214,242	346,000
Alt 16	**Low**	**Point**	**High**
Projects Cost (TPC)	25,000	50,683	101,000
Operation Period Cost	114,000	162,175	243,000
Total	139,000	212,858	344,000
Alt 17	**Low**	**Point**	**High**
Projects Cost (TPC)	1,836,000	3,671,847	7,344,000
Operation Period Cost	999,000	1,426,809	2,140,000
Total	2,835,000	5,098,657	9,484,000

5 Constrained Funding Analysis

The constrained funding analysis discussed in summary in Section 8.2 of this report is based on the alternative specific assumptions and results described in the following sections.

5.1 Alternative 1

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- LAWST Facility construction is deferred pending available funding after HLW processing operations are started.
- TSCR operations and Capital Costs were adjusted to reflect the lower LAW pretreatment rate without the LAWST Facility. In order to approximate the TSCR cost profile for this alternative, it is assumed to be the same as the TSCR cost profile in the WRPS cost model for Alternative 17, which does not include the LAWST Facility.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.
- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- TWCSF project is completed as currently planned in the WRPS cost model (completed by FY 2032).
- Remaining available funding is used to support completion of the HLW Vitrification Facility and the PT Facility (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification Facility and PT Facility cannot be completed, as there is insufficient funding remaining after funding of the ongoing operations activities and projects described above. Under this funding scenario, this alternative is no longer viable, since HLW processing cannot even be started because there is inadequate funding to complete the facility construction and commissioning.
  - By approximately FY 2050, there begins to be less than $100 million per year available for the HLW Vitrification and PT Facility projects. This is not enough to maintain any project progress towards completion since this level does not even cover the project hotel load. Through FY 2050, approximately two-thirds of the current estimate for completion of the project will have been expended, leaving the HLW Vitrification and PT Facility projects incomplete.
- Beginning in FY 2054, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B, even after deleting the annual costs to operate the HLW Vitrification, PT and LAWST facilities.

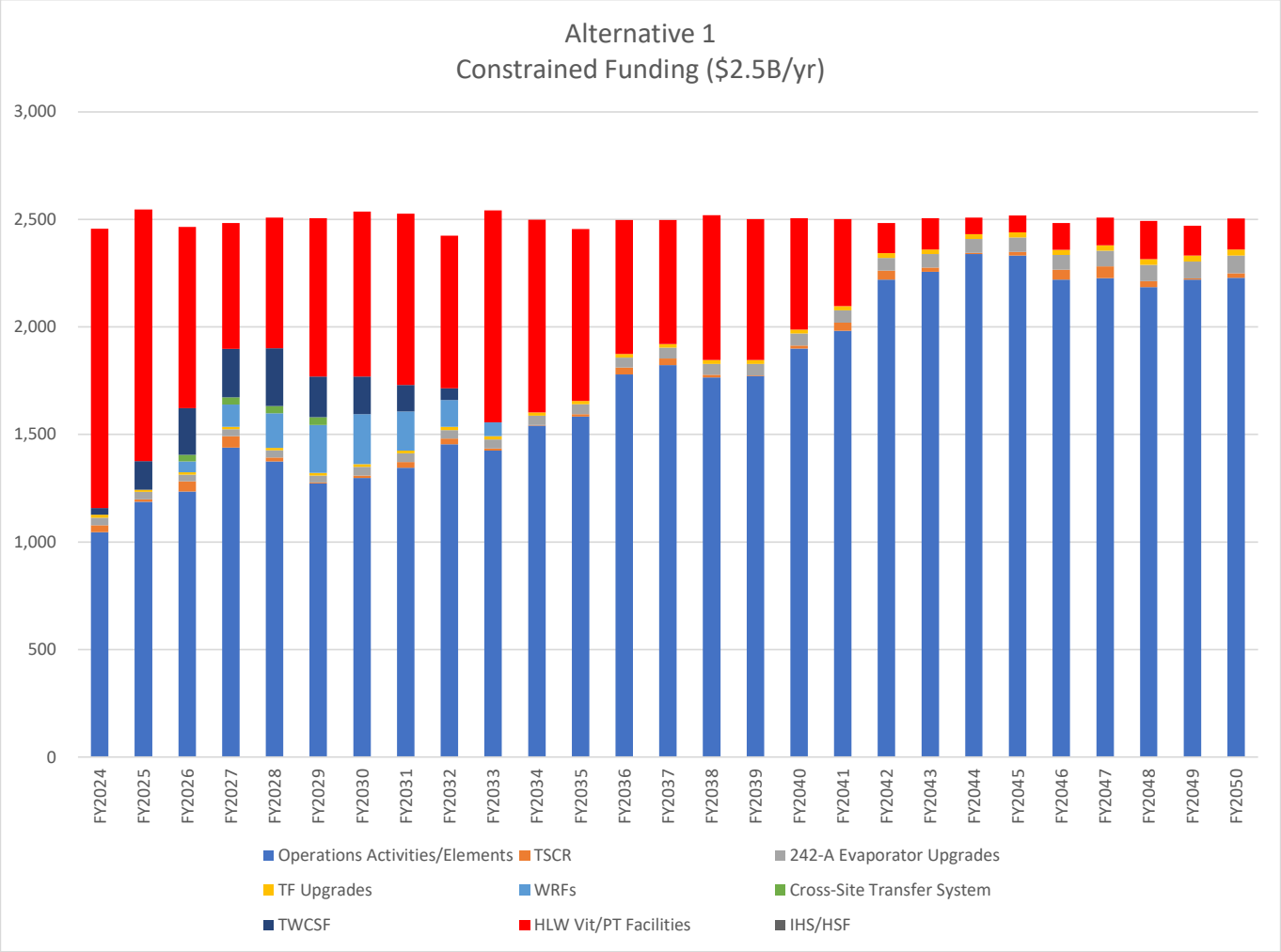


Figure 34: Alternative 1 Constrained Funding Analysis

5.2 Alternative 2

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- LAWST Facility construction is deferred pending available funding after HLW processing operations are started.
- TSCR operations and Capital Costs were adjusted to reflect the lower LAW pretreatment rate without the LAWST Facility. In order to approximate the TSCR cost profile for this alternative, it is assumed to be the same as the TSCR cost profile in the WRPS cost model for Alternative 17, which does not include the LAWST Facility.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.

- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- HFPEM Facility project is completed as currently planned in the WRPS cost model (completed by FY 2032).
- LFE project is completed as currently planned in the WRPS cost model (completed in FY 2035).
- Remaining available funding is used to support completion of the HLW Vitrification Facility (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification Facility is completed in FY 2035 and operations are assumed to start in FY 2036 to the extent possible, pending completion of adequate IHS storage capacity (see below).
- Funding becomes available in FY 2035 to start the HSF and IHS projects. These projects can be completed over a six-year duration, with completion in FY 2040.
  - It may be possible to phase construction of the IHS such that the first storage vault is completed (i.e., operational) prior to completing construction of the remaining vault(s).
  - Even with a phased construction approach for the IHS, HLW treatment operations will be extremely limited until the first IHS storage vault is operational.
- Beginning in FY 2041, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B, even after deleting the annual costs to operate the LAWST Facility.
- Through FY 2040, there will have been approximately $0.7B accrued in unused funding (after funding annual operations and completion of the HLW, IHS, and HSF projects).
  - This funding could possibly be used to construct a new ETF; however, it is not nearly enough to construct the full capacity LAWST facility assumed by the WRPS process model (12 melter capacity) that has an estimated construction cost of approximately $17B in FY 2020 dollars.
- The absence of a LAWST Facility, or even the possible construction of a much smaller LAWST facility, has a significant impact on LAW and HLW treatment rates, and a corresponding significant impact on the duration of the LAW and HLW treatment mission and resultant life cycle costs (LCCs). Without additional process modeling, these schedule impacts and costs cannot be estimated.

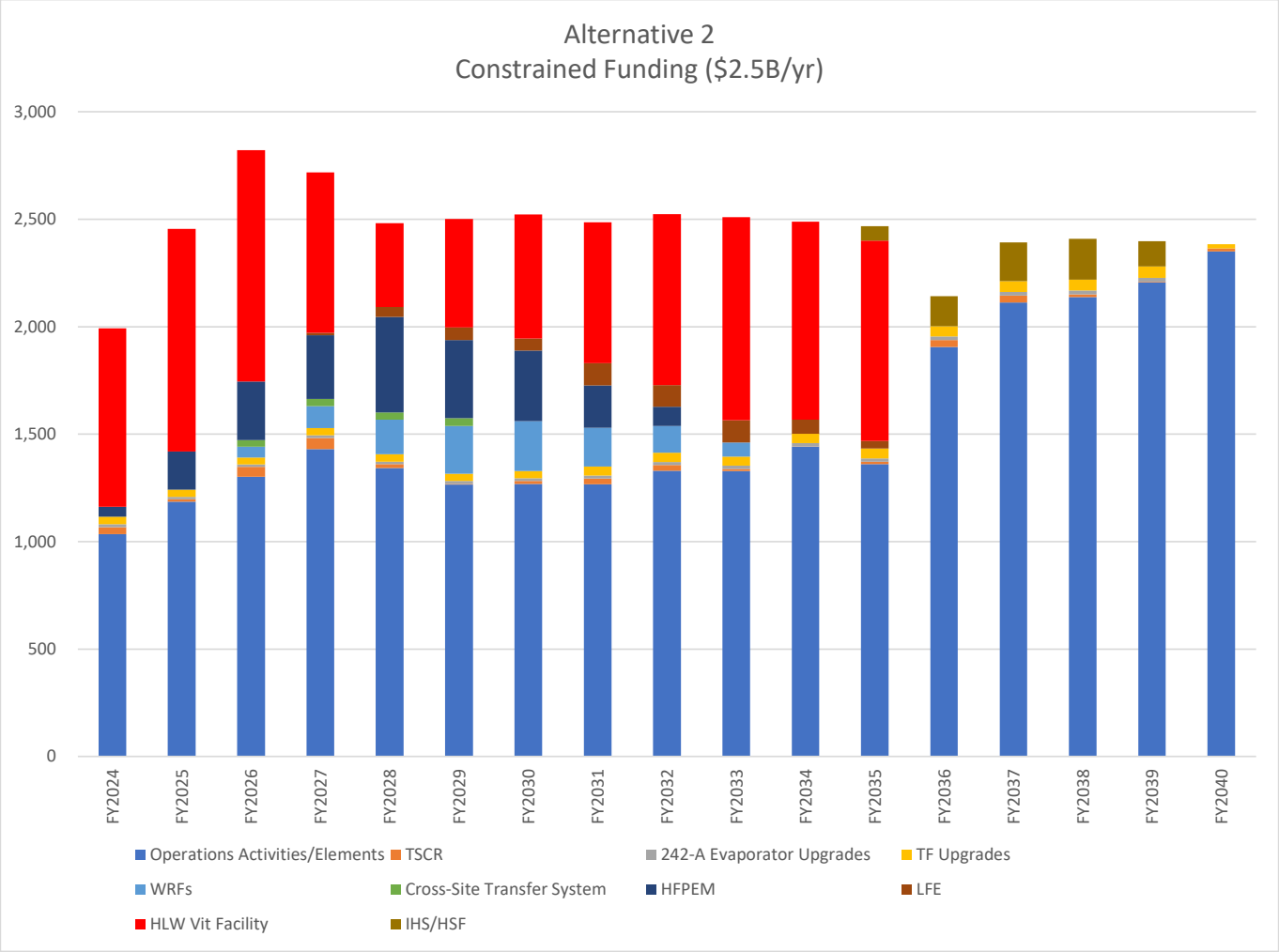


Figure 35: Alternative 2 Constrained Funding Analysis

5.3 Alternative 5

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- LAWST Facility construction is deferred pending available funding after HLW processing operations are started.
- TSCR operations and Capital Costs were adjusted to reflect the lower LAW pretreatment rate without the LAWST Facility. In order to approximate the TSCR cost profile for this alternative, it is assumed to be the same as the TSCR cost profile in the WRPS cost model for Alternative 17, which does not include the LAWST Facility.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.

- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- Remaining available funding is used to support completion of the HLW Vitrification and RPT facilities (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification and PT Facilities cannot be completed, since there is insufficient funding remaining after funding of the ongoing operations activities and projects described above. Under this funding scenario, this alternative is no longer viable, since HLW processing cannot even be started.
  - At the time available funding for the HLW Vitrification and PT Facility project runs out in FY 2043, approximately 83% of the current estimate for completion of the project will have been expended, leaving these facilities incomplete.
- Beginning in FY 2044, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B, even after deleting the annual costs to operate the HLW/RPT and LAWST facilities.

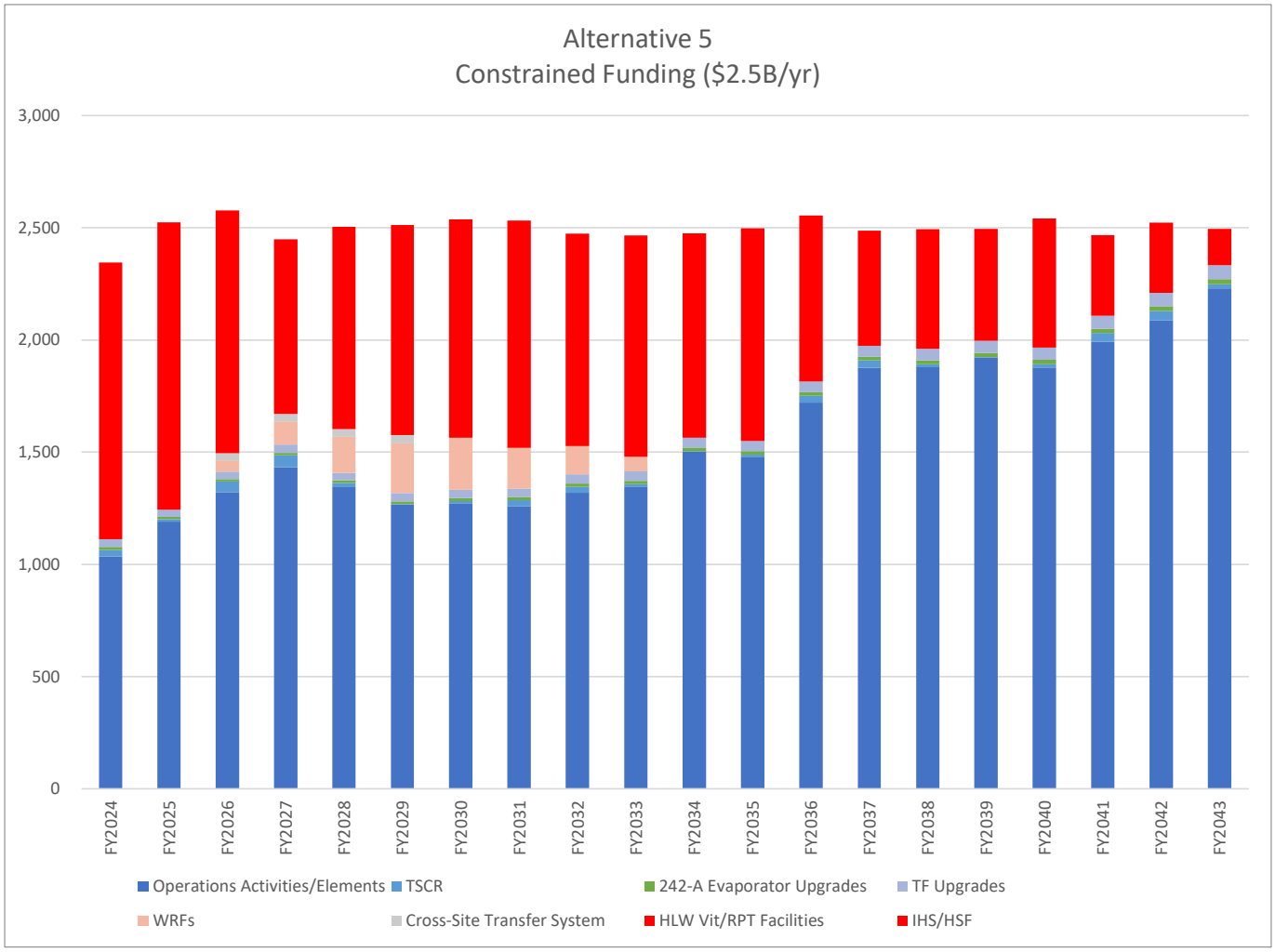


Figure 36: Alternative 5 Constrained Funding Analysis

5.4 Alternative 14

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- LAWST Facility construction is deferred pending available funding after HLW processing operations are started.
- TSCR operations and Capital Costs were adjusted to reflect the lower LAW pretreatment rate without the LAWST Facility. In order to approximate the TSCR cost profile for this alternative, it is assumed to be the same as the TSCR cost profile in the WRPS cost model for Alternative 17, which does not include the LAWST Facility.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.
- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- HFPEM Facility project is completed as currently planned in the WRPS cost model (completed by FY 2032).
- LFE project is completed as currently planned in the WRPS cost model (completed in FY 2035).
- Remaining available funding is used to support completion of the HLW Vitrification Facility (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification Facility is completed in FY 2035 and operations are assumed to start in FY 2036 to the extent possible, pending completion of adequate IHS storage capacity (see below).
- Funding becomes available in FY 2035 to start the HSF and IHS projects. These projects can be completed over a six-year duration, with completion in FY 2040.
  - It may be possible to phase construction of the IHS such that the first storage vault is completed (i.e., operational) prior to completing construction of the remaining vault(s).
  - Even with a phased construction approach for the IHS, HLW treatment operations will be extremely limited until the first IHS storage vault is operational.
- Beginning in FY 2043, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B, even after deleting the annual costs to operate the LAWST Facility.
- Through FY 2042, there will have been approximately $1.5B accrued in unused funding (after funding annual operations and completion of the HLW, IHS, and HSF projects).
  - This funding could possibly be used to construct a new ETF; however, it is not nearly enough to construct the full capacity LAWST facility assumed by the WRPS process model (nine melter capacity) that has an estimated construction cost of approximately $12.5B in FY 2020 dollars.
- The absence of a LAWST Facility, or even the possible construction of a much smaller LAWST facility, has a significant impact on LAW and HLW treatment rates, and a corresponding significant impact on the duration of the LAW and HLW treatment mission and resultant LCCs. Without additional process modeling, these impacts and costs cannot be estimated at this time.

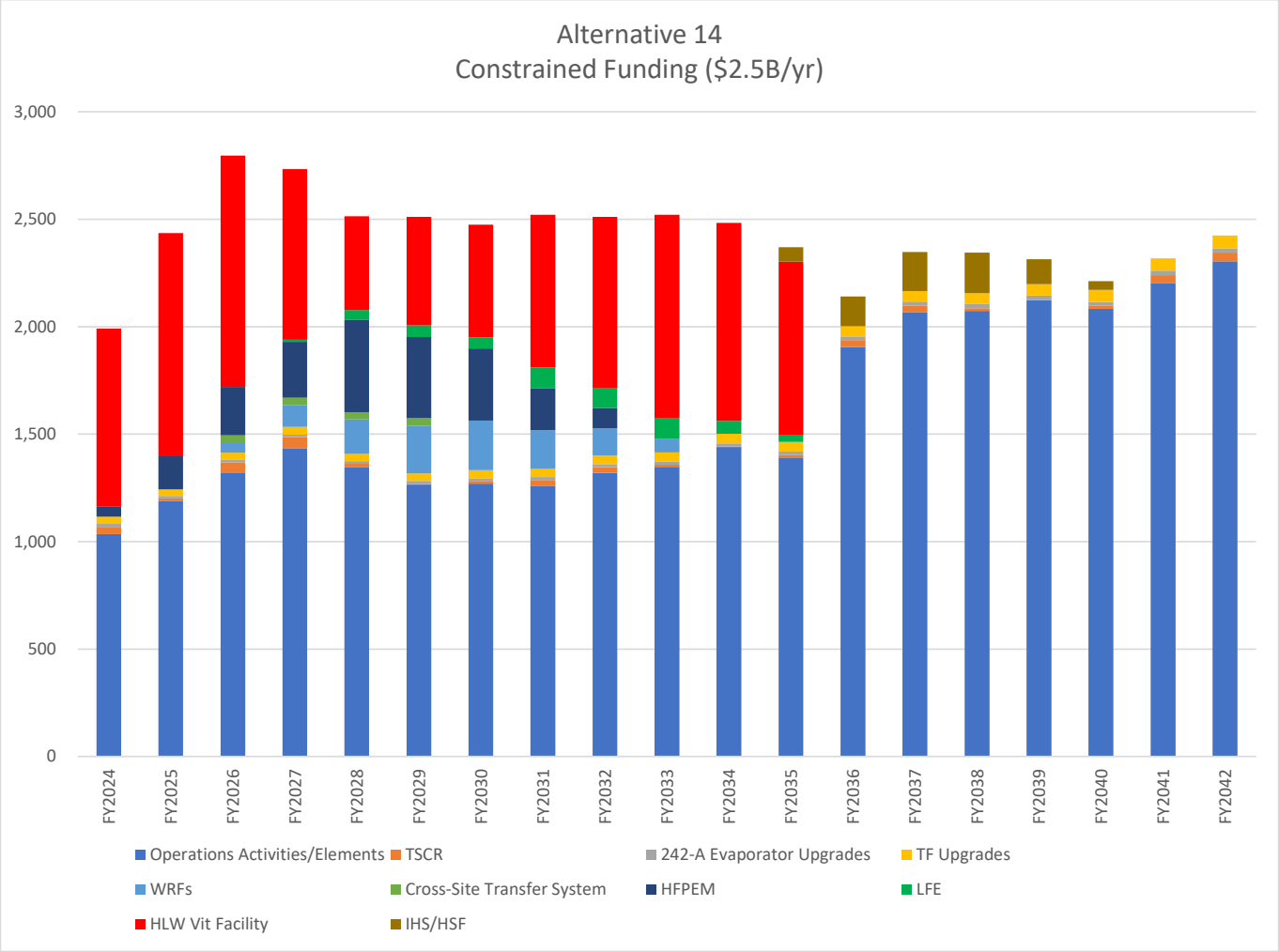


Figure 37: Alternative 14 Constrained Funding Analysis

5.5 Alternative 15

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- LAWST Facility construction is deferred pending available funding after HLW processing operations are started.
- TSCR operations and Capital Costs were adjusted to reflect the lower LAW pretreatment rate without the LAWST Facility. In order to approximate the TSCR cost profile for this alternative, it is assumed to be the same as the TSCR cost profile in the WRPS cost model for Alternative 17 which does not include the LAWST Facility.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.

- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- HEMF project is completed as currently planned in the WRPS cost model (completed by FY 2032).
- LFE project is completed as currently planned in the WRPS cost model (completed in FY 2035).
- Remaining available funding is used to support completion of the HLW Vitrification Facility (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification Facility is completed in FY 2034 and operations are assumed to start in FY 2035, to the extent possible, pending completion of adequate IHS storage capacity (see below).
- Funding becomes available in FY 2032 to start the HSF and IHS projects. These projects can be completed over a six-year duration, with completion in FY 2037.
  - It may be possible to phase construction of the IHS such that the first storage vault is completed (i.e., operational) prior to completing construction of the remaining vault(s).
  - Even with a phased construction approach for the IHS, HLW treatment operations will be extremely limited until the first IHS storage vault is operational.
- Beginning in FY 2042, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B, even after deleting the annual costs to operate the LAWST Facility.
- Through FY 2041, there will have been approximately $2.8B accrued in unused funding (after funding annual operations and completion of the HLW, IHS, and HSF projects).
  - This funding could possibly be used to construct a new ETF; however; it is not nearly enough to construct the full capacity LAWST facility assumed by the WRPS process model (10 melter capacity) that has an estimated construction cost of approximately $15B in FY 2020 dollars.
- The absence of a LAWST Facility, or even the possible construction of a much smaller LAWST facility, has a significant impact on LAW and HLW treatment rates, and a corresponding significant impact on the duration of the LAW and HLW treatment mission and resultant LCCs. Without additional process modeling, these impacts and costs cannot be estimated at this time.

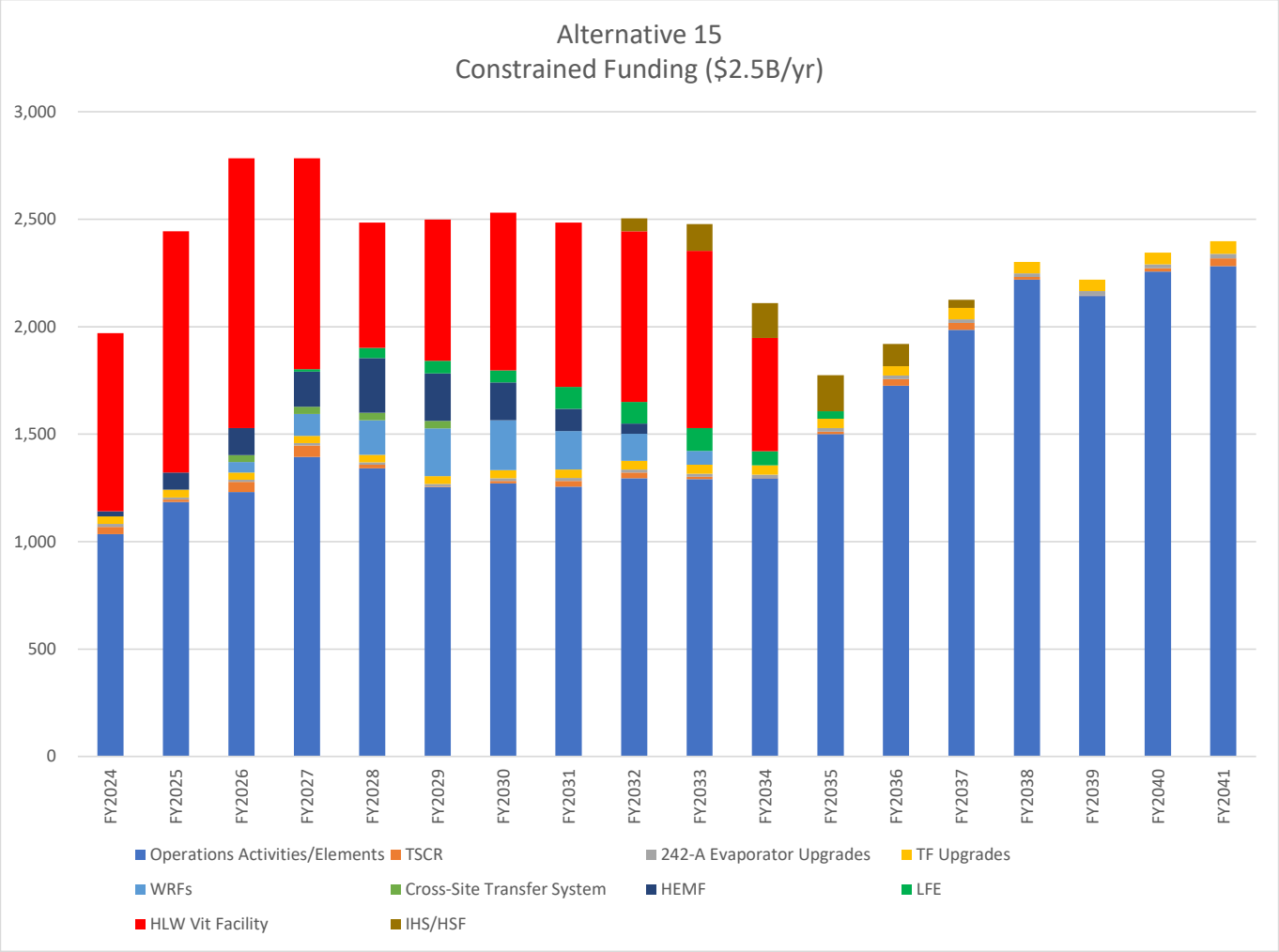


Figure 38: Alternative 15 Constrained Funding Analysis

5.6 Alternative 16

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- LAWST Facility construction is deferred pending available funding after HLW processing operations are started.
- TSCR operations and Capital Costs were adjusted to reflect the lower LAW pretreatment rate without the LAWST Facility. In order to approximate the TSCR cost profile for this alternative, it is assumed to be the same as the TSCR cost profile in the WRPS cost model for Alternative 17, which does not include the LAWST Facility.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.

- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- HEMF project is completed as currently planned in the WRPS cost model (completed by FY 2032).
- LFE project is completed as currently planned in the WRPS cost model (completed in FY 2035).
- Remaining available funding is used to support completion of the HLW Vitrification Facility (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification Facility is completed in FY 2034 and operations are assumed to start in FY 2035, to the extent possible, pending completion of adequate IHS storage capacity (see below).
- Funding does not become available until FY 2034 to start the HSF and IHS projects. These projects can be completed over a six-year duration, with completion in FY 2039.
  - It may be possible to phase construction of the IHS such that the first storage vault is completed (i.e., operational) prior to completing construction of the remaining vault(s).
  - Even with a phased construction approach for the IHS, HLW treatment operations will be extremely limited until the first IHS storage vault is operational.
- Beginning in FY 2041, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B, even after deleting the annual costs to operate the LAWST facilities.
- Through FY 2040, there will have been approximately $2.1B accrued in unused funding (after funding annual operations and completion of the HLW, IHS, and HSF projects).
  - This funding could possibly be used to construct a new ETF; however, it is not nearly enough to construct the full capacity LAWST facility assumed by the WRPS process model (10 melter capacity) that has an estimated construction cost of approximately $15B in FY 2020 dollars.
- The absence of a LAWST Facility, or even the possible construction of a much smaller LAWST Facility, has a significant impact on LAW and HLW treatment rates, and a corresponding significant impact on the duration of the LAW and HLW treatment mission and resultant LCCs. Without additional process modeling, these impacts and costs cannot be estimated at this time.

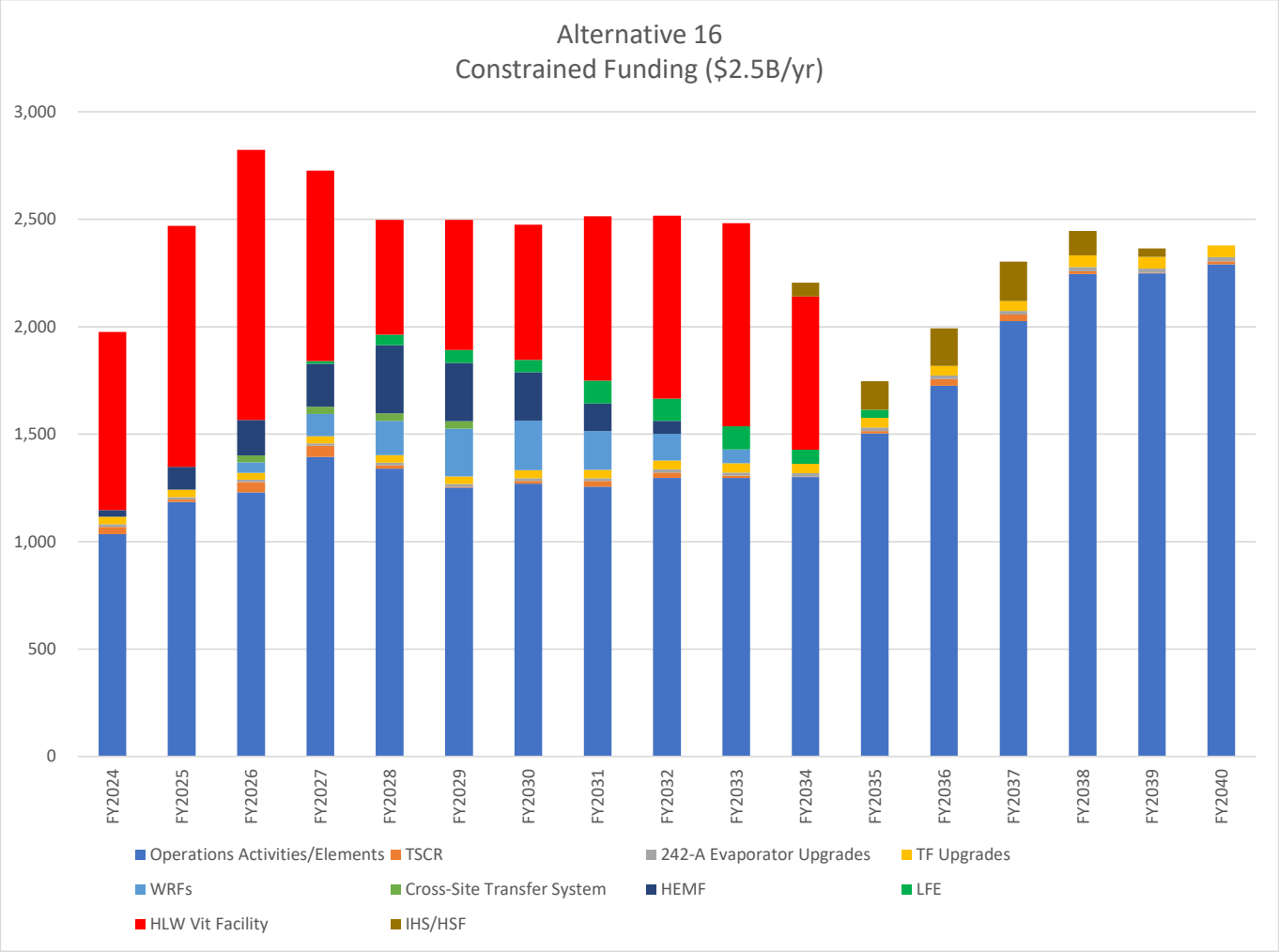


Figure 39: Alternative 16 Constrained Funding Analysis

5.7 Alternative 17

Assumptions

- DFLAW project is completed within the current cost and schedule baseline (including modifications to the ETF needed to support DFLAW operations), and DFLAW operations begin in FY 2024, in accordance with current ORP priorities.
- Tank Farm operations are funded, and expenditures occur, as currently planned in the WRPS cost model, including tank retrievals.
- 242-A Evaporator and Tank Farm Upgrade projects are funded as currently planned in the WRPS cost model.
- East and West Area WRF projects are accelerated from the dates assumed in the WRPS cost model, with both facilities being completed by the end of FY 2033. The WRF projects are assumed to be completed concurrently (one major project) over an 8-year duration.
- Cross-site Transfer Lines (both Supernate and Slurry) are re-activated, along with any potentially needed refurbishments over a 4-year duration (FY 2026 – FY 2029).
- WTV Facility project is completed as currently planned in the WRPS cost model (completed by FY 2032).

- Remaining available funding is used to support completion of the HLW Vitrification Facility (as well as additional work needed to complete BOF and LAB). This work occurs over a duration determined using a spend plan that makes maximum use of remaining available funding.

Results

- HLW Vitrification Facility is completed in FY 2033 and operations are assumed to start in FY 2034.
- Funding is available to complete the HSF and IHS projects by FY 2033.
- Beginning in FY 2052, the annual costs projected by the WRPS cost model will begin to exceed the annual funding cap of $2.5B.
- Through FY 2051, there will have been approximately $10.5B accrued in unused funding (after funding annual operations and completion of the HLW, IHS, and HSF projects).

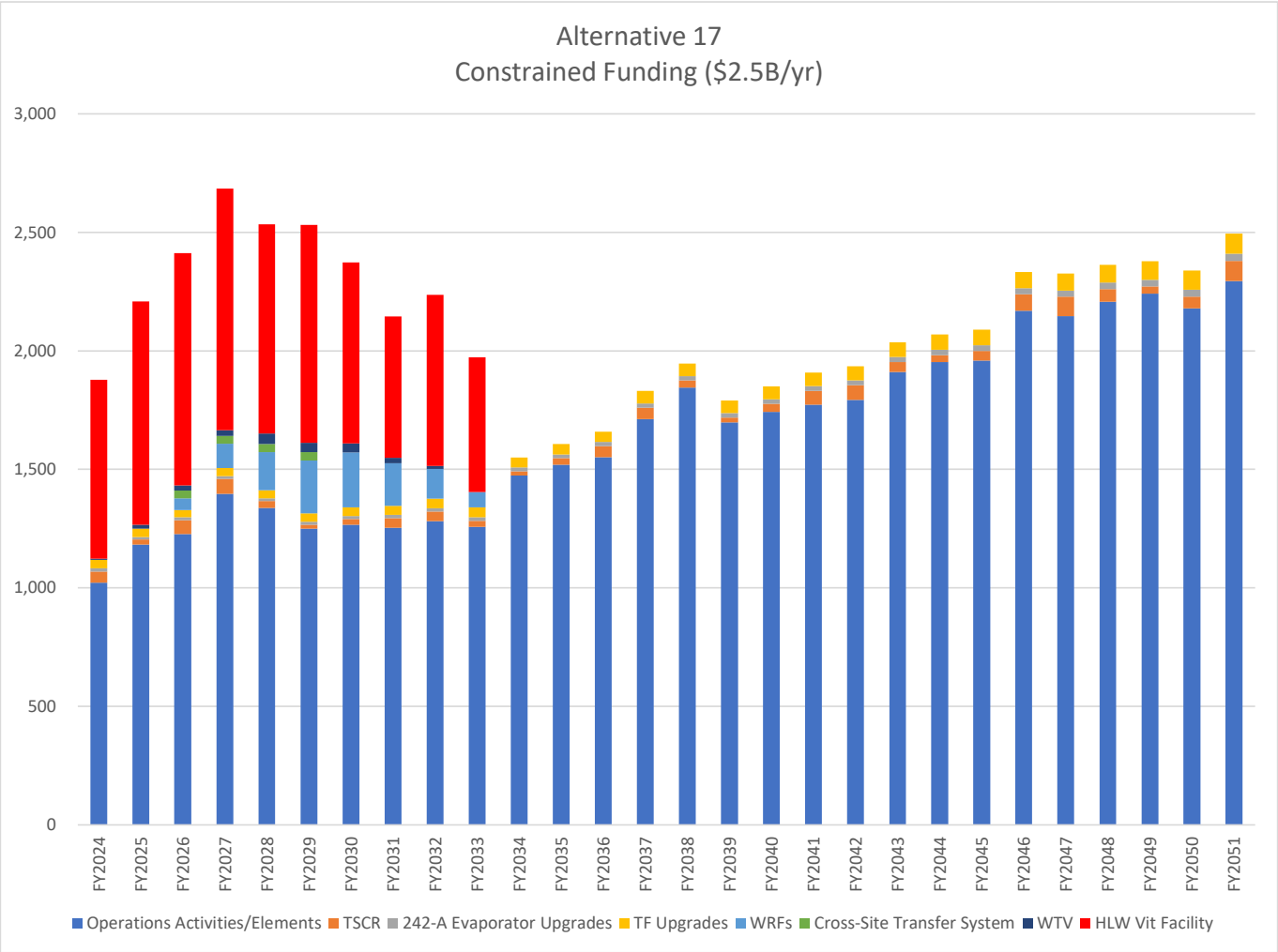


Figure 40: Alternative 17 Constrained Funding Analysis

APPENDIX F: RISK ANALYSIS

1 Project / Technical Threats (Unconstrained Case)

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T1	Lack of maturity of proposed HLW processing critical science and technologies results in delays to the start of HLW and LAW treatment due to (1) additional time required for technology development and testing, (2) additional time required to incorporate design and flowsheet margin to accommodate uncertainty in the efficacy of the technology, and (3) additional time required to make new technologies and science compatible with existing structures, systems, and components.	1	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; most complex alternative, technology maturity issues have been evaluated and designs completed. Consequence: The consequence of occurrence is critical; mixer pumps/pulse jet mixers being tested at full scale with simulant with high solid particles - could be critical, DNFSB technical issues with PT have been resolved but not closed, solids processing technology is key issue.	Early start of critical technology review, early start of cold commissioning.	Very Low	Critical	Low
		2	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is marginal; preparation facility, no filtration.				
		5	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; high solids vessels in PT facility are not used for mixing solids. Consequence: The consequence of occurrence is critical; mixer pumps/pulse jet mixers being tested at full scale with simulant with high solid particles - could be critical, DNFSB technical issues with PT have been resolved but not closed, solids processing technology is key issue.				
		14	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is significant; preparation facility, ability to change design/size of facility, solids processing technology is key issue.				
		15	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is significant; no preparation facility, no filtration, use of DSTs for settling/decant.				
		16	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is marginal; no preparation facility, no filtration, use of DSTs for settling/decant.				
		17	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is marginal; no preparation facility, no filtration, use of DSTs for settle/decant.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T2	Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document, etc.) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan, etc.) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects, impacting the schedule and cost for completing treatment facility/system design, construction, startup and commissioning.	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; execution approach has already been revised. Consequence: The consequence of occurrence is significant; slightly higher impact based on complexity of facilities/PT facility interface.	Accept.	Moderate	Significant	Moderate
		2	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is marginal; more flexibility to accommodate changes in mission and project execution requirements with new facilities.	Accept.	Very High	Marginal	Moderate
		5	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is significant; slightly higher impact based on complexity of facilities/PT facility interface.	Accept.	Very High	Significant	High
		14	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is marginal; more flexibility to accommodate changes in mission and project execution requirements with new facilities.	Accept.	Very High	Marginal	Moderate
		15	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is marginal; more flexibility to accommodate changes in mission and project execution requirements with new facilities.	Accept.	Very High	Marginal	Moderate
		16	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is marginal; more flexibility to accommodate changes in mission and project execution requirements with new facilities.	Accept.	Very High	Marginal	Moderate
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is critical; limited flexibility to accommodate changes due to simplistic approach, scope impacts could be substantial, increases complexity.	Accept.	Very High	Critical	Very High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T3	Unanticipated changes in the code of record for HLW processing projects result in design changes and increased project costs and schedule delays.	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; while there is high certainty the code of record will change, unanticipated changes for the PT facility are moderate. Consequence: The consequence of occurrence is significant; will require redesign of the PT facility.	Assess design to current codes and standards, conduct a gap analysis, address gaps, and/or lock the code of record and realign at hot commissioning.	Moderate	Significant	Moderate
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; changes in the code of record are anticipated. Consequence: The consequence of occurrence is marginal; new structures have more ability to accommodate unanticipated changes and revise design.				
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; unanticipated changes for the PT facility are moderate. Consequence: The consequence of occurrence is significant; will require redesign of the PT facility.	Assess design to current codes and standards, conduct a gap analysis, address gaps, and/or lock the code of record and realign at hot commissioning.	Moderate	Significant	Moderate
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; changes in the code of record are anticipated. Consequence: The consequence of occurrence is marginal; new structures have more ability to accommodate unanticipated changes and revise design.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; pre-treatment is occurring DSTs and the code of record for DSTs is outdated. Consequence: The consequence of occurrence is marginal; new structures have more ability to accommodate unanticipated changes and revise design.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; pre-treatment is occurring DSTs and the code of record for DSTs is outdated. Consequence: The consequence of occurrence is marginal; new structures have more ability to accommodate unanticipated changes and revise design.				
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; only washing in DSTs (no leaching) so the likelihood is lower than Alternatives 15 and 16; erosion and corrosion is remains relevant. Consequence: The consequence of occurrence is marginal; reliance on DST system; includes mixer pumps added to DSTs to mobilize waste.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T4	Changes in the safety basis for HLW processing facilities result in design changes, increased project costs, and schedule delays.	1	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is marginal; hazard category and seismic levels will not change.				
		2	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is marginal; hazard category and seismic levels will not change, new facilities designed to Hazard Category 2.				
		5	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is marginal; hazard category and seismic levels will not change.				
		14	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is marginal; hazard category and seismic levels will not change, new facilities designed to Hazard Category 2.				
		15	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is critical; new facilities designed to Hazard Category 2, new processing activities planned for DSTs requires changes to the safety basis, DST system is old and radiologically-contaminated increasing the difficulty of safety basis changes.	Accept.	Low	Critical	Moderate
		16	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is critical; new facilities designed to Hazard Category 2, new processing activities planned for DSTs requires changes to the safety basis, DST system is old and radiologically-contaminated increasing the difficulty of safety basis changes.	Accept.	Low	Critical	Moderate

			Pre-Mitigation						Post-Mitigation	
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
		17	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is critical; new processing activities planned for DSTs requires changes to the safety basis, DST system is old and radiologically-contaminated increasing the difficulty of safety basis changes.	Accept.	Low	Critical	Moderate

			Pre-Mitigation						Post-Mitigation	
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T5	System interfaces between HLW processing facilities and Tank Farms and WTP facilities are complex and not well-defined resulting in design, construction, startup and commissioning schedule delays and higher project and life-cycle costs.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; system interfaces are complex but well-defined; no changes to functional requirements for existing facilities, controls and requirements for existing facilities are understood with the exception of the TWCS facility. Consequence: The consequence of occurrence is significant; interface complexity will be better understood after DFLAW, impacts apply mostly in startup and commissioning.				
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; more complex, larger new facility.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for the repurposed PT facility are not clearly defined, documented and understood. Consequence: The consequence of occurrence is significant; repurposing the PT facility is more complex.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; more complex, larger new facility.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; impacts remain significant despite simplicity of new facilities.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; impacts remain significant despite simplicity of new facilities.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		17	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; system interfaces are more straightforward. Consequence: The consequence of occurrence is significant; impacts remain significant, interface between Waste Transfer Vault and HLW facility requires development of acceptance criteria for DFHLW.				

			Pre-Mitigation						Post-Mitigation	
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T6	Safety incidents associated with HLW pretreatment and treatment facility construction activities result in delays in project completion.	1	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		2	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		5	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		14	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		15	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		16	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; historical evidence is low probability of construction-related safety incidents, even lower likelihood based on limited construction. Consequence: The consequence of occurrence is negligible; limited construction volume to impact.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T7	Delays in completing construction of the Pretreatment (PT) Facility, and/or the HLW Vitrification Facility, and/or completing facility modifications to address previously identified DNFSB technical and safety issues (e.g., including nuclear safety criticality technical issue [TI] for high density solids), result in delays in facility hot operations and in the overall HLW treatment schedule, and increases in project and lifecycle costs.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; slightly higher likelihood due to alternative using the PT facility and HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is significant; slightly higher impact to address technical issues associated with PT facility and HLW facility.				
		2	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		5	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; slightly higher likelihood due to alternative using the PT facility and HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is significant; slightly higher impact to address technical issues associated with PT facility and HLW facility.				
		14	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		15	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		16	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		17	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T8	The facility modifications that are required to segregate the LAW and HLW pretreatment functions within the PT Facility or "repurpose" its use (i.e., to serve a purpose that was not intended nor described in the facility technical baseline) are more complex than planned resulting in additional facility design changes and delays in hot operations and the overall HLW (and LAW) treatment schedule.	1	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; some facility modifications to implement DNFSB issue resolution but PT facility is not being repurposed. Consequence: The consequence of occurrence is marginal; there are some facility modifications to be made, conceptual design already exists.				
		2	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		5	High	Critical	High	Likelihood: The likelihood of occurrence is high; large volume of equipment to configure in confined spaces increases the likelihood. Consequence: The consequence of occurrence is critical; potentially requires redesign of PT facility configuration (piping, etc.).	Use standard configurations and engineering to reduce design complexity.	Moderate	Critical	Moderate
		14	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		15	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		16	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T9	Site specific conditions (e.g., underground contamination, underground piping, soil conditions etc.) result in extended schedules and increased costs.	1	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; TWCS facility increases footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of TWCS facility.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		5	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; no new construction, no TWCS facility. Consequence: The consequence of occurrence is marginal; impact is minor with no new construction or expansion of existing footprint.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		17	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; limited new construction. Consequence: The consequence of occurrence is marginal; unknown underground piping between PT facility and HLW facility, Waste Transfer Vault is small and relatively easy to relocate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T10	Control of program and contract management changes required to address completion of HLW pretreatment and treatment facilities is inadequate and delays project completion.	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; TWCS facility is new and introduces changes. Consequence: The consequence of occurrence is significant; control of changes for TWCS facility present significant potential impacts.	Improve configuration management and change control, conduct timely changes, and/or focus on interface and requirements management.	Moderate	Marginal	Low
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is significant; larger, more complex new facility.	Improve configuration management and change control, conduct timely changes, and/or focus on interface and requirements management.	Moderate	Marginal	Low
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; repurposing the PT facility will involve changes but they are manageable. Consequence: The consequence of occurrence is significant; delays due to repurposing of PT facility.	Improve configuration management and change control, conduct timely changes, and/or focus on interface and requirements management.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is significant; larger, more complex new facility.	Improve configuration management and change control, conduct timely changes, and/or focus on interface and requirements management.	Moderate	Marginal	Low
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is marginal; new facilities are smaller, less complex.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is marginal; new facilities are smaller, less complex.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; no repurposing of the PT facility or new facilities. Consequence: The consequence of occurrence is negligible; program and contract management changes are minor and manageable.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T11	Existing equipment aging and obsolescence, inadequate facility layup maintenance, and incomplete as-built documentation resulting from the suspension of PT Facility and HLW Facility construction work, result in schedule delays and increased costs.	1	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood due to use of PT facility. Consequence: The consequence of occurrence is significant; requires removal of existing PT equipment, HLW vitrification equipment accounted for in estimate.	Conduct an early evaluation of equipment. Develop and implement a robust facility equipment inspection and maintenance program with established maintenance criteria and spares (or repair kits) recommendations along with sufficient resource allocation to execute and maintain the program.	High	Marginal	Moderate
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		5	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood due to use of PT facility. Consequence: The consequence of occurrence is marginal; consequence lower than Alternative 1, uses less of existing PT equipment HLW vitrification equipment accounted for in estimate.	Conduct an early evaluation of equipment. Develop and implement a robust facility equipment inspection and maintenance program with established maintenance criteria and spares (or repair kits) recommendations along with sufficient resource allocation to execute and maintain the program.	High	Marginal	Moderate
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T12	Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels resulting in schedule delays and increased project costs.	1	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new TWCS facility to be constructed, PT facility and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		2	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		5	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, PT facility to be reconfigured, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		14	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		17	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly lower likelihood, but still high based on need to complete HLW facility. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases, completing HLW facilities is critical to meeting Consent Decree milestones.	Revise contract incentive structure.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T13	Sufficient numbers of qualified design, construction, startup, and commissioning personnel are not available resulting in delayed project schedules and increased project costs.	1	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; includes completing the PT facility and HLW facility, construction of TWCS facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	High	Significant	Moderate
		2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; includes construction of a new large, complex facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	High	Significant	Moderate
		5	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; includes resources required to repurpose and complete the PT facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	High	Significant	Moderate
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; includes construction of a new large, complex facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	High	Significant	Moderate
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; includes construction of a new facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	High	Significant	Moderate
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; includes construction of a new facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	High	Significant	Moderate
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; least amount of design and construction, still need to complete HLW facility. Consequence: The consequence of occurrence is marginal; least amount of resources required.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T14	Delays in Tank Farm upgrades, including installation of mixer pumps and waste transfer and Tank Farm infrastructure upgrades result in schedule delays and increased costs.	1	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is marginal; less reliance on DTSs minimizes delays to start up.				
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is marginal; less reliance on DTSs minimizes delays to start up.				
		5	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is marginal; less reliance on DTSs minimizes delays to start up.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is marginal; less reliance on DTSs minimizes delays to start up.				
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is significant; reliance on DSTs results in further delays to start up.	Conduct early planning and implementation of upgrades, change priority of infrastructure upgrades.	Low	Significant	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is significant; reliance on DSTs results in further delays to start up.	Conduct early planning and implementation of upgrades, change priority of infrastructure upgrades.	Low	Significant	Low
		17	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; least amount of Tank Farm upgrades required. Consequence: The consequence of occurrence is significant; reliance on DSTs results in further delays to start up.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T15	Delays to upgrades for the Effluent Treatment Facility to treat all HLW secondary liquid effluents result in schedule delays and increased costs.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; lower likelihood because alternative uses the FEP evaporator in the PT facility to manage HLW vitrification effluents. Consequence: The consequence of occurrence is significant; ETF upgrade delays extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.				
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood is slightly higher; includes the use of new evaporator. Consequence: The consequence of occurrence is significant; ETF upgrade delays extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	Low	Significant	Low
		5	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; lower likelihood because alternative uses the FEP evaporator in the PT facility to manage HLW vitrification effluents. Consequence: The consequence of occurrence is significant; ETF upgrade delays extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.				
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes the use of new evaporator. Consequence: The consequence of occurrence is significant; ETF upgrade delays extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	Low	Significant	Low
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes the use of new evaporator. Consequence: The consequence of occurrence is significant; ETF upgrade delays extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	Low	Significant	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes the use of new evaporator. Consequence: The consequence of occurrence is significant; ETF upgrade delays extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	Low	Significant	Low
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; lowest likelihood; no new evaporative capability. Consequence: The consequence of occurrence is negligible; no substantive consequence.				

2 Project / Technical Opportunities (Unconstrained Case)

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
01	Use of already procured material and equipment reduces the capital investment required to construct the facilities needed for new HLW pretreatment or to modify and repurpose the PT Facility.	1	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; capital investment realized with already procured equipment. Consequence: The consequence of occurrence is negligible; no substantive consequence for use of already procured equipment.				
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood to use already procured equipment such as piping. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		5	Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is low; capital investment realized with already procured equipment; some equipment may be used for repurposed PT facility. Consequence: The consequence of occurrence is negligible; no substantive consequence for use of already procured equipment.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood to use already procured equipment such as piping. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		15	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; lower likelihood with smaller facility. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
		16	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; lower likelihood with smaller facility. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; limited new equipment needed; little likelihood of using already procured equipment. Consequence: The consequence of occurrence is negligible; no substantive consequence for use of already procured equipment.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
O2	The BOF facilities have excess design capacity to provide utility and process support capabilities to non-WTP facilities.	1	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; BOF facilities designed to support PT facility. Consequence: The consequence of occurrence is negligible; limited utility and process support capability to be provided to non-WTP facilities.				
		2	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		5	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; slightly higher likelihood of excess design capacity with repurposed PT facility. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		14	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		15	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		16	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; excess capacity with no new facilities. Consequence: The consequence of occurrence is negligible; limited utility and process support capability to be provided to non-WTP facilities.				

3 Operations Threats (Unconstrained Case)

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T1	The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules.	1	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; most demand on 242-A, highest number of campaigns - 179, 4.5/year, increases likelihood of occurrence. Consequence: The consequence of occurrence is critical; impacts retrievals.	Conduct more preventive maintenance, early replacement of key components.	High	Critical	High
		2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; number or evaporator campaigns is 30, 1.6/year. Consequence: The consequence of occurrence is significant; more redundant evaporator capability reduces dependency on 242-A.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	Moderate	Marginal	Low
		5	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; number or evaporator campaigns is 24, 1.6/year. Consequence: The consequence of occurrence is significant; redundant evaporator capability, reduces dependency on 242-A.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	Moderate	Marginal	Low
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; number or evaporator campaigns is 24, 1.6/year. Consequence: The consequence of occurrence is significant; more redundant evaporator capability reduces dependency on 242-A.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		15	High	Critical	High	Likelihood: The likelihood of occurrence is high; number of evaporator campaigns is 56, 1.7/year. Consequence: The consequence of occurrence is critical; limited redundant evaporator capability.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	Moderate	Significant	Moderate
		16	High	Critical	High	Likelihood: The likelihood of occurrence is high; number of evaporator campaigns is 65, 2/year. Consequence: The consequence of occurrence is critical; limited redundant evaporator capability.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	Moderate	Significant	Moderate
		17	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; number of evaporator campaigns is 158, 1.6/year, however mission duration increases likelihood of occurrence. Consequence: The consequence of occurrence is crisis; no redundant evaporator capacity.	Conduct more preventive maintenance, early replacement of key components.	High	Critical	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T2	Startup of the cross-site transfer system is delayed impacting waste transfer from 200 West Area to 200 East Area.	1	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		5	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is negligible; waste feed can be delivered from B complex in case of transfer line delay, transfer line isn't needed until later, mission duration provides some schedule flexibility.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T3	The cross-site transfer lines are unavailable or become unavailable (e.g., plugged) during transfers impacting waste transfer from 200 West Area to 200 East Area.	1	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; based on mission duration which is relatively consistent among alternatives except for Alternative 17. Consequence: The consequence of occurrence is marginal; some buffering capacity in TSCR to continue feeding waste.				
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; based on mission duration which is relatively consistent among alternatives except for Alternative 17. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	Moderate	Marginal	Low
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; based on mission duration which is relatively consistent among alternatives except for Alternative 17. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; based on mission duration which is relatively consistent among alternatives except for Alternative 17. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	Moderate	Marginal	Low
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; based on mission duration which is relatively consistent among alternatives except for Alternative 17. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	Moderate	Marginal	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; based on mission duration which is relatively consistent among alternatives except for Alternative 17. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	Moderate	Marginal	Low
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; higher likelihood than other alternatives based on mission duration. Consequence: The consequence of occurrence is negligible; use of a single melter provides extended duration for recovery; East area acts as a buffer to maintain operations.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T4	The Tank Farms' waste feed delivery infrastructure (e.g., pumps, valves, waste receipt facility, etc.) is unable to meet the required waste retrieval production and the feed delivery rate for HLW processing, increasing mission duration and costs.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is lower due to large buffering capacity provided by TWCS facility and pretreatment tanks. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.				
		2	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is lower due to large buffering capacity provided by HFPEM facility and pretreatment tanks. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.				
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on use of smaller pretreatment tanks. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Low	Significant	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on use of smaller pretreatment tanks. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Low	Significant	Low
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood based on use of smaller pretreatment tanks/buffer; single point failure (AP 101, 102, 103). Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Moderate	Significant	Moderate
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood based on use of smaller pretreatment tanks/buffer; single point failure (AP 101, 102, 103). Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Moderate	Significant	Moderate
		17	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; limited staging/storage capability, buffer; single point failure (AP 101, 102, 103). Consequence: The consequence of occurrence is marginal; lower consequence due to extended mission duration.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T5	The 222-S Laboratory facility availability is less than that assumed, resulting in delays in HLW waste characterization and associated delays in waste retrieval and waste transfer schedules.	1	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; slightly lower likelihood of occurrence because pretreatment process control samples go to WTP Analytical Laboratory. Consequence: The consequence of occurrence is marginal; more pretreatment; characterized feed staged/buffering capability; fewer samples, characterize larger batches.				
		2	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; characterized feed staged/buffering capability, large batch sizes; fewer samples.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory.	Moderate	Marginal	Low
		5	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; process control samples go to WTP Analytical Laboratory; characterization sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; smaller tanks, less buffer.				
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization and process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is significant; small batch sizes and a higher number of process control samples, less buffer space (tank size), characterization delays would lead to unavailability of feed.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory. [Note: small batch size and higher number of process control samples keeps post mitigation consequence significant for a post mitigation risk of moderate.]	Moderate	Significant	Moderate
		15	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization and process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; larger feed tanks, more buffer.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory.	Moderate	Marginal	Low
		16	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization and process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; larger feed tanks, more buffer.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory.	Moderate	Marginal	Low
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; characterization and more limited process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; infrequent sample requirements due to low processing rate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T6	The WTP Analytical Laboratory functionality or throughput is less than adequate and unable to support waste performance and internal process control sample analyses, requiring modifications to the existing Analytical Laboratory, or the construction of additional analytical laboratory facilities, delaying HLW processing operations and requiring additional project and lifecycle costs.	1	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; WTP Analytical Laboratory capacity designed for HLW facility and PT facility. Consequence: The consequence of occurrence is marginal; no differentiable impact among alternatives.				
		2	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S.				
		5	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; WTP Analytical Laboratory capacity designed for HLW facility and PT facility. Consequence: The consequence of occurrence is marginal; no differentiable impact among alternatives.				
		14	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S.				
		15	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S				
		16	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists; slow processing rate. Consequence: The consequence of occurrence is negligible; sampling in 222-S; slow processing rate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T7	A leak or other failure in a DST (excluding AP 105, 106, 107 and 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.	1	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is marginal; largest DST margin; buffer capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		2	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is marginal; buffer capacity with 7 tanks.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		5	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is significant; some flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is significant; some flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; impacts use of DSTs for washing/leaching, least/limited flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; impacts use of DSTs for washing/leaching, least/limited flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; impacts use of DSTs for washing/leaching, least/limited flexibility in DST space capacity.	Build more DSTs. [Note: Based on the mission duration, building more DSTs is included in the cost estimate for Alternative 17.]	Very High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T8	HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges) resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; lower likelihood because DSTs are not used for pretreatment. Consequence: The consequence of occurrence is significant; sluicers could be used to retrieve solids.	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Marginal	Low
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; lower likelihood because DSTs are not used for pretreatment. Consequence: The consequence of occurrence is significant; sluicers could be used to retrieve solids.	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Marginal	Low
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; lower likelihood because DSTs are not used for pretreatment. Consequence: The consequence of occurrence is significant; sluicers could be used to retrieve solids.	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
	LAW) treatment schedule and an increase in lifecycle costs.	14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; lower likelihood because DSTs are not used for pretreatment. Consequence: The consequence of occurrence is significant; sluicers could be used to retrieve solids.	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate
		15	High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood of occurrence based on use of mixer pumps in DSTs; increases temperature, vibration and stress in tanks. Consequence: The consequence of occurrence is crisis; consequence is higher than other alternatives based on use DSTs for pretreatment, may involve stoppage of mixer use in DSTs if a failure occurred, mixer pump viability and feed delivery technology become questionable..	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate
		16	High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood of occurrence based on use of mixer pumps in DSTs; increases temperature, vibration and stress in tanks. Consequence: The consequence of occurrence is crisis; consequence is higher than other alternatives based on use DSTs for pretreatment, may involve stoppage of mixer use in DSTs if a failure occurred, mixer pump viability and feed delivery technology become questionable..	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate
		17	High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood of occurrence based on use of mixer pumps in DSTs; increases temperature, vibration and stress in tanks. Consequence: The consequence of occurrence is crisis; consequence is higher than other alternatives based on use DSTs for pretreatment, may involve stoppage of mixer use in DSTs if a failure occurred, mixer pump viability and feed delivery technology become questionable..	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T9	HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations, etc.) which results in extended mission duration and increased costs.	1	High	Critical	High	Likelihood: The likelihood of occurrence is high; higher likelihood than other alternatives due to black cell technology in PT and PT is rate limiting step. Consequence: The consequence of occurrence is critical; black cell and technology limitations; complex operation.	Accept.	High	Critical	High
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; more standard technology (similar to SRS) without black cell technology, designed with new glass model. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Moderate	Significant	Moderate
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; more standard technology (similar to SRS) without black cell technology, designed with new glass model. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Moderate	Significant	Moderate
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; more standard technology (similar to SRS) without black cell technology, designed with new glass model. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Moderate	Significant	Moderate
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; more standard technology (similar to SRS) without black cell technology, designed with new glass model. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Moderate	Significant	Moderate
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; more standard technology (similar to SRS) without black cell technology, designed with new glass model. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Moderate	Significant	Moderate
		17	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; constrained due to LAW and not HLW, need to evaporate excess water from dilute feeds, single melter to maintain. Consequence: The consequence of occurrence is marginal; significant melter idling, second melter on hand to use as an installed spare providing redundancy.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T10	A leak or other failure in a DST (AP 105, AP 106, AP 107 or AP 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is significant; can pretreat supernate in PT facility.	Use other DSTs for redundancy.	Moderate	Marginal	Low
		2	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
	the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.	5	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	Moderate	Marginal	Low
		14	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	Moderate	Marginal	Low
		15	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	Moderate	Marginal	Low
		16	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	Moderate	Marginal	Low
		17	High	Critical	High	Likelihood: The likelihood of occurrence is high; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is longer based on mission duration. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Build more DSTs.	High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T11	The BOF facilities as designed and constructed do not provide the necessary utility and process support capabilities to serve WTP facilities needed for HLW feed sampling, characterization, staging and pretreatment, requiring modifications to the existing BOF facilities or construction of new supplemental BOF facilities, delaying HLW processing operations and increasing project and lifecycle costs.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; BOF facilities are designed to provide required utility and process support. Consequence: The consequence of occurrence is significant; build new facilities; no differentiable difference in impact among alternatives.				
		2	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; slightly lower likelihood; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is significant; build new facilities; no differentiable difference in impact among alternatives.				
		5	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; BOF facilities are designed to provide required utility and process support. Consequence: The consequence of occurrence is significant; build new facilities; no differentiable difference in impact among alternatives.				
		14	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; slightly lower likelihood; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives.				
		15	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; slightly lower likelihood; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is significant; build new facilities; no differentiable difference in impact among alternatives.				
		16	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; slightly lower likelihood; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is significant; build new facilities; no differentiable difference in impact among alternatives.				
		17	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is significant; build new facilities; no differentiable difference in impact among alternatives.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T12	The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and immobilization. Design life extension studies and authorizations are more complex than anticipated resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission.	1	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to mission duration - 2084; pretreatment capacity is limiting. Consequence: The consequence of occurrence is critical; HLW mission duration exceeds WTP design life.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	High	Significant	Moderate
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; HLW facility design life falls within mission duration.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Moderate	Marginal	Low
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; HLW facility design life falls within mission duration.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; HLW facility design life falls within mission duration.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; HLW facility design life falls within mission duration.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Moderate	Marginal	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; HLW facility design life falls within mission duration.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Moderate	Marginal	Low
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; highest likelihood based on mission duration - 2168+. Consequence: The consequence of occurrence is critical; mission life of DSTs.	New facilities planned at 50-60 years of original facilities design life.	Very High	Significant	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T13	The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply, etc.) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs.	1	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to mission duration - 2084. Consequence: The consequence of occurrence is significant; requires upgrade to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	High	Marginal	Moderate
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; requires upgrade to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Moderate	Marginal	Low
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; requires upgrade to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; requires upgrade to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Moderate	Marginal	Low
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; requires upgrade to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Moderate	Marginal	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; Alternatives 2, 5, 14, 15, and 16 all have relatively same mission duration - completion in 2061 - 2064. Consequence: The consequence of occurrence is significant; requires upgrade to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Moderate	Marginal	Low
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; highest likelihood based on mission duration - 2168+. Consequence: The consequence of occurrence is significant; requires multiple upgrades to sitewide infrastructure utilities and services over a much longer period of time.	Conduct advance planning and prepare a sitewide infrastructure plan.	Very High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T14	The skills mix and labor availability to support LAW and HLW processing in parallel are inadequate resulting in delays to scheduled activities and extending mission execution.	1	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal;				
		5	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Post-Mitigation Mitigation	Likelihood	Consequence	Risk Level
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; slow operations rate; reduced number of resources required. Consequence: The consequence of occurrence is negligible; no LAW supplemental treatment.				

4 Operations Opportunities (Unconstrained Case)

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Post-Mitigation Mitigation	Likelihood	Consequence	Risk Level
O1	Glass waste loading improvements can be made by alternate glass formulations. Additional glass modeling of the HLW melters may be able to demonstrate that higher undissolved Al concentrations can be tolerated in the feed while still producing glass meeting the IHLW waste acceptance criteria, and without significantly increasing the number of IHLW canisters produced. Changes in the Al limits may reduce or eliminate the need for caustic leaching, which could reduce the scope and cost of the HLW pretreatment facilities.	1	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized; rate limiting by PT.				
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		5	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		17	Moderate	Negligible	Very Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is negligible; improvements already being realized, limited by lack of leaching.				

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Post-Mitigation Mitigation	Likelihood	Consequence	Risk Level
O2	Operating efficiency is higher than similar nuclear waste treatment facilities accelerating HLW mission completion with reduced lifecycle costs..	1	Low	Optimal	Moderate	Likelihood: The likelihood of occurrence is low; lower likelihood compared to other alternatives due to PT facility complexity. Consequence: The consequence of occurrence is optimal; waste loading requirements; waste feed delivery; built in capacity; redundancy in delivery system.				
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; melters typically operate at 40% or less due to waste feed delivery issues; based on ORP studies, improved operating efficiency is achievable. Consequence: The consequence of occurrence is significant; TF, WTP and ETF efficiencies potentially realized.				
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; melters typically operate at 40% or less due to waste feed delivery issues; based on ORP studies, improved operating efficiency is achievable. Consequence: The consequence of occurrence is significant; TF, WTP and ETF efficiencies potentially realized.				
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; melters typically operate at 40% or less due to waste feed delivery issues; based on ORP studies, improved operating efficiency is achievable. Consequence: The consequence of occurrence is significant; TF, WTP and ETF efficiencies potentially realized.				
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; melters typically operate at 40% or less due to waste feed delivery issues. Consequence: The consequence of occurrence is significant;				

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Post-Mitigation Mitigation	Likelihood	Consequence	Risk Level
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; melters typically operate at 40% or less due to waste feed delivery issues; based on ORP studies, improved operating efficiency is achievable. Consequence: The consequence of occurrence is significant; TF, WTP and ETF efficiencies potentially realized.				
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to mission duration. Consequence: The consequence of occurrence is negligible; idle time; DST space limitation; most benefit by gaining LAW capacity/availability.				

5 Programmatic Threats (Unconstrained Case)

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Post-Mitigation Mitigation	Likelihood	Consequence	Risk Level
T1	Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules, and subsequent processing schedules and associated costs.	1	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; responding to permit requirements are built into design; least deviation from intended purpose, permit required for TWCS facility. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives; PT facility will require a new ventilation air permit.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation.	Moderate	Critical	Moderate
		2	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to change in flowsheet. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		5	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; responding to permit requirements are built into design; minor deviation from intended purpose, no TWCS facility to permit. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives; PT facility will require a new ventilation air permit.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation ; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	Moderate	Critical	Moderate
		14	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to change in flowsheet, use of DSTs. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; involves use of DSTs for different purpose than originally intended including washing and leaching. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; involves use of DSTs for different purpose than originally intended including washing and leaching. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		17	High	Critical	High	Likelihood: The likelihood of occurrence is high; DST being used for washing only. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T2	The start of Direct-Feed LAW (DFLAW) is delayed (e.g., due to regulatory approvals, funding shortfalls or other project issues) resulting in delays to HLW operations.	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is significant; lower impact as operations can continue at reduced throughput, extra tanks, no return to TF - managed in WTP.	Accept.	Moderate	Significant	Moderate
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is significant; lower impact as operations can continue at reduced throughput, extra tanks.	Accept.	Moderate	Significant	Moderate
		5	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		14	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		15	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		16	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		17	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is significant; a two-year delay can be tolerated.	Accept.	Moderate	Critical	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T3	Safety events outside of the LAW and HLW pretreatment and treatment construction zones (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW treatment projects and the implementation of additional engineered and administrative controls. leading to delays in project completion and in increased project costs.	1	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		5	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is the same for all alternatives due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T4	Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and	1	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; safety events occur every 5 - 7 years, slightly higher likelihood based on a 20-year longer operations duration. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	High	Significant	Moderate

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
	HLW processing operations and the implementation of additional engineered and administrative controls leading to delays in operations and in increased lifecycle costs.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; safety events occur every 5 - 7 years, shorter operations duration; probability of a safety event is lower. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Moderate	Significant	Moderate
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; safety events occur every 5 - 7 years, shorter operations duration; probability of a safety event is lower. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Moderate	Significant	Moderate
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; safety events occur every 5 - 7 years, shorter operations duration; probability of a safety event is lower. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Moderate	Significant	Moderate
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; safety events occur every 5 - 7 years, shorter operations duration; probability of a safety event is lower. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Moderate	Significant	Moderate
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; safety events occur every 5 - 7 years, shorter operations duration; probability of a safety event is lower. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Moderate	Significant	Moderate
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; safety events occur every 5 - 7 years, extensive operations duration significantly raises the probability of a safety event. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Very High	Significant	High

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T5	Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved nuclear quality assurance [NQA-1] program, vendor competency and quality of work, long lead procurements, etc.) adversely impact procurement costs and schedules, mission duration and lifecycle costs.	1	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; slightly higher likelihood, additional 20-year mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	High	Significant	Moderate
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; shorter mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Moderate	Significant	Moderate
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; shorter mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Moderate	Significant	Moderate
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; shorter mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Moderate	Significant	Moderate
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; shorter mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Moderate	Significant	Moderate
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; shorter mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; significantly longer mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Very High	Significant	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T6	Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities resulting in extended HLW treatment mission duration and increased costs.	1	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $34 - $46B range. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		2	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $34 - $46B range. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		5	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $34 - $46B range. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		14	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $34 - $46B range. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		15	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $34 - $46B range. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		16	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $34 - $46B range. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		17	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; substantially lower TPC than other alternatives; reduced peak demand. Consequence: The consequence of occurrence is significant; there is schedule flexibility.	Lower cost provides more flexibility to reallocate funding to reduce risk.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T7	The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current Amended Consent Decree (ACD) and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes.	1	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; complies with ACD; no substantive change in PT facility configuration. Consequence: The consequence of occurrence is significant; while it does not deviate significantly from ACD, pause/delay in PT and HLW will require negotiation.	Commence ACD negotiations early and maintain communication on changes/revisions.	Moderate	Significant	Moderate
		2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; pretreatment capability addressed in a different facility (other than the PT facility); ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is significant; requires significant negotiations based on changes/revisions.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Significant	High
		5	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is significant; requires significant negotiations based on changes/revisions.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Significant	High
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is significant; requires significant negotiations based on changes/revisions.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Significant	High
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; not all pre-treatment capability is provided; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is critical; greater deviation from capability, capacity and configuration, no pretreatment capability.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Critical	Very High
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; not all pre-treatment capability is provided; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is critical; greater deviation from capability, capacity and configuration, no pretreatment capability.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Critical	Very High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is critical; single melter, no pretreatment capability, longer operations, more extensive negotiations.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Critical	Very High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T8	The National Geologic Repository, and/or the supporting HLW transportation infrastructure, is not available to allow the shipment of IHLW canisters by the date assumed for planning purposes (i.e. mid 2030's) requiring construction and operation of additional Interim Hanford Storage (IHS) facilities increasing capital investment and lifecycle costs.	1	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		2	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		5	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		14	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		15	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		16	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		17	Very High	Negligible	Low	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is negligible; reduced number of cannisters produced at a slower rate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T9	Changes in the waste acceptance criteria and/or packaging requirements for IHLW disposal lead to additional HLW feed pretreatment requirements and potential changes to HLW glass formulation resulting in design changes to the HLW pretreatment facilities and causing delays in project and treatment schedules and increases in design/construction and operations costs.	1	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; may include changes to packaging requirements and/or allowable radionuclide content. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.				
		2	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; may include changes to packaging requirements and/or allowable radionuclide content. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.				
		5	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; may include changes to packaging requirements and/or allowable radionuclide content. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.				
		14	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; may include changes to packaging requirements and/or allowable radionuclide content. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.				

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Consequence	Risk Level
		15	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; may include changes to packaging requirements and/or allowable radionuclide content. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.				
		16	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; may include changes to packaging requirements and/or allowable radionuclide content. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.				
		17	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood than other alternatives based on mission duration. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.	Accept.	Moderate	Critical	Moderate

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Consequence	Risk Level
T10	New DOE directives/policies or external regulations result in Tank Farm or other non-WTP facility design changes or upgrades, reducing funding availability for design, construction, startup, commissioning, and operations of facilities required for the tank waste treatment mission.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is low for all alternatives (except for Alternative 17 due to duration); historically DOE directives/policies have not changed significantly. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		2	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is low for all alternatives (except for Alternative 17 due to duration); historically DOE directives/policies have not changed significantly. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		5	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is low for all alternatives (except for Alternative 17 due to duration); historically DOE directives/policies have not changed significantly. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		14	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is low for all alternatives (except for Alternative 17 due to duration); historically DOE directives/policies have not changed significantly. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		15	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is low for all alternatives (except for Alternative 17 due to duration); historically DOE directives/policies have not changed significantly. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		16	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is low for all alternatives (except for Alternative 17 due to duration); historically DOE directives/policies have not changed significantly. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		17	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood than other alternatives due to mission duration. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Accept.	High	Significant	Moderate

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Consequence	Risk Level
T11	The design, construction, startup, commissioning and operation of HLW pretreatment and treatment facilities are delayed due to issues raised by external stakeholders (e.g., Defense Nuclear Facility Safety Board [DNFSB], GAO, IG, etc.] extending mission completion and increasing project and lifecycle costs.	1	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; Alternative 1 has been vetted by external stakeholders. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on complexity of alternative. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Develop foundational, historically acceptable designs, and early and continuous engagement with stakeholders.	Moderate	Significant	Moderate
		5	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on complexity of alternative. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Develop foundational, historically acceptable designs, and early and continuous engagement with stakeholders.	Moderate	Significant	Moderate
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on complexity of alternative. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Develop foundational, historically acceptable designs, and early and continuous engagement with stakeholders.	Moderate	Significant	Moderate
		15	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; less complex alternative, smaller in scope, limited new technology. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Consequence	Risk Level
		16	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; less complex alternative, smaller in scope, limited new technology. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		17	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; less complex alternative, smaller in scope, scope limited to DCRT. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Consequence	Risk Level
T12	High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path) which results in increased lifecycle costs.	1	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		5	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate

6 Programmatic Opportunities (Unconstrained Case)

#	Risk Description	Pre-Mitigation Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Consequence	Risk Level
01	A change (or reclassification) in the methodology for classifying waste as HLW in accordance with DOE Order 435.1, or a change in the interpretation of the requirements of the Order, may reduce the volume of tank waste classified as HLW resulting in scaling down the capacity of the HLW pretreatment facilities and the HLW Vitrification Facility, or potentially eliminating some of the functional requirements for these facilities thereby reducing capital and	1	Moderate	Efficient	Moderate	Likelihood: The likelihood of occurrence is moderate; waste reclassification language already published, slightly higher likelihood based on additional 20-year mission. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		2	Low	Efficient	Moderate	Likelihood: The likelihood of occurrence is low; waste reclassification language already published. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		5	Low	Efficient	Moderate	Likelihood: The likelihood of occurrence is low; waste reclassification language already published. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
	operating costs, or reducing mission duration.	14	Low	Efficient	Moderate	Likelihood: The likelihood of occurrence is low; waste reclassification language already published. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		15	Low	Efficient	Moderate	Likelihood: The likelihood of occurrence is low; waste reclassification language already published. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		16	Low	Efficient	Moderate	Likelihood: The likelihood of occurrence is low; waste reclassification language already published. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		17	Moderate	Optimal	High	Likelihood: The likelihood of occurrence is moderate; higher likelihood based on extended mission duration and potential for additional waste reclassification changes. Consequence: The consequence of occurrence is optimal; avoids building replacement facilities based on long duration; reduction in operations duration and lifecycle costs would be even higher (greater than 20%).				

7 Project / Technical Threats (Constrained Case)

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T1	Lack of maturity of proposed HLW processing critical science and technologies results in delays to the start of HLW and LAW treatment due to (1) additional time required for technology development and testing, (2) additional time required to incorporate design and flowsheet margin to accommodate uncertainty in the efficacy of the technology, and (3) additional time required to make new technologies and science compatible with existing structures, systems, and components.	2	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is marginal; preparation facility, no filtration.				
		14	Very Low	Significant	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is significant; preparation facility, ability to change design/size of facility, solids processing technology is key issue.				
		15	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is significant; no preparation facility, no filtration, use of DSTs for settling/decant.				
		16	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is marginal; no preparation facility, no filtration, use of DSTs for settling/decant.				
		17	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; significant amount of testing to date, no new technology. Consequence: The consequence of occurrence is marginal; no preparation facility, no filtration, use of DSTs for settle/decant.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T2	Changes in mission requirements (e.g., RPP Mission Analysis, Program Requirements Document, etc.) and/or project execution requirements (e.g., project functions and requirements, Project Execution Plan, etc.) result in the need to reevaluate the HLW treatment mission, project execution approach, and/or the technical, cost, and schedule baselines for the HLW pretreatment and treatment projects, impacting the schedule and cost for completing treatment facility/system design, construction, startup and commissioning.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is significant; inability to construct LAW supplemental treatment and effluent treatment facility present significant treatment mission and project execution challenges.	Accept.	Very High	Significant	High
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is significant; inability to construct LAW supplemental treatment and effluent treatment facility present significant treatment mission and project execution challenges.	Accept.	Very High	Significant	High
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is significant; inability to construct LAW supplemental treatment and effluent treatment facility present significant treatment mission and project execution challenges.	Accept.	Very High	Significant	High
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is significant; inability to construct LAW supplemental treatment and effluent treatment facility present significant treatment mission and project execution challenges.	Accept.	Very High	Significant	High
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; revises the current execution approach. Consequence: The consequence of occurrence is critical; limited flexibility to accommodate changes due to simplistic approach, scope impacts could be substantial, increases complexity.	Accept.	Very High	Critical	Very High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T3	Unanticipated changes in the code of record for HLW processing projects result in design changes and increased project costs and schedule delays.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; changes in the code of record are anticipated. Consequence: The consequence of occurrence is significant; limited resources and flexibility to accommodate unanticipated changes and revise design.	Increase rigor of design reviews, implement more discipline in freezing the code of record and minimize changes.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; changes in the code of record are anticipated. Consequence: The consequence of occurrence is significant; limited resources and flexibility to accommodate unanticipated changes and revise design.	Increase rigor of design reviews, implement more discipline in freezing the code of record and minimize changes.	Moderate	Marginal	Low
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; pre-treatment is occurring DSTs and the code of record for DSTs is outdated. Consequence: The consequence of occurrence is significant; limited resources and flexibility to accommodate unanticipated changes and revise design.	Increase rigor of design reviews, implement more discipline in freezing the code of record and minimize changes.	Moderate	Marginal	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; pre-treatment is occurring DSTs and the code of record for DSTs is outdated. Consequence: The consequence of occurrence is significant; limited resources and flexibility to accommodate unanticipated changes and revise design.	Increase rigor of design reviews, implement more discipline in freezing the code of record and minimize changes.	Moderate	Marginal	Low
		17	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; only washing in DSTs (no leaching) so the likelihood is lower than Alternatives 15 and 16; erosion and corrosion is remains relevant. Consequence: The consequence of occurrence is significant; limited resources and flexibility to accommodate unanticipated changes and revise design.	Increase rigor of design reviews, implement more discipline in freezing the code of record and minimize changes.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T4	Changes in the safety basis for HLW processing facilities result in design changes, increased project costs, and schedule delays.	2	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is marginal; hazard category and seismic levels will not change, new facilities designed to Hazard Category 2.				
		14	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is marginal; hazard category and seismic levels will not change, new facilities designed to Hazard Category 2.				
		15	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is critical; new facilities designed to Hazard Category 2, new processing activities planned for DSTs requires changes to the safety basis, DST system is old and radiologically-contaminated increasing the difficulty of safety basis changes.	Accept.	Low	Critical	Moderate
		16	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is critical; new facilities designed to Hazard Category 2, new processing activities planned for DSTs requires changes to the safety basis, DST system is old and radiologically-contaminated increasing the difficulty of safety basis changes.	Accept.	Low	Critical	Moderate
		17	Low	Critical	Moderate	Likelihood: The likelihood of occurrence is low; historically the number of safety incidents is minimal, few lost work days, strong safety culture. Consequence: The consequence of occurrence is critical; new processing activities planned for DSTs requires changes to the safety basis, DST system is old and radiologically-contaminated increasing the difficulty of safety basis changes.	Accept.	Low	Critical	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T5	System interfaces between HLW processing facilities and Tank Farms and WTP facilities are complex and not well-defined resulting in design, construction, startup and commissioning schedule delays and higher project and life-cycle costs.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; more complex, larger new facility.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; more complex, larger new facility.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; impacts remain significant despite simplicity of new facilities.	Early identification, definition, and management of interfaces.	Low	Significant	Low

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; the interfaces for proposed new facilities are less defined and understood. Consequence: The consequence of occurrence is significant; impacts remain significant despite simplicity of new facilities.	Early identification, definition, and management of interfaces.	Low	Significant	Low
		17	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; system interfaces are more straightforward. Consequence: The consequence of occurrence is significant; impacts remain significant, interface between Waste Transfer Vault and HLW facility requires development of acceptance criteria for DFHLW without solids leaching.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T6	Safety incidents associated with HLW pretreatment and treatment facility construction activities result in delays in project completion.	2	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		14	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		15	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		16	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; historical evidence is low probability of construction-related safety incidents. Consequence: The consequence of occurrence is marginal; experience with construction-related safety incidents indicates a safety stand downs with minor impacts to cost and schedule.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; historical evidence is low probability of construction-related safety incidents, even lower likelihood based on limited construction. Consequence: The consequence of occurrence is negligible; limited construction volume to impact.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T7	Delays in completing construction of the Pretreatment (PT) Facility, and/or the HLW Vitrification Facility, and/or completing facility modifications to address previously identified DNFSB technical and safety issues (e.g., including nuclear safety criticality technical issue [TI] for high density solids), result in delays in facility hot operations and in the overall HLW treatment schedule, and increases in project and lifecycle costs.	2	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		14	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		15	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		16	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				
		17	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; applies only to HLW facility, previously identified DNFSB issues have been resolved but not closed. Consequence: The consequence of occurrence is marginal; lower impact, requires only addressing HLW facility.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T8	The facility modifications that are required to segregate the LAW and HLW pretreatment functions within the PT Facility or "repurpose" its use (i.e., to serve a purpose that was not intended nor described in the facility technical baseline) are more complex than planned resulting in additional facility design	2	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		14	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		15	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
	changes and delays in hot operations and the overall HLW (and LAW) treatment schedule.	16	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; PT facility not being used. Consequence: The consequence of occurrence is negligible; impact is inconsequential given PT facility is not being used.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T9	Site specific conditions (e.g., underground contamination, underground piping, soil conditions etc.) result in extended schedules and increased costs.	2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; new construction expands footprint. Consequence: The consequence of occurrence is significant; slightly higher impact with delay in construction of new facilities.	Conduct sampling, modeling and rerouting as necessary.	Moderate	Significant	Moderate
		17	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; limited new construction. Consequence: The consequence of occurrence is marginal; unknown underground piping between PT facility and HLW facility, Waste Transfer Vault is small and relatively easy to relocate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T10	Control of program and contract management changes required to address completion of HLW pretreatment and treatment facilities is inadequate and delays project completion.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is significant; larger, more complex new facility.	Improve configuration management and change control, conduct timely changes, and/or focus on interface and requirements management.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is significant; larger, more complex new facility.	Improve configuration management and change control, conduct timely changes, and/or focus on interface and requirements management.	Moderate	Marginal	Low
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is marginal; new facilities are smaller, less complex.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; addition of new facilities presents changes. Consequence: The consequence of occurrence is marginal; new facilities are smaller, less complex.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; no repurposing of the PT facility or new facilities. Consequence: The consequence of occurrence is negligible; program and contract management changes are minor and manageable.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T11	Existing equipment aging and obsolescence, inadequate facility layup maintenance, and incomplete as-built documentation resulting from the suspension of PT Facility and HLW Facility construction work, result in schedule delays and increased costs.	2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment for new facilities. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; limited use of existing equipment. Consequence: The consequence of occurrence is marginal; no use of PT facility; HLW vitrification equipment accounted for in estimate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T12	Contractor performance in planning, managing, and executing design (including errors and omissions), construction, startup, and commissioning is below planned levels resulting in schedule delays and increased project costs.	2	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		14	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; probability is very high based on experience, new facility to be constructed, and HLW facility to be completed. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases.	Revise contract incentive structure, revise acquisition strategy, and/or break up larger projects into multiple smaller, more manageable projects.	High	Significant	Moderate
		17	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly lower likelihood, but still high based on need to complete HLW facility. Consequence: The consequence of occurrence is critical; contractor performance to date has resulted in significant schedule delays and cost increases.	Revise contract incentive structure.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T13	Sufficient numbers of qualified design, construction, startup, and commissioning personnel are not available resulting in delayed project schedules and increased project costs.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes construction of a new large, complex facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	Moderate	Significant	Moderate
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes construction of a new large, complex facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	Moderate	Significant	Moderate
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes construction of a new facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	Moderate	Significant	Moderate
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; includes construction of a new facility, and complete HLW facility. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase hiring incentives, support (funding and services) local trade schools for trades that are in high demand, revise the sequencing of work from single shift to multiple shifts, increase remote support.	Moderate	Significant	Moderate
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; least amount of design and construction, still need to complete HLW facility. Consequence: The consequence of occurrence is marginal; least amount of resources required.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T14	Delays in Tank Farm upgrades, including installation of mixer pumps and waste transfer and Tank Farm infrastructure upgrades result in schedule delays and increased costs.	2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; less resources, tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is marginal; less reliance on DTSs minimizes delays to start up.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; less resources, tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is marginal; less reliance on DTSs minimizes delays to start up.				
		15	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; less resources, tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is significant; reliance on DSTs results in further delays to start up.	Conduct early planning and implementation of upgrades, change priority of infrastructure upgrades.	Low	Significant	Low
		16	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; less resources, tanks to be reconfigured, installation of new pumps, upgrades to pump pits, upgrade to ventilation systems. Consequence: The consequence of occurrence is significant; reliance on DSTs results in further delays to start up.	Conduct early planning and implementation of upgrades, change priority of infrastructure upgrades.	Low	Significant	Low
		17	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; least amount of Tank Farm upgrades required. Consequence: The consequence of occurrence is significant; reliance on DSTs results in further delays to start up.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T15	Delays to upgrades for the Effluent Treatment Facility to treat all HLW secondary liquid effluents result in schedule delays and increased costs.	2	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; constrained funding very likely to delay ETF upgrades. Consequence: The consequence of occurrence is critical; ETF upgrade delays significantly extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	High	Critical	High
		14	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; constrained funding very likely to delay ETF upgrades. Consequence: The consequence of occurrence is critical; ETF upgrade delays significantly extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	High	Critical	High
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; constrained funding very likely to delay ETF upgrades. Consequence: The consequence of occurrence is critical; ETF upgrade delays significantly extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	High	Critical	High
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; constrained funding very likely to delay ETF upgrades. Consequence: The consequence of occurrence is critical; ETF upgrade delays significantly extend the mission; no discernable difference in consequence among alternatives except for Alternative 17.	Conduct early planning and implementation of upgrades, revise priorities for upgrade projects.	High	Critical	High
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; lowest likelihood; no new evaporative capability. Consequence: The consequence of occurrence is negligible; no substantive consequence.				

8 Project / Technical Opportunities (Constrained Case)

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
O1	Use of already procured material and equipment reduces the capital investment required to construct the facilities needed for new HLW pretreatment or to modify and repurpose the PT Facility.	2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood to use already procured equipment such as piping. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood to use already procured equipment such as piping. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		15	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; lower likelihood with smaller facility. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		16	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; lower likelihood with smaller facility. Consequence: The consequence of occurrence is marginal; minimal reduction in capital investment based on limited use of already procured equipment.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; limited new equipment needed; little likelihood of using already procured equipment. Consequence: The consequence of occurrence is negligible; no substantive consequence for use of already procured equipment.				

			Pre-Mitigation						Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
02	The BOF facilities have excess design capacity to provide utility and process support capabilities to non-WTP facilities.	2	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		14	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		15	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		16	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of excess design capacity for alternatives with new facilities. Consequence: The consequence of occurrence is marginal; some utility and process support capability may be provided to non-WTP facilities.				
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; excess capacity with no new facilities. Consequence: The consequence of occurrence is negligible; limited utility and process support capability to be provided to non-WTP facilities.				

9 Operations Threats (Constrained Case)

			Pre-Mitigation						Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T1	The 242-A Evaporator facility availability is less than assumed due to equipment reliability issues or abnormal operational events or accidents, resulting in delays to the planned tank retrieval schedules and/or waste feed delivery schedules.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; mission duration increases likelihood of occurrence. Consequence: The consequence of occurrence is significant; more redundant evaporator capability reduces dependency on 242-A.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	High	Marginal	Moderate
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; mission duration increases likelihood of occurrence. Consequence: The consequence of occurrence is significant; more redundant evaporator capability reduces dependency on 242-A.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	High	Marginal	Moderate
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; mission duration increases likelihood of occurrence. Consequence: The consequence of occurrence is critical; limited redundant evaporator capability.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	High	Significant	Moderate
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; mission duration increases likelihood of occurrence. Consequence: The consequence of occurrence is critical; limited redundant evaporator capability.	Conduct more preventive maintenance, early replacement of key components, and/or rerouting to reduce significant additional load.	High	Significant	Moderate
		17	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; mission duration increases likelihood of occurrence. Consequence: The consequence of occurrence is crisis; no redundant evaporator capacity.	Conduct more preventive maintenance, early replacement of key components.	High	Critical	High

			Pre-Mitigation						Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T2	Startup of the cross-site transfer system is delayed impacting waste transfer from 200 West Area to 200 East Area.	2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is significant; no discernable difference in impact for all alternatives except for Alternative 17.	Conduct proactive planning and early testing, resequence waste feed.	Moderate	Marginal	Low
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; startup typically delayed to need date based on funding; modeling assumes just-in-time delivery for startup and testing of lines, transfers begin in mid 2030s. Consequence: The consequence of occurrence is negligible; waste feed can be delivered from B complex in case of transfer line delay, transfer line isn't needed until later, mission duration provides some schedule flexibility.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T3	The cross-site transfer lines are unavailable or become unavailable (e.g., plugged) during transfers impacting waste transfer from 200 West Area to 200 East Area.	2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; based on substantially extended mission duration under constrained funding. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	High	Significant	Moderate
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; based on substantially extended mission duration under constrained funding. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	High	Significant	Moderate
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; based on substantially extended mission duration under constrained funding. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	High	Significant	Moderate
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; based on substantially extended mission duration under constrained funding. Consequence: The consequence of occurrence is significant; mission driven by SST retrievals.	Develop and implement corrective measures (tools, procedures, etc.) to unplug line.	High	Significant	Moderate
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; based on mission duration. Consequence: The consequence of occurrence is negligible; use of a single melter provides extended duration for recovery; East area acts as a buffer to maintain operations.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T4	The Tank Farms' waste feed delivery infrastructure (e.g., pumps, valves, waste receipt facility, etc.) is unable to meet the required waste retrieval production and the feed delivery rate for HLW processing, increasing mission duration and costs.	2	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; likelihood is lower due to large buffering capacity provided by HFPEM facility and pretreatment tanks. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.				
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on use of smaller pretreatment tanks. Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Low	Significant	Low
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood based on use of smaller pretreatment tanks/buffer; single point failure (AP 101, 102, 103). Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Moderate	Significant	Moderate
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood based on use of smaller pretreatment tanks/buffer; single point failure (AP 101, 102, 103). Consequence: The consequence of occurrence is significant; no differentiable difference in impact among alternatives except for Alternative 17.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Moderate	Significant	Moderate
		17	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; limited staging/storage capability, buffer; single point failure (AP 101, 102, 103). Consequence: The consequence of occurrence is marginal; lower consequence due to extended mission duration.	Increase redundancy (lines, etc.); expand spares program (pumps, valves, etc.); and/or improve preventive maintenance program.	Moderate	Marginal	Low

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T5	The 222-S Laboratory facility availability is less than that assumed, resulting in delays in HLW waste characterization and associated delays in waste retrieval and waste transfer schedules.	2	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; characterized feed staged/buffering capability, large batch sizes; fewer samples.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory.	Moderate	Marginal	Low
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization and process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is significant; small batch sizes and a higher number of process control samples, less buffer space (tank size), characterization delays would lead to unavailability of feed.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory. [Note: small batch size and higher number of process control samples keeps post mitigation consequence significant for a post mitigation risk of moderate.]	Moderate	Significant	Moderate
		15	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization and process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; larger feed tanks, more buffer.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory.	Moderate	Marginal	Low
		16	High	Marginal	Moderate	Likelihood: The likelihood of occurrence is high; higher likelihood of occurrence; characterization and process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; larger feed tanks, more buffer.	Install more laboratory equipment run multiple shifts, provide additional upgrades to 222-S to increase capacity, outsource sampling, and/or increase use of WTP Laboratory.	Moderate	Marginal	Low
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; characterization and more limited process control sampling occurs in DST system and uses 222-S for analysis. Consequence: The consequence of occurrence is marginal; infrequent sample requirements due to low processing rate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T6	The WTP Analytical Laboratory functionality or throughput is less than adequate and unable to support waste performance and internal process control sample analyses, requiring modifications to the existing Analytical Laboratory, or the construction of additional analytical laboratory facilities, delaying HLW processing operations and requiring additional project and lifecycle costs.	2	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S.				
		14	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S.				
		15	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S				
		16	Very Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists. Consequence: The consequence of occurrence is marginal; sampling in 222-S.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; likelihood is lower for all alternatives (except for Alternative 1 and 5); WTP Analytical Laboratory has capacity for the HLW facility and PT facility, if the PT facility is not used then redundancy exists; slow processing rate. Consequence: The consequence of occurrence is negligible; sampling in 222-S; slow processing rate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T7	A leak or other failure in a DST (excluding AP 105, 106, 107 and 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in	2	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is marginal; buffer capacity with 7 tanks.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
	the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.	14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is significant; some flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; impacts use of DSTs for washing/leaching, least/limited flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; impacts use of DSTs for washing/leaching, least/limited flexibility in DST space capacity.	Build more DSTs. [Note: Alternative estimates do not include the cost of building more DSTs with the exception of the cost estimate for Alternative 17.]	Very High	Marginal	Moderate
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; DSTs have already experienced leaks; likelihood is the same for all alternatives. Consequence: The consequence of occurrence is critical; impacts use of DSTs for washing/leaching, least/limited flexibility in DST space capacity.	Build more DSTs. [Note: Based on the mission duration, building more DSTs is included in the cost estimate for Alternative 17.]	Very High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T8	HLW pretreatment functions are planned for DSTs for which the DSTs were not intended (e.g., operation of mixer pumps in DSTs increases waste temperatures above established limits which increases risk of DST corrosion, pitting, or other DST integrity challenges) resulting in an increased likelihood of DST degradation and failure of the primary containment barrier with associated delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; lower likelihood because DSTs are not used for pretreatment. Consequence: The consequence of occurrence is significant; sluicers could be used to retrieve solids.	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Marginal	Low
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; lower likelihood because DSTs are not used for pretreatment. Consequence: The consequence of occurrence is significant; sluicers could be used to retrieve solids.	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate
		15	High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood of occurrence based on use of mixer pumps in DSTs; increases temperature, vibration and stress in tanks. Consequence: The consequence of occurrence is crisis; consequence is higher than other alternatives based on use DSTs for pretreatment, may involve stoppage of mixer use in DSTs if a failure occurred, mixer pump viability and feed delivery technology become questionable..	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate
		16	High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood of occurrence based on use of mixer pumps in DSTs; increases temperature, vibration and stress in tanks. Consequence: The consequence of occurrence is crisis; consequence is higher than other alternatives based on use DSTs for pretreatment, may involve stoppage of mixer use in DSTs if a failure occurred, mixer pump viability and feed delivery technology become questionable..	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate
		17	High	Crisis	Very High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood of occurrence based on use of mixer pumps in DSTs; increases temperature, vibration and stress in tanks. Consequence: The consequence of occurrence is crisis; consequence is higher than other alternatives based on use DSTs for pretreatment, may involve stoppage of mixer use in DSTs if a failure occurred, mixer pump viability and feed delivery technology become questionable..	Improve DST inspection and integrity programs; build new DSTs; and/or develop improved mixer pumps.	Moderate	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T9	HLW pretreatment and treatment facilities cannot sustain operations at assumed treatment throughput rates (e.g., design error, technology limitations, etc.) which results in extended mission duration and increased costs.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; throughput rates limited due to insufficient resources for LAW supplemental treatment and effluent treatment capabilities. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Very High	Significant	High
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; throughput rates limited due to insufficient resources for LAW supplemental treatment and effluent treatment capabilities. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Very High	Significant	High
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; throughput rates limited due to insufficient resources for LAW supplemental treatment and effluent treatment capabilities. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Very High	Significant	High

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; throughput rates limited due to insufficient resources for LAW supplemental treatment and effluent treatment capabilities. Consequence: The consequence of occurrence is significant; HLW vitrification facility is rate limiting step.	Accept.	Very High	Significant	High
		17	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; constrained due to LAW and not HLW, need to evaporate excess water from dilute feeds, single melter to maintain. Consequence: The consequence of occurrence is marginal; significant melter idling, second melter on hand to use as an installed spare providing redundancy.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T10	A leak or other failure in a DST (AP 105, AP 106, AP 107 or AP 108) causes alteration in waste feed delivery schedules and the need for DST space to accommodate waste from the leaking/failed tank, resulting in delays in the overall HLW (and LAW) treatment schedule and an increase in lifecycle costs.	2	High	Critical	High	Likelihood: The likelihood of occurrence is high; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives based on mission duration with constrained funding. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	High	Marginal	Moderate
		14	High	Critical	High	Likelihood: The likelihood of occurrence is high; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives based on mission duration with constrained funding. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	High	Marginal	Moderate
		15	High	Critical	High	Likelihood: The likelihood of occurrence is high; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives based on mission duration with constrained funding. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	High	Marginal	Moderate
		16	High	Critical	High	Likelihood: The likelihood of occurrence is high; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is the same for all alternatives based on mission duration with constrained funding. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Use other DSTs for redundancy.	High	Marginal	Moderate
		17	High	Critical	High	Likelihood: The likelihood of occurrence is high; DSTs have already experienced leaks however AP 105 - AP 108 are newer, considering only 4 tanks; likelihood is similar to other alternatives based on mission duration. Consequence: The consequence of occurrence is critical; DFLAW required for supernate pretreatment.	Build more DSTs.	High	Marginal	Moderate

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T11	The BOF facilities as designed and constructed do not provide the necessary utility and process support capabilities to serve WTP facilities needed for HLW feed sampling, characterization, staging and pretreatment, requiring modifications to the existing BOF facilities or construction of new supplemental BOF facilities, delaying HLW processing operations and increasing project and lifecycle costs.	2	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is critical; limited resources to build new facilities; no differentiable difference in impact among alternatives.				
		14	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is critical; limited resources to build new facilities; no differentiable difference in impact among alternatives.				
		15	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is critical; limited resources to build new facilities; no differentiable difference in impact among alternatives.				
		16	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is critical; limited resources to build new facilities; no differentiable difference in impact among alternatives.				
		17	Very Low	Critical	Low	Likelihood: The likelihood of occurrence is very low; PT facility not used; use BOF facilities at lowest rate. Consequence: The consequence of occurrence is critical; limited resources to build new facilities; no differentiable difference in impact among alternatives.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T12	The HLW mission operations extend significantly beyond the design life of facilities including DSTs, waste transfer lines, Tank Farm infrastructure, 242-A evaporator, 222-S Laboratory, and new and repurposed facilities for HLW and LAW pretreatment and	2	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; mission duration exceeds the design life of facilities.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Very High	Significant	High
		14	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; mission duration exceeds the design life of facilities.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Very High	Significant	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
	immobilization. Design life extension studies and authorizations are more complex than anticipated resulting in facility upgrades and life extension or construction of replacement facilities to complete the overall HLW and LAW treatment mission.	15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; mission duration exceeds the design life of facilities.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Very High	Significant	High
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; mission duration exceeds the design life of facilities.	Advanced planning for design life of facilities; implement life extension plans; improved rigor in inspections.	Very High	Significant	High
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; mission life of DSTs.	New facilities planned at 50-60 years of original facilities design life.	Very High	Significant	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T13	The availability of sitewide infrastructure utilities and services (e.g., roads, high voltage power, raw water supply, etc.) is less than adequate to support the tank waste treatment mission and results in extended schedules and increased costs.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; based on extended mission duration. Consequence: The consequence of occurrence is significant; requires multiple upgrades to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Very High	Marginal	Moderate
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; based on extended mission duration. Consequence: The consequence of occurrence is significant; requires multiple upgrades to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Very High	Marginal	Moderate
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; based on extended mission duration. Consequence: The consequence of occurrence is significant; requires multiple upgrades to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Very High	Marginal	Moderate
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; based on extended mission duration. Consequence: The consequence of occurrence is significant; requires multiple upgrades to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Very High	Marginal	Moderate
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; based on extended mission duration. Consequence: The consequence of occurrence is significant; requires multiple upgrades to sitewide infrastructure utilities and services.	Conduct advance planning and prepare a sitewide infrastructure plan.	Very High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T14	The skills mix and labor availability to support LAW and HLW processing in parallel are inadequate resulting in delays to scheduled activities and extending mission execution.	2	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal;				
		14	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		15	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		16	Low	Marginal	Very Low	Likelihood: The likelihood of occurrence is low; no differentiable difference in likelihood for all alternatives except for Alternative 17; supplemental LAW is driver for resource requirements. Consequence: The consequence of occurrence is marginal; no differentiable difference in impacts for all alternatives except for Alternative 17.				
		17	Very Low	Negligible	Very Low	Likelihood: The likelihood of occurrence is very low; slow operations rate; reduced number of resources required. Consequence: The consequence of occurrence is negligible; no LAW supplemental treatment.				

10 Operations Opportunities (Constrained Case)

			Pre-Mitigation						Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
01	Glass waste loading improvements can be made by alternate glass formulations. Additional glass modeling of the HLW melters may be able to demonstrate that higher undissolved Al concentrations can be tolerated in the feed while still producing glass meeting the IHLW waste acceptance criteria, and without significantly increasing the number of IHLW canisters produced. Changes in the Al limits may reduce or eliminate the need for caustic leaching, which could reduce the scope and cost of the HLW pretreatment facilities.	2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is marginal; improvements already being realized.				
		17	Moderate	Negligible	Very Low	Likelihood: The likelihood of occurrence is moderate; glass waste loading improvements have undergone laboratory testing and demonstrated only modest increases in waste loading, similar likelihood for all alternatives. Consequence: The consequence of occurrence is negligible; improvements already being realized, limited by lack of leaching.				

			Pre-Mitigation						Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
02	Operating efficiency is higher than similar nuclear waste treatment facilities accelerating HLW mission completion with reduced lifecycle costs.	2	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; improved efficiency is limited by inadequate LAW supplemental treatment and effluent treatment capability and capacity. Consequence: The consequence of occurrence is significant; TF, WTP efficiencies potentially realized.				
		14	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; improved efficiency is limited by inadequate LAW supplemental treatment and effluent treatment capability and capacity. Consequence: The consequence of occurrence is significant; TF, WTP efficiencies potentially realized.				
		15	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; improved efficiency is limited by inadequate LAW supplemental treatment and effluent treatment capability and capacity. Consequence: The consequence of occurrence is significant; TF, WTP efficiencies potentially realized.				
		16	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; improved efficiency is limited by inadequate LAW supplemental treatment and effluent treatment capability and capacity. Consequence: The consequence of occurrence is significant; TF, WTP efficiencies potentially realized.				
		17	High	Negligible	Very Low	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to mission duration. Consequence: The consequence of occurrence is negligible; idle time; DST space limitation; most benefit by gaining LAW capacity/availability.				

11 Programmatic Threats (Constrained Case)

			Pre-Mitigation						Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T1	Delays in the approval (or inability to obtain approval) of new permits or changes to existing permits for HLW treatment facilities negatively impact project costs and schedules, and subsequent processing schedules and associated costs.	2	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to change in flowsheet. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		14	High	Critical	High	Likelihood: The likelihood of occurrence is high; slightly higher likelihood due to change in flowsheet, use of DSTs. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; involves use of DSTs for different purpose than originally intended including washing and leaching. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; involves use of DSTs for different purpose than originally intended including washing and leaching. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High
		17	High	Critical	High	Likelihood: The likelihood of occurrence is high; DST being used for washing only. Consequence: The consequence of occurrence is critical; same level of rigor for DSTs for all alternatives.	Early and ongoing dialogue with permitting authority, ensure high quality and accuracy of documentation; significant deviation, requires extensive negotiation, early action, and sequencing of inspections.	High	Critical	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T2	The start of Direct-Feed LAW (DFLAW) is delayed (e.g., due to regulatory approvals, funding shortfalls or other project issues) resulting in delays to HLW operations.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is significant; lower impact as operations can continue at reduced throughput, extra tanks.	Accept.	Moderate	Significant	Moderate
		14	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		15	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		16	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is critical; limited space buffer from HLW returns.	Accept.	Moderate	Critical	Moderate
		17	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; no discernable difference among alternatives. Consequence: The consequence of occurrence is significant; a two-year delay can be tolerated.	Accept.	Moderate	Critical	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T3	Safety events outside of the LAW and HLW pretreatment and treatment construction zones (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW treatment projects and the implementation of additional engineered and administrative controls. leading to delays in project completion and in increased project costs.	2	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is lower due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		14	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is lower due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		15	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is lower due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		16	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is lower due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				
		17	Moderate	Marginal	Low	Likelihood: The likelihood of occurrence is moderate; considers LAW operations, likelihood is lower due to the length of design and construction even if a safety event occurs. Consequence: The consequence of occurrence is marginal; based on historical experience, the relative cost and schedule impact is the same for all alternatives.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T4	Safety events outside of the LAW and HLW processing operations (e.g., noxious vapors, tank waste spills or other operational mishaps) result in work stoppage on LAW and HLW processing operations and the implementation of additional engineered and administrative controls leading to delays in operations and in increased lifecycle costs.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is moderate; safety events occur every 5 - 7 years, extensive operations duration significantly raises the probability of a safety event. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Very High	Significant	High
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; safety events occur every 5 - 7 years, extensive operations duration significantly raises the probability of a safety event. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Very High	Significant	High
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; safety events occur every 5 - 7 years, extensive operations duration significantly raises the probability of a safety event. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Very High	Significant	High
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; safety events occur every 5 - 7 years, extensive operations duration significantly raises the probability of a safety event. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Very High	Significant	High
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; safety events occur every 5 - 7 years, extensive operations duration significantly raises the probability of a safety event. Consequence: The consequence of occurrence is significant; based on experience, the vapors issue impacted the schedule by 2 years.	Accept.	Very High	Significant	High

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T5	Supply chain management challenges for equipment and components (e.g., limited availability of vendors with an approved nuclear quality assurance [NQA-1] program, vendor competency and quality of work, long lead procurements, etc.) adversely impact procurement costs and schedules, mission duration and lifecycle costs.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; significantly longer mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Very High	Significant	High
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; significantly longer mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Very High	Significant	High
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; significantly longer mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Very High	Significant	High
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; significantly longer mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Very High	Significant	High
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; significantly longer mission duration. Consequence: The consequence of occurrence is significant; there is a large volume of structures, components, and safety systems requiring an approved NQA-1 program.	Develop and maintain vendor supply chain partnerships, establish proactive measures such as duplicate vendor qualifications ,and/or use advance procurements to purchase spares.	Very High	Significant	High

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T6	Funding shortfalls delay completion of design, construction, startup, and commissioning of HLW pretreatment and vitrification facilities resulting in extended HLW treatment mission duration and increased costs.	2	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $12 - $13B range, completion of HLW facilities does not leave sufficient funding to allow construction of a full capacity LAWST facility, which reduces the LAW processing rate and reduces the HLW processing rate. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		14	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $12 - $13B range, completion of HLW facilities does not leave sufficient funding to allow construction of a full capacity LAWST facility, which reduces the LAW processing rate and reduces the HLW processing rate. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		15	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $12 - $13B range, completion of HLW facilities does not leave sufficient funding to allow construction of a full capacity LAWST facility, which reduces the LAW processing rate and reduces the HLW processing rate. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		16	Very High	Crisis	Very High	Likelihood: The likelihood of occurrence is very high; with the exception of Alternative 17; the TPC for all alternatives is in the $12 - $13B range, completion of HLW facilities does not leave sufficient funding to allow construction of a full capacity LAWST facility, which reduces the LAW processing rate and reduces the HLW processing rate. Consequence: The consequence of occurrence is crisis; project suspended based on affordability, supplemental LAW costs.	Consider more affordable technologies other than glass for supplemental LAW.	Very High	Critical	Very High
		17	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; lower TPC than other alternatives; reduced peak demand. Consequence: The consequence of occurrence is significant; there is schedule flexibility.	Lower cost provides some flexibility to reallocate funding to reduce risk.	High	Significant	Moderate

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T7	The schedule for completing design, construction, startup, and commissioning of the required HLW pretreatment and treatment facilities deviates from the current Amended Consent Decree (ACD) and associated existing regulatory framework, which increases the time and level of effort required to negotiate ACD changes.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; pretreatment capability addressed in a different facility (other than the PT facility); ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is significant; requires significant negotiations based on changes/revisions.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Significant	High
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is significant; requires significant negotiations based on changes/revisions.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Significant	High
		15	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; not all pre-treatment capability is provided; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is critical; greater deviation from capability, capacity and configuration, no pretreatment capability.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Critical	Very High
		16	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; not all pre-treatment capability is provided; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is critical; greater deviation from capability, capacity and configuration, no pretreatment capability.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Critical	Very High
		17	Very High	Critical	Very High	Likelihood: The likelihood of occurrence is very high; ACD based on capability and configuration; configuration deviates from agreed upon ACD requirements. Consequence: The consequence of occurrence is critical; single melter, no pretreatment capability, longer operations, more extensive negotiations.	Commence ACD negotiations early and maintain communication on changes/revisions.	Very High	Critical	Very High

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T8	The National Geologic Repository, and/or the supporting HLW transportation infrastructure, is not available to allow the shipment of IHLW canisters by the date assumed for planning purposes (i.e. mid 2030's) requiring construction and operation of additional Interim Hanford Storage (IHS) facilities increasing capital investment and lifecycle costs.	2	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		14	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		15	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
		16	Very High	Marginal	Moderate	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is marginal; same for all alternatives (except for Alternative 17) based on the number of cannisters produced.	Accept.	Very High	Marginal	Moderate
		17	Very High	Negligible	Low	Likelihood: The likelihood of occurrence is very high; likelihood is the same for all alternatives; not likely the National Geologic Repository is available by mid 2030's. Consequence: The consequence of occurrence is negligible; reduced number of cannisters produced at a slower rate.				

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T9	Changes in the waste acceptance criteria and/or packaging requirements for IHLW disposal lead to additional HLW feed pretreatment requirements and potential changes to HLW glass formulation resulting in design changes to the HLW pretreatment facilities and causing delays in project and treatment schedules and increases in design/construction and operations costs.	2	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.	Accept.	Moderate	Critical	Moderate
		14	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.	Accept.	Moderate	Critical	Moderate
		15	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.	Accept.	Moderate	Critical	Moderate
		16	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.	Accept.	Moderate	Critical	Moderate
		17	Moderate	Critical	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on mission duration. Consequence: The consequence of occurrence is critical; changes in packaging requirements result in redesign of HLW vitrification facility.	Accept.	Moderate	Critical	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T10	New DOE directives/policies or external regulations result in Tank Farm or other non-WTP facility design changes or upgrades, reducing funding availability for design, construction, startup, commissioning, and operations of facilities required for the tank waste treatment mission.	2	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; high likelihood due to mission duration. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Accept.	High	Significant	Moderate
		14	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; high likelihood due to mission duration. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Accept.	High	Significant	Moderate
		15	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; high likelihood due to mission duration. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Accept.	High	Significant	Moderate
		16	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; high likelihood due to mission duration. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Accept.	High	Significant	Moderate
		17	High	Significant	Moderate	Likelihood: The likelihood of occurrence is high; high likelihood due to mission duration. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Accept.	High	Significant	Moderate

#	Risk Description	Alternative	Pre-Mitigation Likelihood	Pre-Mitigation Consequence	Pre-Mitigation Risk Level	Rationale	Mitigation	Post-Mitigation Likelihood	Post-Mitigation Consequence	Post-Mitigation Risk Level
T11	The design, construction, startup, commissioning and operation of HLW pretreatment and treatment facilities are delayed due to issues raised by external stakeholders (e.g., Defense Nuclear Facility Safety Board [DNFSB], GAO, IG, etc.] extending mission completion and increasing project and lifecycle costs.	2	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on complexity of alternative. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Develop foundational, historically acceptable designs, and early and continuous engagement with stakeholders.	Moderate	Significant	Moderate
		14	Moderate	Significant	Moderate	Likelihood: The likelihood of occurrence is moderate; slightly higher likelihood based on complexity of alternative. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.	Develop foundational, historically acceptable designs, and early and continuous engagement with stakeholders.	Moderate	Significant	Moderate
		15	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; less complex alternative, smaller in scope, limited new technology. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
		16	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; less complex alternative, smaller in scope, limited new technology. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				
		17	Low	Significant	Low	Likelihood: The likelihood of occurrence is low; less complex alternative, smaller in scope, scope limited to DCRT. Consequence: The consequence of occurrence is significant; the relative impact is the same for all alternatives.				

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
T12	High activity solid waste is generated that cannot be treated or disposed of (no currently defined treatment capability or disposition path) which results in increased lifecycle costs.	2	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		14	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		15	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		16	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate
		17	Very High	Significant	High	Likelihood: The likelihood of occurrence is very high; there is certainty that all alternatives will generate waste that currently has no defined and approved treatment capability and/or disposition path. Consequence: The consequence of occurrence is significant; impact is relative for all alternatives; despite differences in quantities of melters and IX columns, there is no substantive difference in consequences among the alternatives.	Flush melters and reduce volume, develop and implement a strategy for IX columns.	Moderate	Significant	Moderate

12 Programmatic Opportunities (Constrained Case)

			Pre-Mitigation					Post-Mitigation		
#	Risk Description	Alternative	Likelihood	Consequence	Risk Level	Rationale	Mitigation	Likelihood	Consequence	Risk Level
O1	A change (or reclassification) in the methodology for classifying waste as HLW in accordance with DOE Order 435.1, or a change in the interpretation of the requirements of the Order, may reduce the volume of tank waste classified as HLW resulting in scaling down the capacity of the HLW pretreatment facilities and the HLW Vitrification Facility, or potentially eliminating some of the functional requirements for these facilities thereby reducing capital and operating costs, or reducing mission duration.	2	Moderate	Efficient	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on extended mission duration and potential for additional waste reclassification changes. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		14	Moderate	Efficient	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on extended mission duration and potential for additional waste reclassification changes. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		15	Moderate	Efficient	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on extended mission duration and potential for additional waste reclassification changes. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		16	Moderate	Efficient	Moderate	Likelihood: The likelihood of occurrence is moderate; likelihood based on extended mission duration and potential for additional waste reclassification changes. Consequence: The consequence of occurrence is efficient; reduction in operations duration and lifecycle costs would be substantial (10 - 20%).				
		17	Moderate	Optimal	High	Likelihood: The likelihood of occurrence is moderate; likelihood based on extended mission duration and potential for additional waste reclassification changes. Consequence: The consequence of occurrence is optimal; avoids building replacement facilities based on long duration; reduction in operations duration and lifecycle costs would be even higher (greater than 20%).				

APPENDIX G: ALTERNATIVES ANALYSIS DETAILS

1 Evaluation Scoring

The Waste Treatment and Immobilization Plant (WTP) high-level waste (HLW) Enterprise Construction Management Services (ECMS) Analysis of Alternatives (AoA) Team used the scoring scale summarized in Table 88 to score each evaluation criterion for each alternative.

Table 88: Alternative Evaluation Scoring Scale

Criteria Evaluation	Score
Fully meets the criterion	1.00
Generally meets the criterion	0.75
Somewhat meets the criterion	0.50
Barely meets the criterion	0.25
Does not meet the criterion at all	0.00

2 Evaluation Summary, Unconstrained Funding

Each alternative was scored for each evaluation criterion using the agreed-upon scoring system. Table 89 shows the AoA Team's unweighted scoring results for the unconstrained funding case.

Table 89: Scoring of Alternatives, Unweighted Scores, Unconstrained Funding

#	Evaluation Criteria	Alt 1	Alt 2	Alt 5	Alt 14	Alt 15	Alt 16	Alt 17
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	1.00	1.00	1.00	1.00	1.00	1.00	1.00
EC-2	Lower HLW project Total Project Cost (TPC) range[20]	0.25	0.25	0.25	0.50	0.50	0.50	1.00
EC-3	Lower operational, technical, and programmatic risk	0.75	0.75	0.50	0.75	0.50	0.50	0.50
EC-4	Lower HLW processing Life Cycle Cost (LCC) (present value (PV) range)	0.50	0.75	0.75	1.00	1.00	1.00	0.00
EC-5	Alternative allows for earlier completion of HLW treatment	0.75	1.00	1.00	1.00	1.00	1.00	0.00
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	0.50	1.00	1.00	1.00	0.75	0.75	0.00
EC-7	Fewer IHLW canisters produced	0.75	1.00	0.75	0.75	1.00	1.00	0.00
EC-8	Lower volume of Immobilized Low Activity Waste (ILAW) generated by HLW processing	0.75	0.25	0.50	0.50	0.25	0.25	1.00
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	0.50	0.00	0.25	0.25	0.00	0.25	1.00
	Totals	5.75	6.00	6.00	6.75	6.00	6.25	4.50

[20] For comparative purposes, TPC includes costs for Tank Waste Characterization and Staging Facility (TWCSF), HLW Feed Preparation and Effluent Management (HFPEM) Facility, HLW Effluent Management Facility (HEMF), Waste Transfer Vault (WTV), LAW Feed Evaporator (LFE), Secondary Waste Treatment, a LAW Supplemental Treatment (LAWST) Facility, and HLW/Pretreatment (PT) completion, while excluding ancillary/supporting projects common to all alternatives such as LAW/Balance of Facilities (BOF)/Analytical Laboratory/Direct Feed LAW (DFLAW) Completion, Hanford Shipping Facility/Interim Hanford Storage (HSF/IHS), and needed Tank Farm projects. For Alternative 17, replacement facilities during the mission duration are also excluded.

Table 90 shows the team's weighted scoring results for the unconstrained funding case.

Table 90: Scoring of Alternatives, Weighted Scores, Unconstrained Funding

#	Evaluation Criteria	NRW[21]	Alt 1	Alt 2	Alt 5	Alt 14	Alt 15	Alt 16	Alt 17
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
EC-2	Lower HLW project TPC range[22]	20.0	5.0	5.0	5.0	10.0	10.0	10.0	20.0
EC-3	Lower operational, technical, and programmatic risk	20.0	15.0	15.0	10.0	15.0	10.0	10.0	10.0
EC-4	Lower HLW processing LCC (PV range)	12.0	6.0	9.0	9.0	12.0	12.0	12.0	0.0
EC-5	Alternative allows for earlier completion of HLW treatment	8.0	6.0	8.0	8.0	8.0	8.0	8.0	0.0
EC-6	Increased flexibility within the Tank Farm system to recover from single point failures	8.0	4.0	8.0	8.0	8.0	6.0	6.0	0.0
EC-7	Fewer IHLW canisters produced	4.0	3.0	4.0	3.0	3.0	4.0	4.0	0.0
EC-8	Lower volume of LAW generated by HLW processing	4.0	3.0	1.0	2.0	2.0	1.0	1.0	4.0
EC-9	Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing	4.0	2.0	0.0	1.0	1.0	0.0	1.0	4.0
	Totals	100	64.0	70.0	66.0	79.0	71.0	72.0	58.0

3 Evaluation Details, Unconstrained Funding

Table 91: Rationale for Alternative Scoring, Unconstrained Funding

Evaluation Criterion 1: Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the Amended Consent Decree (ACD) and are rated Fully Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the ACD and are rated Fully Meets.
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility (RPT)	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the ACD and are rated Fully Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the ACD and are rated Fully Meets.
15	DFHLW from DSTs and Effluent Management in New HLW HEMF	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the ACD and are rated Fully Meets.
16	DFHLW from Double-Shell Tanks (DSTs) and HLW Feed Concentration and Effluent Management in New HEMF	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the ACD and are rated Fully Meets.

[21] Normalized Relative Weighting

[22] For comparative purposes, TPC includes costs for TWCSF/HFPEM/HEMF/WTV, LFE, Secondary Waste Treatment, a LAWST Facility, and HLW/PT completion, while excluding ancillary/supporting projects common to all alternatives such as LAW/BOF/LAB/DFLAW Completion, HSF/IHS, needed Tank Farm projects. For Alternative 17, replacement facilities during the mission duration are also excluded.

17	DFHLW from DSTs without HLW Effluent Management	1.00	In the unconstrained funding case, all alternatives are assumed to meet the date for completion of hot commissioning stipulated in the ACD and are rated Fully Meets.

Evaluation Criterion 2: Lower HLW project Total Project Cost (TPC) range[23]

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.25	Alternative 1 has the fifth lowest TPC range, which is discernably higher than Alternative 16 and is therefore rated Barely Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.25	Alternative 2 has the highest TPC range but is not significantly different from Alternatives 1 and 5, and is therefore rated Barely Meets.
5	HLW Pretreatment and Effluent Management in RPT Facility	0.25	Alternative 5 has the sixth lowest TPC range, which is not significantly different from Alternatives 1 and 2, and is therefore rated Barely Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.50	Alternative 14 has the second lowest TPC range, is significantly higher than Alternative 17 and is rated Somewhat Meets.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.50	Alternative 15 has the third lowest TPC range but is not significantly different from Alternative 14 and is therefore rated Somewhat Meets.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.50	Alternative 16 has the fourth lowest TPC range but is not significantly different from Alternative 15 and is rated Somewhat Meets.
17	DFHLW from DSTs without HLW Effluent Management	1.00	Alternative 17 has the lowest TPC range and is rated Fully Meets. Note that the TPC is for initial facilities only and does not include the capital costs associated with replacement facilities over the mission life.

Evaluation Criterion 3: Lower operational, technical, and programmatic risk

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.75	Unmitigated composite risk score is Moderate. Individual ratings for Operational, Technical, and Programmatic risk were in the low end of the Moderate range, therefore Alternative 1 is rated Generally Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.75	Unmitigated composite risk score is Moderate. Individual ratings are in the low end of the Moderate range for Operational, the high end of the Moderate range for Programmatic risk, and Low for Technical risks, therefore Alternative 2 is rated Generally Meets.
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	0.50	Unmitigated composite risk score is Moderate. Individual ratings are in the low end of the Moderate range for Operational and Technical, and the high end of the moderate range for Programmatic risks, therefore Alternative 5 is rated Somewhat Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.75	Unmitigated composite risk score is Moderate for Operational and Programmatic risk, and Low for Technical risk, therefore Alternative 14 is rated Generally Meets.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.50	Unmitigated composite risk score is Moderate. Individual ratings are in the high end of the Moderate range for Operational and Programmatic risks and the low end of the Moderate range for Technical risks, therefore Alternative 15 is rated Somewhat Meets.

[23] For comparative purposes, TPC includes costs for TWCSF/HFPEM/HEMF/WTV, LFE, Secondary Waste Treatment, a LAWST Facility, and HLW/PT completion, while excluding ancillary/supporting projects common to all alternatives such as LAW/BOF/LAB/DFLAW Completion, HSF/IHS, needed Tank Farm projects. For Alternative 17, replacement facilities during the mission duration are also excluded.

16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.50	Unmitigated composite risk score is Moderate. Individual ratings are in the high end of the Moderate range for Operational and Programmatic risks and the low end of the Moderate range for Technical risks, therefore Alternative 16 is rated Somewhat Meets.
17	DFHLW from DSTs without HLW Effluent Management	0.50	Unmitigated composite risk score is Moderate. Individual ratings are in the high end of the Moderate range for Operational and Programmatic risks and Low for Technical risks, therefore Alternative 16 is rated Somewhat Meets.

Evaluation Criterion 4: Lower HLW processing LCC (present value (PV) range)

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.50	Alternative 1 has the sixth lowest LCC, is discernable from Alternative 3, and is rated Somewhat Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.75	Alternative 2 has the fourth lowest LCC, is discernable from Alternative 15, and is rated Generally Meets.
5	HLW Pretreatment and Effluent Management in RPT Facility	0.75	Alternative 3 has the fifth lowest LCC but is not statistically differentiable from Alternative 2 and is rated Generally Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	1.00	Alternative 14 has the lowest LCC and is rated Fully Meets.
15	DFHLW from DSTs and Effluent Management in New HLW HEMF	1.00	Alternative 15 has the third lowest LCC but is not statistically differentiable from Alternative 15 and is rated Fully Meets.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	1.00	Alternative 16 has the second lowest LCC but is not statistically differentiable from Alternative 14 and is rated Fully Meets.
17	DFHLW from DSTs without HLW Effluent Management	0.00	Alternative 17 has the highest LCC by far and is rated Does Not Meet.

Evaluation Criterion 5: Alternative allows for earlier completion of HLW treatment

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.75	HLW treatment is completed 20 years later than Alternatives 5 and 14. This is a significant difference and therefore Alternative 1 is rated Generally Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	1.00	Alternative 2 has the earliest HLW treatment completion date and is rated Fully Meets.
5	HLW Pretreatment and Effluent Management in RPT Facility	1.00	Alternatives 5 and 14 have the second latest HLW treatment completion dates but are rated Fully Meets because the difference from Alternative 2 is only about 2 years (HLW treatment completes 07/2062 for Alt 2 vs. 09/2064 for Alt 14).
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	1.00	Alternatives 5 and 14 have the second latest HLW treatment completion dates but are rated Fully Meets because the difference from Alternative 2 is only about 2 years (HLW treatment completes 07/2062 for Alt 2 vs. 09/2064 for Alt 14).
15	DFHLW from DSTs and Effluent Management in New HEMF	1.00	Alternative 15 has the third earliest HLW treatment completion date but is rated Fully Meets because the difference from Alternative 2 is only about 2-1/2 years (HLW treatment completes 07/2061 for Alt 2 and 03/2064 for Alt 15).
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	1.00	Alternative 16 has the second earliest HLW treatment completion date but is rated Fully Meets because the difference from Alternative 2 is only 1 year (HLW treatment completes 07/2061 for Alt 2 and 10/2062 for Alt 16).
17	DFHLW from DSTs without HLW Effluent Management	0.00	HLW treatment is incomplete as of CY2168 for this alternative, with approximately 15% of HLW remaining. Completion is estimated approximately 100 later than Alternative 1 and is rated Does Not Meet.

Evaluation Criterion 6: Increased flexibility within the Tank Farm system to recover from single point failures			
Alt No.	**Alternative Description**	**Score**	**Rationale**
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.50	See Section 4 of this appendix.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.75	See Section 4 of this appendix.
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	0.75	See Section 4 of this appendix.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.75	See Section 4 of this appendix.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.75	See Section 4 of this appendix.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.75	See Section 4 of this appendix.
17	DFHLW from DSTs without HLW Effluent Management	0.50	See Section 4 of this appendix.
Evaluation Criterion 7: Fewer IHLW canisters produced			
Alt No.	**Alternative Description**	**Score**	**Rationale**
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.75	Alternatives 1, 5 & 14 produce the same number of IHLW canisters, approximately 16% more than Alternative 2, and are rated Generally Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	1.00	Alternative 2 produces the second fewest IHLW canisters. The difference in number produced between this alternative and Alternatives 15 & 16 is not statistically significant therefore all three are rated Fully Meets.
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	0.75	Alternatives 1, 5 & 14 produce the same number of IHLW canisters, approximately 16% more than Alternative 2, and are rated Generally Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.75	Alternatives 1, 5 & 14 produce the same number of IHLW canisters, approximately 16% more than Alternative 2, and are rated Generally Meets.
15	DFHLW from DSTs and Effluent Management in New HEMF	1.00	Alternatives 15 & 16 produce fewest IHLW canisters and are rated Fully Meets.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	1.00	Alternatives 15 & 16 produce fewest IHLW canisters and are rated Fully Meets.
17	DFHLW from DSTs without HLW Effluent Management	0.00	The model results for Alternative 17 indicate production of 14,900 IHLW canisters as of CY2168, with approximately 15% of the HLW remaining to be immobilized. Extrapolating the remainder of the waste, the number of IHLW canisters produced would be more than double than for Alternatives 2, 15, and 16, and 85% more than for Alternatives 1, 5, and 14, therefore Alternative 17 is rated Does Not Meet.

Evaluation Criterion 8: Lower volume of ILAW generated by HLW processing

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.75	Alternative 1 has the second lowest number of ILAW Containers and is rated Generally Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.25	Alternative 2 has the fifth lowest number of ILAW Containers, is statistically worse than Alternatives 5 & 14, and is not statistically different from Alternatives 15 & 16. It is rated Barely Meets.
5	HLW Pretreatment and Effluent Management in Repurposed PT Facility	0.50	Alternatives 5 & 14 produce several ILAW Containers between those produced by Alternatives 1 & 2 and are rated Somewhat Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.50	Alternatives 5 & 14 produce several ILAW Containers between those produced by Alternatives 1 & 2 and are rated Somewhat Meets.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.25	Alternative 15 has the highest number of ILAW Containers, is not statistically different from Alternatives 15 & 16, and is rated Barely Meets.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.25	Alternative 16 has the second highest number of ILAW Containers, is not statistically different from Alternatives 15 & 16, and is rated Barely Meets.
17	DFHLW from DSTs without HLW Effluent Management	1.00	Because Alternative 17 IHLW loading is relatively low, much of the LAW is immobilized in IHLW canisters. Extrapolating the model results from 2168 until all HLW is immobilized, the number of ILAW Containers is still lower for Alternative 17 than the other alternatives, therefore it is rated Fully Meets.

Evaluation Criterion 9: Lower volume of secondary liquid effluent (process condensate) generated by HLW and LAW processing[24]

Alt No.	Alternative Description	Score	Rationale
1	HLW Characterization and Staging in New TWCSF and HLW (and LAW) Pretreatment in PT Facility (Baseline Case)	0.50	Alternative 1 produces the second lowest peak volume of process condensate produced annually, produces more than double the annual amount produced by Alternative 17 and is rated Somewhat Meets.
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.00	Alternatives 2 and 15 produce the highest peak volume of process condensate annually and are rated Does Not Meet.
5	HLW Pretreatment and Effluent Management in RPT Facility	0.25	Alternatives 5, 14, & 16 produce similar peak volumes of process condensate annually, produce a volume between those of Alternative 1 and Alternatives 2 & 15, and are rated Barely Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.25	Alternatives 5, 14, & 16 produce similar peak volumes of process condensate annually, produce a volume between those of Alternative 1 and Alternatives 2 & 15, and are rated Barely Meets.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.00	Alternatives 2 and 15 produce the highest peak volume of process condensate annually and are rated Does Not Meet.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.25	Alternatives 5, 14, & 16 produce similar peak volumes of process condensate annually, produce a volume between those of Alternative 1 and Alternatives 2 & 15, and are rated Barely Meets.
17	DFHLW from DSTs without HLW Effluent Management	1.00	Alternative 17 has the lowest peak volume of process condensate produced annually, the amount is less than half that of Alternative 2, and therefore is rated Fully Meets.

[24] Based on volume produced annually

4 Evaluation Criterion 6, Increased Flexibility Within Tank Farm System to Recover from Single Point Failures

The additional details for Criterion 6 from the Study Plan stated that, "*WRPS flowsheet modeling will determine the DST volumes and free space over time. Modeling results will also provide data on the number of required evaporator runs, waste transfers, and availability of other Tank Farm facilities and infrastructure that may be needed to recover from tanks leaks or other single point failures (e.g., 242-A Evaporator and waste transfer lines).*"

Since the Study Plan was developed before the AoA Team fully understood the WRPS modeling constraints, the actual analysis differs slightly from the plan. Criterion 6 is scored for each alternative with consideration for the following factors:

- Cross-site transfers, applying qualitative judgment based on the average number per year and highest number in any year (Table 92)
- 242-A Evaporator campaigns, applying qualitative judgment based on the average number per year and highest number in any year (Table 92). Mission duration was also considered, since the duration of Alternative 17 makes it inconceivable that the 242-A Evaporator would not have to be replaced.
- SST retrieval completion durations, which are a function of SST retrieval delays due to lack of DST free space from modeling (Table 93).

These three sub-criteria were evaluated individually, using the same methodology used to rate alternatives relative to the nine Evaluation Criteria. The results for the sub-criteria were then averaged to determine an Evaluation Criterion 6 rating for each Alternative.

Table 92: Cross Site Transfers and Evaporator Campaigns by Alternative[25]

Alt #	Average Number of Cross Site Transfers per Year	Highest Number of Cross-Site Transfers in any Year (CY)	Average Number of 242-A Evaporator Campaigns per Year	Highest Number of 242-A Evaporator Campaigns in any Year *Capped at 6 per year (CY)	Total Number of 242-A Evaporator Campaigns	242-A Evaporator Utilization
1	3.6	9 (2070)	3.2	6 (Starting in 2040-45, 2056-58, 2060-66, 2068 and 2070-73)	179	9%
2	7.2	15 (2045)	0.8	3 (2049-50)	30	1%
5[26]	7.3	18 (2047)	0.6	3 (2035 and 2057)	24	1%
14	7.3	18 (2047)	0.6	3 (2035 and 2057)	24	1%
15	7	15 (2059)	1.3	5 (2049)	56	3%
16	7.7	16 (2058)	1.6	4 (2034, 2045 and 2053)	65	3%
17	2	12 (2160)	1.1	6 (2097)	158	2%

Table 93: SST Retrieval Durations

Alternative #	SST Retrieval Finish Date	SST Retrieval Duration (Years)
1	6/1/2073	51
2	4/1/2056	34
5	4/1/2058	36

[25] Based on TOPSim modeling results
[26] Not modeled however transfer rates are assumed to be the same as Alt 14

Alternative #	SST Retrieval Finish Date	SST Retrieval Duration (Years)
14	4/1/2058	36
15	5/1/2059	37
16	12/2/2057	36
17	8/1/2159	138

Note: SST Retrieval Start Date is 1/1/2022 for all Alternatives

4.1 Cross Site Transfers

Alternative 17 was judged to offer the greatest degree of flexibility in consideration of the average and peak number of cross site transfers and was rated as *Fully Meets the Criterion*. It has the lowest average number per year, at 2, and although the peak number of 12 is higher than the Alternative 1 peak of 9, the extremely long mission duration of Alternative 17 offsets this factor.

Alternative 1 was judged to offer the second greatest degree of flexibility and was rated as *Generally Meets the Criterion*. The average of 3.6 transfers per year is 80% higher than Alternative 17 and approximately half of the number of transfers for the other alternatives. The peak cross site transfers per year of 9 is the lowest of all alternatives.

Alternatives 2, 5, 14, 15, and 16 are not significantly different from each other with regard to the average and peak numbers of cross site transfers, with the average ranging from 7 to 7.7 and the peak from 15 to 18. They were judged discernably less flexible than Alternative 1 and were rated as *Somewhat Meets the Criterion*.

4.2 242-A Evaporator Campaigns

Alternative 1 stood out as having both the highest average number of campaigns per year at 4.5, more than double the average of other alternatives, the highest number of campaigns in any year, and the highest utilization rate. The model capped the number of 242-A Evaporator campaigns at six per year, and Alternative 1 reached this cap 21 times. Although Alternative 17 also reached the annual maximum of six campaigns, it only reached this limit one time. Alternative 1 was considered significantly worse than all other alternatives except Alternative 17 and was rated as *Barely Meets the Criterion*.

Alternative 17 has a low average number of campaigns per year at 1.6 and, as previously mentioned, a peak of 6 annual campaigns occurring in one year. The utilization rate for this alternative is 2%, which is between the utilization rates of Alternatives 2, 4, and 5 at 1% and Alternatives 15 and 16 at 3%. However, given the extremely long mission duration for this alternative, it is not realistic to expect that the existing 242-A Evaporator would remain available on demand. The alternative was therefore rated as *Barely Meets the Criterion*.

Alternatives 2, 5, and 14 are statistically very similar, have the lowest utilization rates, have roughly half the total number of campaigns as Alternatives 15 and 16. These alternatives are rated as *Fully Meets the Criterion.*

The remaining Alternatives, 15 and 16, were not statistically discernable from each other but, as noted, had a much higher rate of utilization than Alternatives 2, 5, and 14 and were rated as *Generally Meets the Criterion*.

4.3 SST Retrieval Completion Durations

With a duration of 138 years, Alternative 17 was rated as *Does Not Meet the Criterion*. The slow rate of waste immobilization drives this duration and keeps waste in single-shell tanks (SSTs) for a period of time that far exceeds their design life.

Alternative 1 has a much shorter duration than Alternative 17 at 51 years. This duration is much closer to, but still discernable from, those for Alternatives 2, 5, 14, 15, and 16. This alternative is therefore rated as *Generally Meets the Criterion*.

Alternatives 2, 5, 14, 15, and 16 have SST retrieval durations that are not significantly different and are clearly shorter than Alternative 1 by approximately 20 years, and are therefore rated as *Fully Meets the Criterion*.

4.4 Calculation of Criterion 6 Ratings

Table 88 shows the numerical values associated with each of the criteria scoring levels, and Table 94 shows the calculated average of the sub-criteria. The spreads in the averages were used to assign an overall score for each alternative relative to Evaluation Criterion 6.

Table 94: Evaluation Criterion 6 Rating Calculation

Alternative	Cross Site Transfers	242-A Evaporator Campaigns	SST Retrievals	Average	EC-6 Rating
1	0.75	0.25	0.75	0.58	Somewhat Meets
2	0.50	1.00	1.00	0.83	Fully Meets
5	0.50	1.00	1.00	0.83	Fully Meets
14	0.50	1.00	1.00	0.83	Fully Meets
15	0.50	0.75	1.00	0.75	Generally Meets
16	0.50	0.75	1.00	0.75	Generally Meets
17	1.00	0.25	0.00	0.42	Doesn't Meet

5 Evaluation Summary, Constrained Funding

The constrained funding scenario assumes an annual funding limit of $2.5B. At this funding level, Alternatives 1 and 5 fail to complete HLW vitrification facilities, cannot begin to process HLW, and are accordingly non-viable. The AoA Team determined that performing a complete analysis of these two non-viable alternatives did not make sense and could lead to confusion in the results. Thus, they were eliminated from the constrained funding case cost, schedule, and risk analysis.

The $2.5B annual funding limit also resulted in a lack of available funding to construct and operate a LAWST Facility or a new, higher capacity Effluent Treatment Facility (ETF) for any of the alternatives. Not having these facilities has a significant impact on LAW and HLW treatment rates, and a corresponding significant impact on the duration of the LAW and HLW treatment mission and resultant life cycle costs. Without additional process modeling, these cost and schedule impacts cannot be estimated. In fact, the only evaluation criteria not dependent upon additional process modeling are the first three (which are all weighted equally as "Highest Importance." The AoA Team considered analyzing Evaluation Criteria 4-9 qualitatively, but determined that such an analysis would be highly speculative and would detract from the value of the AoA. As a result, only Criteria 1-3 were evaluated in the constrained funding case. Table 95 shows the AoA Team's unweighted scoring results for the unconstrained funding case.

Table 95: Scoring of Alternatives, Unweighted Scores, Constrained Funding

#	Evaluation Criteria	Alt 2	Alt 14	Alt 15	Alt 16	Alt 17
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	0.50	0.50	0.75	0.75	1.00
EC-2	Lower HLW project TPC[27] range	0.25	0.25	0.50	0.50	1.00
EC-3	Lower operational, technical, and programmatic risk	0.50	0.50	0.25	0.25	0.75
	Totals	1.25	1.25	1.50	1.50	2.75

Because only three Evaluation Criteria are considered in the constrained funding case, weighting was recalculated. Since all three were weighted "Highest Importance," their normalized relative weightings are equal. Weighted results are shown in Table 96.

Table 96: Scoring of Alternatives, Weighted Scores, Constrained Funding

#	Evaluation Criteria	NRW[28]	Alt 2	Alt 14	Alt 15	Alt 16	Alt 17
EC-1	Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning	33.3	16.7	16.7	25.0	25.0	33.3
EC-2	Lower HLW project TPC[27] range	33.3	8.3	8.3	16.7	16.7	33.3
EC-3	Lower operational, technical, and programmatic risk	33.3	16.7	16.7	8.3	8.3	25.0
	Totals	100.0	41.7	41.7	50.0	50.0	91.7

6 Evaluation Details, Constrained Funding

Table 97: Rationale for Alternative Scoring, Constrained Funding

Evaluation Criterion 1: Alternative allows for earlier completion of HLW Vitrification Facility hot commissioning

Alt No.	Alternative Description	Score	Rationale
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.50	Alternatives 2 and 14 achieve completion of hot commissioning of the HLW Vitrification Facility in FY2036, about a year later than Alternatives 15 and 16, and are rated as Somewhat Meet.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.50	Alternatives 2 and 14 achieve completion of hot commissioning of the HLW Vitrification Facility in FY2036, about a year later than Alternatives 15 and 16, and are rated as Somewhat Meet.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.75	Alternatives 15 and 16 achieve completion of hot commissioning of the HLW Vitrification Facility in FY2035, about a year later than Alternative 17, and are rated as Generally Meet.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.75	Alternatives 15 and 16 achieve completion of hot commissioning of the HLW Vitrification Facility in FY2035, about a year later than Alternative 17, and are rated as Generally Meet.
17	DFHLW from DSTs without HLW Effluent Management	1.00	Alternative 17 has the earliest completion of hot commissioning of the HLW Vitrification Facility, estimated to occur in FY2034. Since it meets the ACD milestone, it is rated as Fully Meets.

[27] For comparative purposes, TPC includes costs for TWCSF/HFPEM/HEMF/WTV, LFE, Secondary Waste Treatment, a LAWST Facility, and HLW/PT completion, while excluding ancillary/supporting projects common to all alternatives such as LAW/BOF/LAB/DFLAW Completion, HSF/IHS, needed Tank Farm projects. For Alternative 17, replacement facilities during the mission duration are also excluded. Secondary Waste Treatment capability and a LAWST Facility are excluded for all alternatives.
[28] NRW = Normalized Relative Weighting

Evaluation Criterion 2: Lower HLW project Total Project Cost (TPC) range[29]			
Alt No.	**Alternative Description**	**Score**	**Rationale**
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.25	Alternative 2 has the highest TPC at $12.8B which is not significantly higher than Alternative 14 and therefore is rated the same as Barely Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.25	Alternative 14 has the second highest TPC at $12.7B. This is significantly higher than Alternative 16 and is therefore rated Barely Meets.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.50	Alternative 15 has the second lowest TPC at $11.6B. This is $2.7B higher than Alternative 17, a significant enough increase to rate it as Somewhat Meets rather than Generally Meets.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.50	Alternative 16 has the third lowest TPC at $11.8B, which is not significantly higher than Alternative 15 and therefore is rated the same as Somewhat Meets.
17	DFHLW from DSTs without HLW Effluent Management	1.00	Alternative 17 has the lowest TPC at $8.9B and is rated as Fully Meets.
Evaluation Criterion 3: Lower operational, technical, and programmatic risk			
Alt No.	**Alternative Description**	**Score**	**Rationale**
2	HLW Pretreatment and Effluent Management in New HFPEM Facility	0.50	Alternative 2 has the second lowest risk score, which is significantly higher than Alternative 17 and is therefore rated as Somewhat Meets.
14	HLW Pretreatment (with Filtration) and Effluent Management in New HFPEM Facility	0.50	Alternative 14 has a slightly higher risk score than Alternative 2 but the difference is not significant enough to rate the two alternatives differently therefor both are rated as Somewhat Meet.
15	DFHLW from DSTs and Effluent Management in New HEMF	0.25	Alternatives 15 and 16 have the highest, identical risk scores and are rated as Barely Meet.
16	DFHLW from DSTs and HLW Feed Concentration and Effluent Management in New HEMF	0.25	Alternatives 15 and 16 have the highest, identical risk scores and are rated as Barely Meet.
17	DFHLW from DSTs without HLW Effluent Management	0.75	Alternative 17 has the lowest unmitigated risk score and is rated as Generally Meets.
Note: The unmitigated risk rating for all alternatives is Moderate. Scoring for this criterion is based on the differences between the alternatives' numerical composite risk scores.			

[29] TPC includes facilities required to achieve start of HLW treatment operations (TWCSF/HFPEM/HEMF/WTV, LLFE, Secondary Liquid Waste Treatment, LAWST, HLW/PT) but exclude ancillary projects common to all alternatives (e.g., LAW/BOF/LAB/DFLAW completion, HSF, IHS, Tank Farm projects)

APPENDIX H: GAO AOA & COST ESTIMATING BEST PRACTICES EVALUATION

1 GAO AoA Best Practice Compliance

Step	Phase I: Initialize the AoA Process	Yes / No	AoA Compliance / Approach
1	Define mission need. The customer defines the mission need without a predetermined solution.	Yes	The mission need is defined through the Atomic Energy Act of 1954 and the DOE Organization Act of 1977 which directed DOE and its predecessors to manage defense-related nuclear wastes. Consistent with that responsibility, and in accordance with Public Law 97-90, in June of 1983, the President submitted the Defense Waste Management Plan (DWMP) to Congress. The DWMP establishes, as an objective, that the high-level waste (HLW) be immobilized and prepared for shipment to a geologic repository. The Hanford Waste Vitrification Plant (HWVP) Project was established to achieve permanent disposal of Hanford defense wastes with safe, environmentally acceptable, and cost-effective disposal methods that meet applicable regulations. The HWVP was to immobilize pretreated waste in borosilicate glass, cast the glass into stainless steel canisters, and store the canisters at Hanford until they are shipped to a Federal geologic repository. The HWVP was renamed the WTP.
2	Define functional requirements. The customer defines functional requirements based on mission need without a predetermined solution.	Yes	The HLW AoA Team spent a significant amount of time and at least one on-site meeting to gather documentation defining functional requirements. Document discovery continued as an ongoing process.
3	Develop AoA time frame. The customer provides the team conducting the analysis enough time to complete the AoA to ensure a robust and complete analysis.	Yes	The WTP HLW AoA was conducted from April 2019 through June 2020. The team was provided initial document sets, received a two-day briefing on the HLW mission need and current status, and conducted numerous site visits throughout the AoA process. Adequate time was provided to conduct a thorough analysis.
4	Establish AoA Team. This team consists of members with a variety of necessary skill sets, specific knowledge, and abilities to successfully execute the study.	Yes	The HLW AoA Team included members with diverse expertise, including project management, risk management, cost estimating, scheduling, waste treatment, construction management, and regulatory involvement.
5	Define selection criteria. The AoA Team or the decision maker defines selection criteria based on the mission need. The defined criteria are based on mission needs and are independent of a particular capital asset or technological solution.	Yes	Nine evaluation criteria were established, reviewed, and discussed during early information gathering site visits. These were discussed and documented in the approved Study Plan.
6	Weight selection criteria. The AoA Team or the decision maker weights the selection criteria to reflect the relative importance of each criterion.	Yes	The evaluation criteria were weighted by assigning a relative importance to each criterion developed for the WTP HLW AoA.
7	Develop AoA process plan. The AoA Team creates a plan to include proposed methodologies for identifying, analyzing, and selecting alternatives prior to beginning the AoA process.	Yes	The plan for identifying, analyzing, and ranking alternatives was summarized in the task proposal, discussed in the initial kick-off meeting, discussed again during site visits, and documented in the Study Plan.

Step	Phase II: Initialize the AoA Process	Yes / No	AoA Compliance / Approach
8	Develop list of alternatives. The AoA Team identifies and considers a diverse range of alternatives to meet the mission need.	Yes	Through an iterative process, including during site visits and subsequent team calls, the HLW AoA Team brainstormed and screened 17 potentially viable alternatives to meet the mission need and program requirements. Seven alternatives were fully evaluated
9	Describe alternatives. The AoA Team describes alternatives in enough detail to allow robust analysis.	Yes	Descriptions, layouts, and facility diagrams were developed during several site visits and collaboration meetings. All descriptions are documented in the AoA report, Appendix A and Appendix B.
10	Include baseline alternative. The AoA Team includes one alternative to represent the status quo to provide a basis of comparison among alternatives.	Yes	Alternative 1 (the baseline case) was included and fully evaluated as a potential solution. NOTE: The "program of record" was not included in the evaluation by Steering Committee approval. This "alternative" was deemed completely non-viable as it does not address DNFSB technical issues, and in no circumstance would be acceptable to the State of Washington Department of Ecology. Alternative 1 incorporates solutions to DNFSB technical issues, many of which are already completed or are under development.
11	Assess alternatives' viability. The AoA Team screens the list of alternatives to eliminate those alternatives that are not viable, and it documents the reasons for eliminating any alternatives.	Yes	Alternatives were screened against the three screening criteria approved in the Study Plan. As the analysis progressed, additional alternatives were recommended for subsequent screening to the Steering Committee. Screening rationale is documented in Appendix D.

Step	Phase III: Analyze Alternatives	Yes / No	AoA Compliance / Approach
12	Identify significant risks and mitigation strategies. The AoA Team identifies and documents the significant risks and mitigation strategies for each alternative.	Yes	Five alternatives failed to pass initial screening. As the AoA progressed, an additional five alternatives were subsequently screened out with Steering Committee approval. Details and rational are provided in Appendix D.
13	Determine and quantify benefits/effectiveness. The AoA Team uses a standard process to document the benefits and effectiveness of each alternative.	Yes	The costs, risks, and benefits associated with WTP HLW alternatives were evaluated qualitatively and quantitatively.
14	Tie benefits/effectiveness to mission need. The AoA Team explains how each measure of effectiveness supports the mission need.	Yes	The rationale for scoring each of the WTP HLW AoA's evaluation criteria, and how they meet the mission need, is documented in the AoA report (Appendix G)
15	Develop life-cycle cost estimates (LCCEs). The AoA Team develops an LCCE for each alternative, including all costs from inception of the project through design, development, operation, maintenance, and disposal.	Yes	Life-cycle cost estimates, in the form of estimate ranges and present value, were developed and documented for each of the seven alternatives. LCCEs included design, construction, startup and commissioning; operations and maintenance; and deactivation and decommissioning costs.
16	Include confidence interval or range for LCCEs. The AoA Team presents the LCCE for each alternative with a confidence interval or range, and not solely as a point estimate.	Yes	LCCEs for the seven alternatives were presented as ranges, in addition to point estimates, using confidence levels documented in the Cost Estimating Plan and AoA report.
17	Perform sensitivity analysis. The AoA Team tests and documents the sensitivity of the cost and benefit and effectiveness estimates for each alternative to risks and changes in key assumptions.	Yes	Sensitivity analyses scenarios were developed by the HLW AoA Team. The scenarios tested changes to the weighting of evaluation criteria. Results of each scenario are documented in the AoA report.

Step	Phase IV: Document & Review the AoA	Yes / No	AoA Compliance / Approach
18	Document AoA process in a single document. The AoA Team documents all steps taken to identify, analyze, and select alternatives in a single document.	Yes	The WTP HLW AoA process and approach to identify and evaluate alternatives to meet mission and program requirements is documented in the AoA Report

Step	Phase IV: Document & Review the AoA	Yes / No	AoA Compliance / Approach
19	Document assumptions and constraints. The AoA Team documents and justifies all assumptions and constraints used in the AoA process.	Yes	Assumptions and constraints for the AoA are documented in the AoA report.
20	Ensure AoA process is impartial. The AoA Team conducts the analysis without a predetermined solution. The AoA process informs the decision-making process rather than reflecting the validation of a predetermined solution.	Yes	The AoA Team conducted the AoA without any predetermined solution. Multiple alternatives were identified, discussed, screened, and evaluated in accordance with the established methodology.
21	Perform an independent review. An entity independent of the AOA process reviews the extent to which all best practices have been followed.	Yes	EM provided independent review of the AoA process, including review of the alternatives, mission and program requirements, evaluation criteria, and alternative screening and scoring
22	Compare alternatives. The AoA Team or the decision maker compares the alternatives using PV, if possible, to select a preferred alternative.	Yes	The WTP HLW alternatives' LCCEs were also presented as present values for comparison and documented in the cost estimate section of the report. Results were presented to the Steering Committee.

2 GAO Cost Estimating Best Practice Compliance

Step	Description	Associated Task(s)	AoA Compliance / Approach
1	Define estimate's purpose	1. Determine estimate's purpose, required level of detail, and overall scope. 2. Determine who will receive the estimate.	The estimate purpose is described in the Estimate Plan. The estimates will inform the DOE decision makers as well as other interested parties regarding the basis for the alternative analysis and will support alternative selection by DOE.
2	Develop estimating plan	1. Determine the cost estimating team and develop its master schedule. 2. Determine who will do the independent cost estimate; outline the cost estimating approach. 3. Develop the estimate timeline.	An Estimate Plan was developed and provided as an Attachment to the AoA Study Plan.
3	Define program characteristics	1. Identify the program's purpose and its system and performance characteristics and all system configurations. 2. Any technology implications. 3. Program acquisition schedule and acquisition strategy. 4. Its relationship to other existing systems, including predecessor or similar legacy systems. 5. Support (manpower, training, etc.) and security needs and risk items. 6. System quantities for development, test, and production. 7. Deployment and maintenance plans.	Program characteristics and alternative descriptions are documented in the AoA Study Plan and AoA Report
4	Determine estimating structure	1. Define a work breakdown structure (WBS) and describe each element in a WBS dictionary (a major automated information system may have only a cost element structure). 2. Choose the best estimating method for each WBS element; Identify potential cross-checks for likely cost and schedule drivers. 3. Develop a cost estimating checklist.	A WBS was developed and used for the RPP System Plan and that same WBS was used for the AoA estimates and schedules for all alternatives to the extent elements are appropriate. The Estimate Plan describes the general estimate methodology and approach planned to be used which is focused on capital projects and other life cycle cost elements. Actual methodology used for estimate development is further documented in Appendix E of the AoA Report. The use of the System Plan model output accomplishes the objective of having an estimate checklist.
5	Identify ground rules and assumptions	1. Clearly define what the estimate includes and excludes. 2. Identify global and program-specific assumptions, such as the estimate's base year, including time-phasing and life cycle. 3. Identify program schedule information by phase and program acquisition strategy. 4. Identify any schedule or budget constraints, inflation assumptions, and travel costs. 5. Specify equipment the government is to furnish as well as the use of existing facilities or new modification or development. 6. Describe effects of new ways of doing business.	Appendix E of the AoA Report documents all assumptions used for the LCCE for each alternative. A separate report that documents the results of the WRPS modeling efforts provides further documentation of assumptions used to generate the LCCEs (*High-Level Waste Analysis of Alternatives Model Results Report)*.

Step	Description	Associated Task(s)	AoA Compliance / Approach
6	Obtain data	1. Create a data collection plan with emphasis on collecting current and relevant technical, programmatic, cost, and risk data. 2. Investigate possible data sources. 3. Collect data and normalize them for cost accounting, inflation, learning, and quantity adjustments. 4. Analyze the data for cost drivers, trends, and outliers and compare results against rules of thumb and standard factors derived from historical data. 5. Interview data sources and document all pertinent information, including an assessment of data reliability and uncertainty. 6. Store data for future estimates.	The AoA Team used a variety of data sources and references to develop the LCCEs for the AoA alternatives, as documented in the AoA Report and the *High-Level Waste Analysis of Alternatives Model Results Report*.
7	Develop point estimate and compare it to an independent cost estimate	1. Develop the cost model, estimating each WBS element, using the best methodology from the data collected, and including all estimating assumptions. 2. Express costs in constant year dollars. 3. Time-phase the results by spreading costs in the years they are expected to occur, based on the program schedule. 4. Sum the WBS elements to develop the overall point estimate. 5. Validate the estimate by looking for errors like double counting and omitted costs. 6. Compare estimate against the independent cost estimate and examine where and why there are differences. 7. Perform cross-checks on cost drivers to see if results are similar. 8. Update the model as more data become available or as changes occur and compare results against previous estimates.	These steps have been completed as appropriate and documented in the AoA Report. An independent cost estimate has not been completed.
8	Conduct sensitivity analysis	1. Test the sensitivity of cost elements to changes in estimating input values and key assumptions. 2. Identify effects on the overall estimate of changing the program schedule or quantities. 3. Determine which assumptions are key cost drivers and which cost elements are affected most by changes.	Key assumptions were identified, and Sensitivity Analyses was conducted to the extent possible. The results of those analyses are described in the AoA Report.
9	Conduct Risk and uncertainty analysis	1. Determine and discuss with technical experts the level of cost, schedule, and technical risk associated with each WBS element. 2. Analyze each risk for its severity and probability. 3. Develop minimum, most likely, and maximum ranges for each risk element. 4. Determine type of risk distributions and reason for their use. 5. Ensure that risks are not correlated. 6. Use an acceptable statistical analysis method (e.g., Monte Carlo simulation) to develop a confidence interval around the point estimate. 7. Identify the confidence level of the point estimate. 8. Identify the amount of contingency funding and add this to the point estimate to determine the risk-adjusted cost estimate. 9. Recommend that the project or program office develop a risk management plan to track and mitigate risks.	The AoA includes a qualitative risk assessment suitable for comparison of the alternatives. A quantitative risk analysis, using Monte Carlo simulation, was not done for this AoA. Rather, cost estimate ranges are provided based on prescribed uncertainty ranges for Class 5 estimates, informed additionally by the results of the qualitative risk assessment.

Step	Description	Associated Task(s)	AoA Compliance / Approach
10	Document the estimate	1. Document all steps used to develop the estimate so that a cost analyst unfamiliar with the program can recreate it quickly and produce the same result. 2. Document the purpose of the estimate, the team that prepared it, and who approved the estimate and on what date. 3. Describe the program, its schedule, and the technical baseline used to create the estimate. 4. Present the program's time-phased life-cycle cost. 5. Discuss all ground rules and assumptions. 6. Include auditable and traceable data sources for each cost element and document for all data sources how the data were normalized. 7. Describe in detail the estimating methodology and rationale used to derive each WBS element's cost (prefer more detail over less). 8. Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified. 9. Document how the estimate compares to the funding profile. 10. Track how this estimate compares to any previous estimates.	The LCCE for each alternative is fully described and documented in the final AoA Report.
11	Present estimate to management for approval	1. Develop a briefing that presents the documented life-cycle cost estimate. 2. Include an explanation of the technical and programmatic baseline and any uncertainties. 3. Compare the estimate to an independent cost estimate (ICE) and explain any differences. 4. Compare the estimate (life-cycle cost estimate (LCCE)) or independent cost estimate to the budget with enough detail to easily defend it by showing how it is accurate, complete, and high in quality. 5. Focus in a logical manner on the largest cost elements and cost drivers. 6. Make the content clear and complete so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results. 7. Make backup slides available for more probing questions. 8. Act on and document feedback from management. 9. Request acceptance of the estimate.	A briefing to EM management and others, as needed, will be scheduled after the AoA is completed. It will be clearly noted that these rough-order-of -magnitude estimates are provided to facilitate the comparison and evaluation of alternatives, and that they are not intended or suitable for budgeting purposes.
12	Update the estimate to reflect actual costs and changes	1. Update the estimate to reflect changes in technical or program assumptions or keep it current as the program passes through new phases or milestones. 2. Replace estimates with EVM EAC and independent estimate at completion (EAC) from the integrated EVM system. 3. Report progress on meeting cost and schedule estimates. 4. Perform a post mortem and document lessons learned for elements whose actual costs or schedules differ from the estimate. 5. Document all changes to the program and how they affect the cost estimate.	N/A

APPENDIX I: REFERENCES

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