UNITED STATES DEPARTMENT OF ENERGY
NATIONAL NUCLEAR SECURITY ADMINISTRATION
Office of Cost Estimating and Program Evaluation (CEPE)

Surplus Plutonium Disposition Dilute and Dispose Option Independent Cost Estimate (ICE) Report

April 2018

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Cost Estimating and Program Evaluation

Approval

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Record of Changes

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0	April 2018	Initial Report of the Dilute and Dispose ICE Report	N/A

Executive Summary

Per the Plutonium Management and Disposition Agreement (PMDA), the United States (US) and Russia are both committed to dispose 34 metric tons (MT) of weapons-grade plutonium (Pu) by converting it into mixed oxide (MOX) fuel that consists of a mixture of oxidized Pu and uranium (U) that can be sold to commercial nuclear power plants for peaceful purposes. Due to significant growth in estimates-at-completion (EACs) of MOX construction from the original plan in 1999, the President's Fiscal Year (FY) 2018 budget supports the plan to terminate the MOX project and pursue an alternative disposition method that will achieve significant long-term savings. This alternative disposition method is Dilute and Dispose (D&D), which provides radiological and physical protection for the material in permanent geological disposal. In addition, the FY2018 National Defense Authorization Act (NDAA) authorizes the Secretary of Energy to terminate the MOX project if the cost for the alternative—the D&D option—would be less than half of the estimated remaining lifecycle cost of the MOX project. The NDAA further stipulated that remaining D&D lifecycle costs must be determined in a manner comparable to the cost estimating and assessment best practices of the Government Accountability Office.

The September 2016 US MOX fuel program lifecycle cost estimate used in the MOX liability audit report is $56.0B, of which $7.6B are sunk costs through FY17 and $48.4B are remaining. However, this MOX lifecycle estimate did not include costs funded outside of the MOX program, such as transportation costs, decontamination and decommissioning of the MOX facility, and operations of the Waste Isolation Pilot Plant facility. After including these costs and correcting other issues in the estimate, the remaining Estimate-To-Complete (ETC) for the MOX fuel program is $49.4B.

The March 2018 D&D ICE ranges between $17.2B and $19.9B, with a most likely ETC cost of $18.2B in Then Year dollars, excluding $20 million in sunk costs. The remaining D&D ETC lifecycle cost is therefore 35% to 40% of the remaining MOX fuel program ETC lifecycle cost.

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1 Introduction

The current approach in the US to dispose of 34 metric tons (MT) of surplus plutonium (Pu) is the mixed oxide (MOX) fuel approach, per a Plutonium Management and Disposition Agreement (PMDA) between the US and Russia. This involves disposing of surplus weapon-grade Pu by irradiating it into MOX fuel or by any other method that the parties may agree upon in writing. In 1997, the US Department of Energy (DOE) decided to pursue the MOX pathway using light water reactors in combination with immobilization using a can-in-canister approach. Since that time, the cost of the MOX approach has increased dramatically compared to early estimates, and the down-blending or dilution of the Pu oxide has been successfully demonstrated in support of the closure of Rocky Flats.

Due to the dramatic cost increases and the demonstrated feasibility of the down-blending or dilution approach, DOE chartered a Plutonium Disposition Working Group in 2014 that reviewed and evaluated cost options for the disposal of surplus Pu, including both MOX fuel and Dilute and Dispose (D&D) approaches. Congress subsequently directed the National Nuclear Security Administration (NNSA) to conduct an independent review of the Plutonium Disposition Working Group report, which was completed by The Aerospace Corporation in April 2015 and followed by a Congressional request for a "Red Team" review of Pu disposition options, which was completed in August 2015. The conclusions reached in each of these evaluations support the fundamental business case that D&D is a more cost-effective means of dispositioning surplus Pu.

In 2017, NNSA directed the Office of Cost Estimating and Program Evaluation (CEPE) to develop an independent cost estimate (ICE) in support of the D&D alternative to the current Mixed Oxide (MOX) Fuel Fabrication project to disposition 34 MT of surplus Pu. This report documents the results of the D&D ICE completed by CEPE in March 2018.

2 Cost Methodology

2.1 Purpose of Estimate

CEPE developed the D&D ICE to evaluate the cost-effectiveness of the D&D program as an alternative to the current MOX Fuel Fabrication project for disposition of 34 MT of surplus Pu.

2.2 Overview of Estimating Approach

This D&D lifecycle estimate was developed in accordance with GAO cost estimating and assessment best practices. The estimate is primarily based on historical costs, technical data, schedules, labor rates, staffing profiles, and vendor quotes that were provided by the Office of Material Management and Minimization (NA-23) within Defense Nuclear Nonproliferation during their ongoing Life Cycle Cost Estimate (LCCE).

In general, CEPE analyzed the end-to-end workflow of the Pu D&D program to organize the cost estimate by function and site. The cost and schedule analysis includes the costs to process 34 MT over the lifecycle of the program (2018-2050). The cost estimating methodology matrix in Table 1 below outlines the cost estimating approach for all of the cost elements.

Table 1 – Dilute and Dispose Work Breakdown Structure

WBS	Scope	Data Sources	Estimating Approach
23.3.2.1.1, 23.3.2.1.2 23.3.2.1.2.1, 23.3.2.1.2.2,	PANTEX Operations	Staging and Survelliance Staffing Profile	Calculated based on Labor Rates (with adjustments)
23.3.2.1.2.2	Packaging (Pantex to LANL)	Staffing Profile and PANTEX Historical Material Costs	Calculated based on Labor Rates (with adjustments)
23.3.2.2.2.1, 23.3.2.2.2.2	LANL Operations	Historical Actuals of ARIES Production	Extrapolation Of Actuals & Scaling
23.3.2.2.2.3, 23.3.2.2.2.4	LANL Facilities	Historical Actuals of ARIES Production	Historical Nuclear Facilities Cost Growth - 20%
23.3.2.2.1.1, 23.3.2.2.1.2, 23.3.2.2.1.3	H-Canyon Operations	H-B Line Historical Actuals	Extrapolation Of Actuals & Scaling
23.3.2.3.2.1, 23.3.2.3.2.2, 23.3.2.3.2.3	SRS Operations (K-Area/E-Area)	SRS Operations Staffing Profile	Calculated based on Labor Rates (with adjustments)
23.3.2.3.1.2, 23.3.2.3.2.2	SRS Facilities (K-Area/E-Area)	Scaled based on KIS Actuals	Historical Nuclear Facilities Cost Growth - 20%
23.3.2.4.1, 23.3.2.4.2	WIPP Operations	Historical Actuals of WIPP Operations	Extrapolation Of Actuals & Scaling
23.3.1.1.1, 23.3.1.1.2 , 23.3.1.1.3,	Program Management and Integration	PMI Staffing Requirements + NEPA Direct Costs	Calculated based on Labor Rates (with adjustments)
23.3.2.6	MOX Termination and Closeout	MOX Re-Purposing Data	Analysis and Adjustment of MOX Re-Purposing Data
23.3.2.5.3	Transportation (OST)	Historical OST Actuals and Vendor Quotes	Extrapolation of Actuals with Scaling Adjustements
23.3.2.5.1	Transportation (DOE) Packaging of CCOs and to WIPP	Historical DOE Actuals and Vendor Quotes	Extrapolation of Actuals with Scaling Adjustements

The actual Work Breakdown Structure (WBS) elements, by function, are depicted in WBS diagram illustrated in Figure 1 below. A detailed WBS dictionary containing detailed explanation of each WBS element is available upon request. A list of data sources used for this estimate is included in Appendix B.

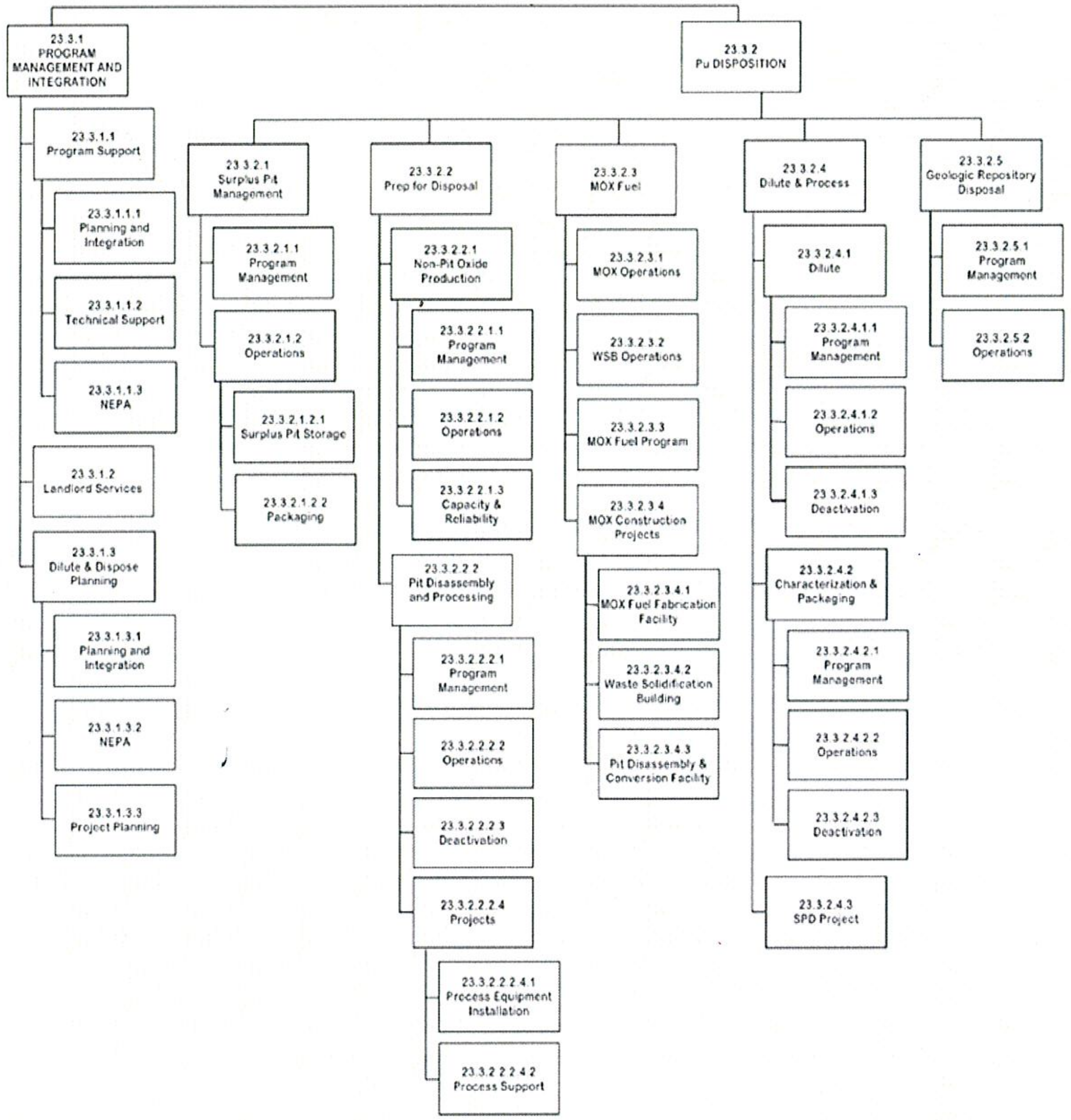

Figure 1 – Pu Disposition Program Work Breakdown Structure Diagram

All estimates identify risk ranges for each major element within the D&D estimate. The ICE identifies major risk drivers in construction costs, site staffing profiles, transportation, and disposal costs.

2.3 Estimate Assumptions

2.3.1 General Assumptions

- The estimate is based on processing of all 34 MT of Pu, which includes 26.2 MT of surplus pit Pu from NNSA and 7.8 MT of non-pit Pu from the DOE Office of Environmental Management (DOE-EM) operations.
- All cost estimates were developed in base year FY2017 dollars.
- The ICE is based on data sources as provided as of March 30, 2018.
- The D&D ICE is based on a CD-0 maturity level.
- Each individual site and operation estimate start from using historical data or projections derived from historical processes. In most cases, the most likely estimate for the ICE represents the 50th percentile of a Monte Carlo simulation, factoring in risk and uncertainty for each operation.
- The LANL unclassified throughput is assumed to be 100 Kgs per year from FY18 to FY22 and 1117 Kgs per year from FY23 to FY45. This is illustrated in the throughput tables below in Figure 2. A classified annex for the actual LANL throughput is also available.
- The SRS K-Area dilute and down-blending unclassified throughput is assumed to be 400Kgs per year in FY26, 820 Kgs per year in FY 27 and 1640 Kgs per year from FY28 to FY47 for both NNSA and DOE-EM material. This is illustrated below in Figure 3. A classified annex for the actual SRS throughput is also available.
- The use of annual average throughputs for LANL and SRS will adequately account variations in production output.
- 7.8 MT of DOE-EM Pu oxide will be down-blended in K-Area using existing processes within the K-Area Interim Surveillance (KIS) program rather than NNSA's proposed K-Area infrastructure; DOE-EM will use the same line, personnel and infrastructure as planned for 6MT of Pu that is part of a separate DOE-EM disposition program (this 6MT of Pu disposition is outside of the scope of this estimate.)
- 7.8 MT of DOE-EM Pu oxide will be packaged by NNSA in SRS E-Area on the same cost basis as NNSA's 26.2 MT of Pu, or any alternative processing stream for DOE-EM material will result in a similar cost.
- The major drivers for long-term Waste Isolation Pilot Plant (WIPP) requirements are programs other than D&D.
- Any further MOX construction and Waste Solidification Building operations costs after termination are not assumed to be part of D&D Scope for the ICE.
- Overall, the costs for base operations/infrastructure/upgrades of site facilities are based on existing processes, actual costs, engineering analysis, and staffing profiles funded by the owning program.

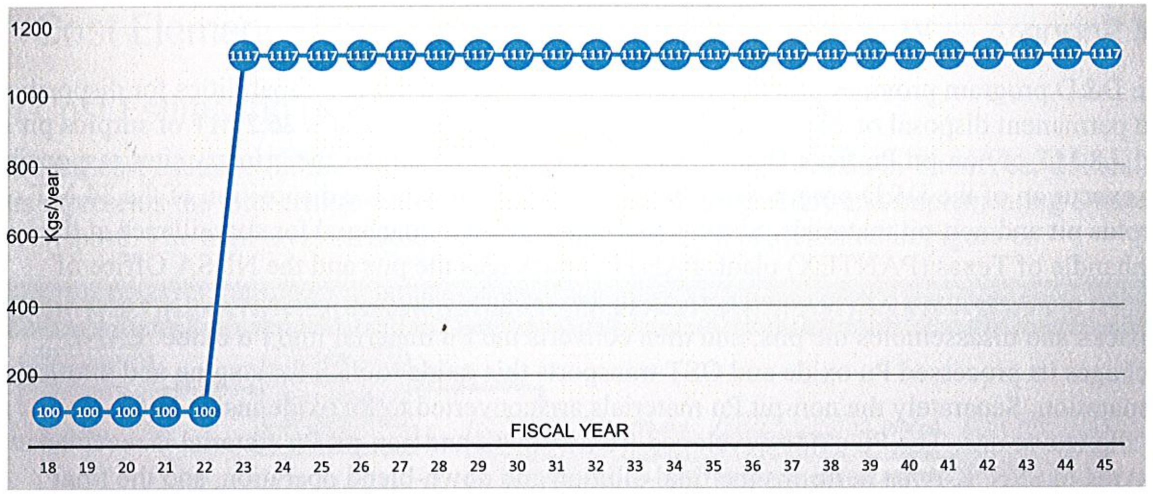

Figure 2 – LANL Oxidation Throughput Table (Ramp up to 1117 Kgs per year)

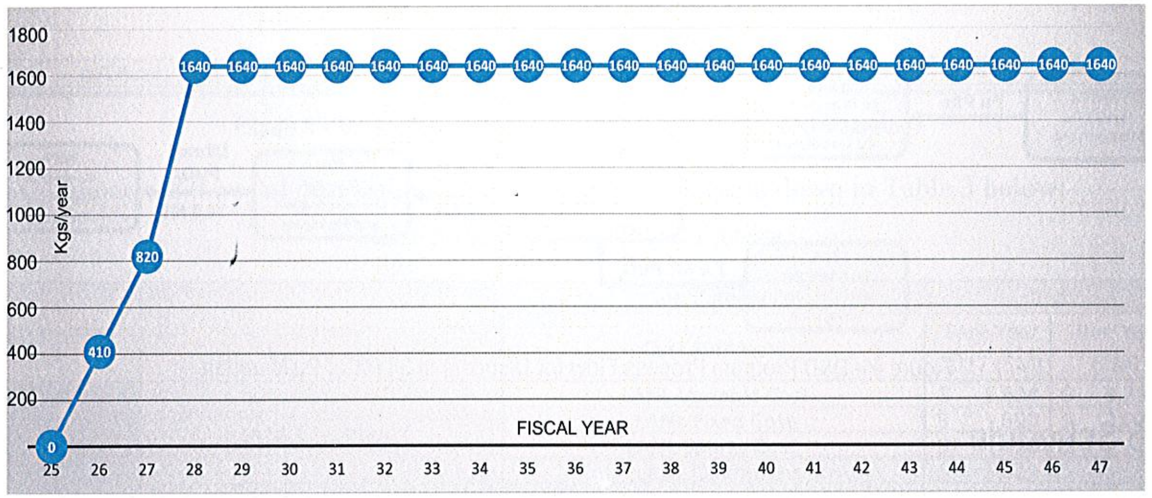

Figure 3 – SRS Dilution Throughput Table (Ramp up to 1640 Kgs per year)

2.3.2 Time Work of Money Assumptions

All cost estimates were developed in FY2017 dollars and converted to Then Year dollars using the escalation rates shown in Table 2. (Prior year estimates, when used, have been escalated to the base period using the same rates.) These escalation factors were chosen to enable direct and accurate comparisons to the MOX liability audit report. These escalation factors are in line with others used within the NNSA complex.

Table 2 – Annual Escalation Rates by Site

Site/Activity	Escalation Rate
PANTEX	2%
LANL	4.1%
PMI	2%
K-Area Ops	4%
Other SRS	2%
All Other	2%

2.4 Scope

The D&D program provides processing, characterization, and storage capabilities for disposition and permanent disposal of 34 MT of weapons-usable Pu. This includes 26.2 MT of surplus pit Pu and 7.8 MT of non-pit Pu from DOE-EM. Figure 4 below illustrates the primary sites responsible for execution of the D&D program process flow associated with the disposition of the 34 MT of surplus pit and non-pit materials. Surplus pits are staged and managed for surveillance at the Panhandle of Texas (PANTEX) plant. PANTEX packages the pits and the NNSA Office of Secure Transportation (OST) delivers them to Los Alamos National Laboratory (LANL). LANL unpacks and disassembles the pits, and then converts the Pu material into Pu oxide. LANL packages its processed Pu oxide and OST transports this oxide to SRS for staging and dilution preparation. Separately the non-pit Pu materials are converted to Pu oxide inside H-Canyon or at an alternative site. The Pu oxide developed from both pit and non-pit Pu material is received at K-Area in SRS. K-Area performs the final dilution and down-blend operation, and the final product is readied in E-Area for characterization and packaging. Finally, the diluted Pu oxide is shipped to the WIPP for permanent disposal by DOE commercial transportation.

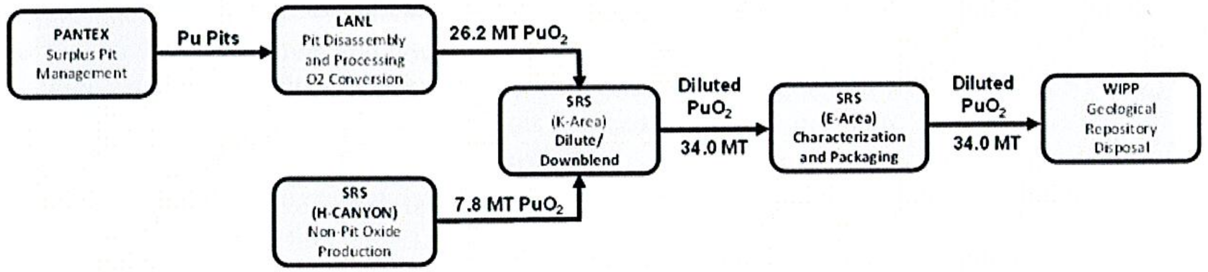

Figure 4 – D&D Program Process Flow for Disposal of 34 MT of Pu Materials

2.5 Schedule

NA-23 provided a plan that identifies the scope, major functions, and timelines that affect the D&D program. Figure 5 shows the D&D program schedule from FY2018 to FY2050.

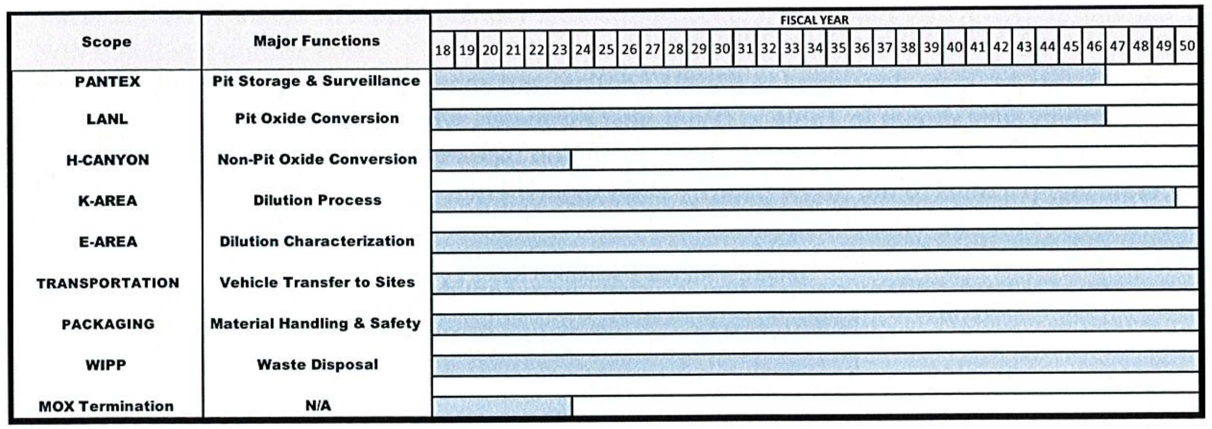

Figure 5 – D&D Program Schedule

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3 Cost Element Scope, Estimates, and Methodology

3.1 Cost Estimating High Level Results and Summary

The total cost estimate for the Dilute and Dispose Option is $18.2 billion in Then Year dollars. This represents the total cost to the DOE Complex for forgoing MOX and implementing Dilute and Dispose. The high level breakdown by site and operation is presented in Figure 6.

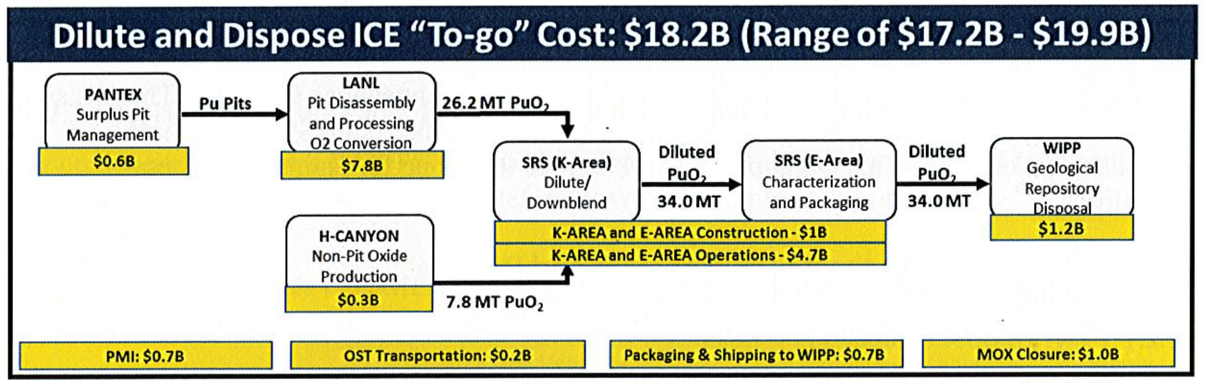


Figure 6 – Dilute and Dispose Cost Breakdown by Site and Operation

The summary of the total cost estimate subcategories are broken down in Table 3 below:

Table 3 – Summary of D&D Cost Estimate

Scope Area	Category	Sub-Category Cost Summary	Cost Base Year 2017 ($M)	 Then Year ($M)
LANL	LANL Operations	LANL Variable Cost	$ 1,604	$ 3,283
		LANL Fixed Cost	$ 990	$ 2,026
		LANL Spares Cost	$ 26	$ 54
		Total LANL Operations Cost	$ 2,620	$ 5,363
	LANL Facilities	Total LANL Facilties Cost	$ 1,206	$ 2,387
	LANL Totals	**LANL Totals**	**$ 3,826**	**$ 7,750**
PANTEX	**PANTEX Totals**	**PANTEX Totals**	**$ 441**	**$ 612**
SRS	K-Area / E-Area Operations Scope	K-Area Operations	$ 1,348	$ 2,848
		E-Area Operations	$ 1,074	$ 1,589
		SRS PMI	$ 205	$ 292
		Total K-Area /E-Area Operations Cost	$ 2,627	$ 4,729
	K-Area / E-Area Facilities Scope	K-Area Facilities	$ 548	$ 880
		E-Area Facilities	$ 72	$ 89
		Total K-Area /E-Area Facilities Cost	$ 620	$ 969
	H-Canyon Operations	H-Canyon Totals	$ 309	$ 331
	SRS Totals	**SRS Totals**	**$ 3,556**	**$ 6,029**
WIPP	**WIPP OPERATIONS**	**WIPP Totals**	**$ 832**	**$ 1,245**
NNSA	**NNSA PMI**	**NNSA PMI Totals**	**$ 490**	**$ 682**
MOX	**MOX Closeout**	**MOX Closeout Totals**	**$ 906**	**$ 971**
Transportation & Packaging	OST Transportation	Transportation (PANTEX to LANL to SRS)	$ 157	$ 229
	DOE EM Transportation	Transportation (SRS to WIPP)	$ 67	$ 101
	Criticality Control Over-Pack (CCOs)	CCOs and Other Packaging	$ 370	$ 554
	Transportation & Packaging	**TRANSPORTATION & PACKAGING Totals**	**$ 594**	**$ 884**
		ICE Totals	**$ 10,645**	**$ 18,173**

3.2 PANTEX

3.2.1 PANTEX Background

Within the D&D mission, PANTEX will manage surplus pit materials and package and ship them to LANL for disassembly and conversion to a form suitable for the D&D approach. The pits will be packaged into an approved Type B container for transport to LANL. PANTEX will need to establish and maintain the packaging line(s) for the MD-2 (Type B) container approved to replace the FL container. PANTEX will perform the annual maintenance as required by the Type B container Safety Analysis Report for Packaging (SARP). This project will include establishing and maintaining the capabilities to perform the maintenance activities. The pits and containers are, as required, part of the storage sample surveillance plan. Storage sample surveillance is ongoing. This D&D project will include the scope for maintaining these capabilities.

3.2.2 PANTEX Cost Estimate Development and Results

3.2.2.1 PANTEX Cost Estimating Process

Figure 7 provides a process flow illustrating how the PANTEX operations cost estimates were developed:

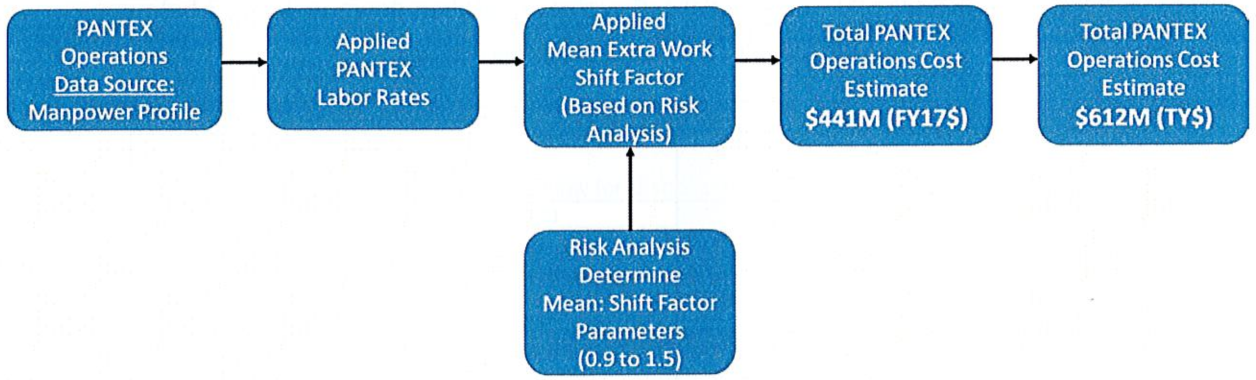


Figure 7 – PANTEX Cost Estimating Process Flow

3.2.2.2 PANTEX Starting Point

The primary data source for the PANTEX operations estimate was the staffing profile provided by the NA-23 program office that shows Full Time Equivalents (FTEs) required for surplus pit management, surplus pit surveillance, packaging and shipment and other functions necessary to operate on a 10 hour work day schedule at four days per week. This staffing profile, shown in Figure 8, shows a ramp up from approximately 18-22 FTEs to approximately 30- 42 FTEs. This FTE staffing profile is based on labor shifts of 40 hours per week from FY2018 to FY2046.

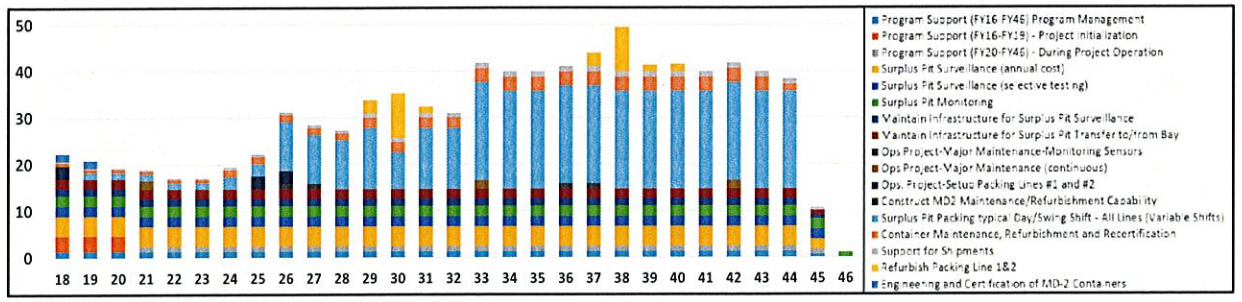


Figure 8 – PANTEX Staffing Profile (October 2017)

3.2.2.3 PANTEX Composite Labor Rates

The composite labor rates PANTEX provided, displayed in Table 4, were applied to the staffing profile displayed in Figure 8 based on a ten-hour work day at four days per week.

Table 4 – PANTEX Composite Annual Labor Rates by Cost Functions
Contractor Proprietary

PANTEX Cost Elements	Labor Rates	
Program Support (FY16-FY46) Program Management	$	462,322
Program Support (FY16-FY19) - Project Initialization	$	312,508
Program Support (FY20-FY46) - During Project Operation	$	348,033
Surplus Pit Surveillance (annual cost)	$	396,196
Surplus Pit Monitoring	$	242,579
Maintain Infrastructure for Surplus Pit Surveillance	$	332,244
Maintain Infrastructure for Surplus Pit Transfer to/from Bay	$	308,278
Ops Project-Major Maintenance-Monitoring Sensors	$	448,909
Ops Project-Major Maintenance (continuous)	$	522,186
Project-Setup Packing Lines #1 and #2	$	217,696
Surplus Pit Packing typical Day/Swing Shift - All Lines (Variable Shifts)	$	394,008
Container Maintenance, Refurbishment and Recertification	$	428,963
Support for Shipments	$	300,760
Refurbish Packing Line 2	$	458,097

3.2.2.4 PANTEX Operations Risk

Risk analysis for PANTEX operations is based on a triangular distribution of scaling factors applied to the effort estimate, shown in Table 5. Low represents the assumed realization of opportunities for efficiency from the starting point. The point estimate requires the addition of a fifth day of shift work (adding 25% to the initial estimate). The high requires the addition of a fifth and sixth day of shift work (adding 50% to the initial estimate).

Table 5 – PANTEX Operations Extra Shift Parameter (Triangular Distribution)

Triangular Parameter	Scaling Factor
Low	0.9
Point	1.25
High	1.5
50% Confidence	1.22

3.2.2.5 PANTEX Operations Cost Estimate

After applying risk and running a Monte Carlo model, the scaling value at the 50th percentile was determined to be 1.22 for additional labor. This factor was applied to the calculated staffing profile and multiplied by the associated PANTEX labor rates. This resulted in a total most likely cost estimate of $441M in FY2017 dollars. The total cost in Then Year dollars over the time period is $612M. This is summarized in Table 6.

Table 6 – PANTEX Operations Total Cost

PANTEX Operations	Cost Summary	FY2017 ($M)	Then Year ($M)
	PANTEX Operations	**$ 441**	**$ 612**

3.3 LANL

3.3.1 LANL Background

3.3.1.1 LANL Process and Scope

The oxidation process used for pit Pu in D&D will be similar to the existing Advanced Recovery and Integrated Extraction System (ARIES) capability at LANL that processes both U and Pu, as shown in Figure 9. This includes the receipt of surplus pits from PANTEX, the disassembly of the surplus pits, the staging and storage of material, and the conversion of the Pu pit material to oxide as well as the characterization and packaging of oxide into a 9977 container for transport to SRS. Further descriptions of ARIES operations are provided in Appendix C.

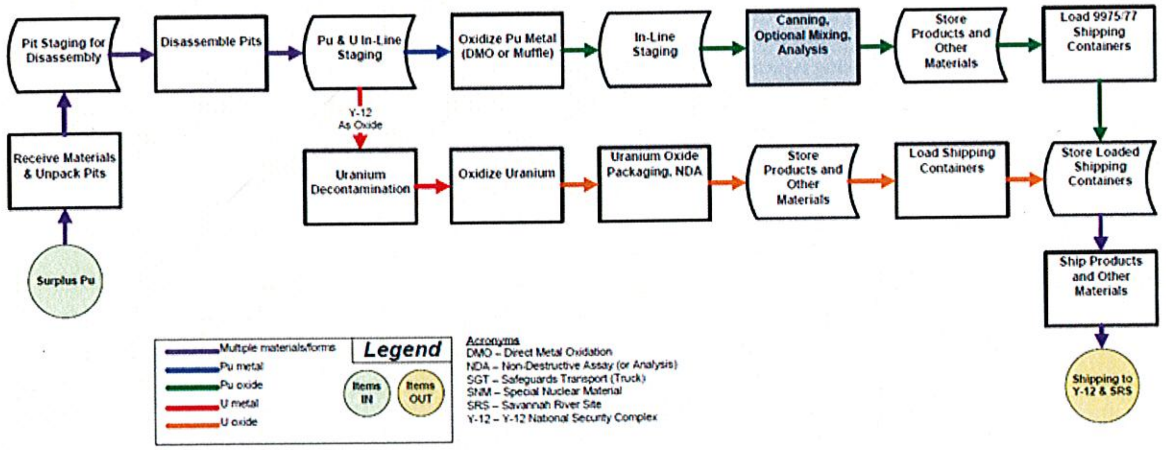


Figure 9 – Advanced Recovery and Integrated Extraction System (ARIES) Flow

All LANL operations for D&D are planned for the Plutonium Facility-4 (PF-4). ARIES currently occupies 7.5% of the facility floor space, primarily in two wings of the building. According to LANL, this floor space would increase to approximately 12% for the D&D approach and would utilize space in the same or nearby rooms to minimize material movement requirements. The following major installation projects are needed to produce the planned throughput:

- Disassembly: Four new lathes – one "simple" lathe currently in process, one additional simple lathe, and two full-capability lathes

- Oxidation: Four new furnaces (in addition to the two existing Direct Metal Oxidation [DMO] and two existing muffle furnaces) – two DMO and two muffle furnaces
- Packaging: One new automated packaging system, similar to the current Robotic Integrated Packaging System (RIPS)
- U electro-decontamination: One new system
- Trunk lines and a transfer glovebox to facilitate material movement
- Radiography: One new radiography system
- Inline Storage: Two new material staging gloveboxes with engineered features
- Two new blending gloveboxes
- Decommissioning and Decontamination of an existing room that would be taken over by the ARIES program for new installations
- Two new buildings: An Operations Warehouse/Mock-Up Facility/Machine Shop and a Logistics Support Center

3.3.1.2 LANL Operations History

The first certified oxide lot of 242 kg was achieved in FY2011. Shipment of certified oxide to SRS for long-term storage started in FY2012. In July of 2013, operations paused and the facility's ability to produce new oxide was halted. In 2014 and 2015, LANL continued work to complete formal readiness/restart requirements. In 2016, LANL re-entered operations on all but one ARIES component (DMO-2 furnace) and disassembled pits for the first time in more than two years. Table 7 summarizes the actual historical annual kilograms of Pu that were converted to oxide from FY2011 to FY2017.

Table 7 – History of ARIES Plutonium Oxide Production

Fiscal Year	Annual Target for kg Pu Converted to Oxide	Actual Annual kg Pu Converted to Oxide	History
2011	200	242	First Certified Oxide
2012	150	200	Second Certified Oxide
2013	150	150	Certified Remaining from 2011 and 2012 Inventory
2014	50	25	Certified Remaining from 2011 and 2012 Inventory
2015	50	50	Certified Remaining from 2011 and 2012 Inventory
2016	0	0	Did not produce or Certifiy any Oxide
2017	100	100	First Converted Oxide of Re-Start

From an historical perspective, the operations in FY2011 represent the greatest efficiency within the ARIES project when the maximum of 242 kg was produced.

3.3.2 LANL Cost Estimate Development and Results

3.3.2.1 LANL Cost Estimating Process

Figure 10 provides a process flow illustrating how the LANL Operations, Spares and Facilities cost estimates were developed:

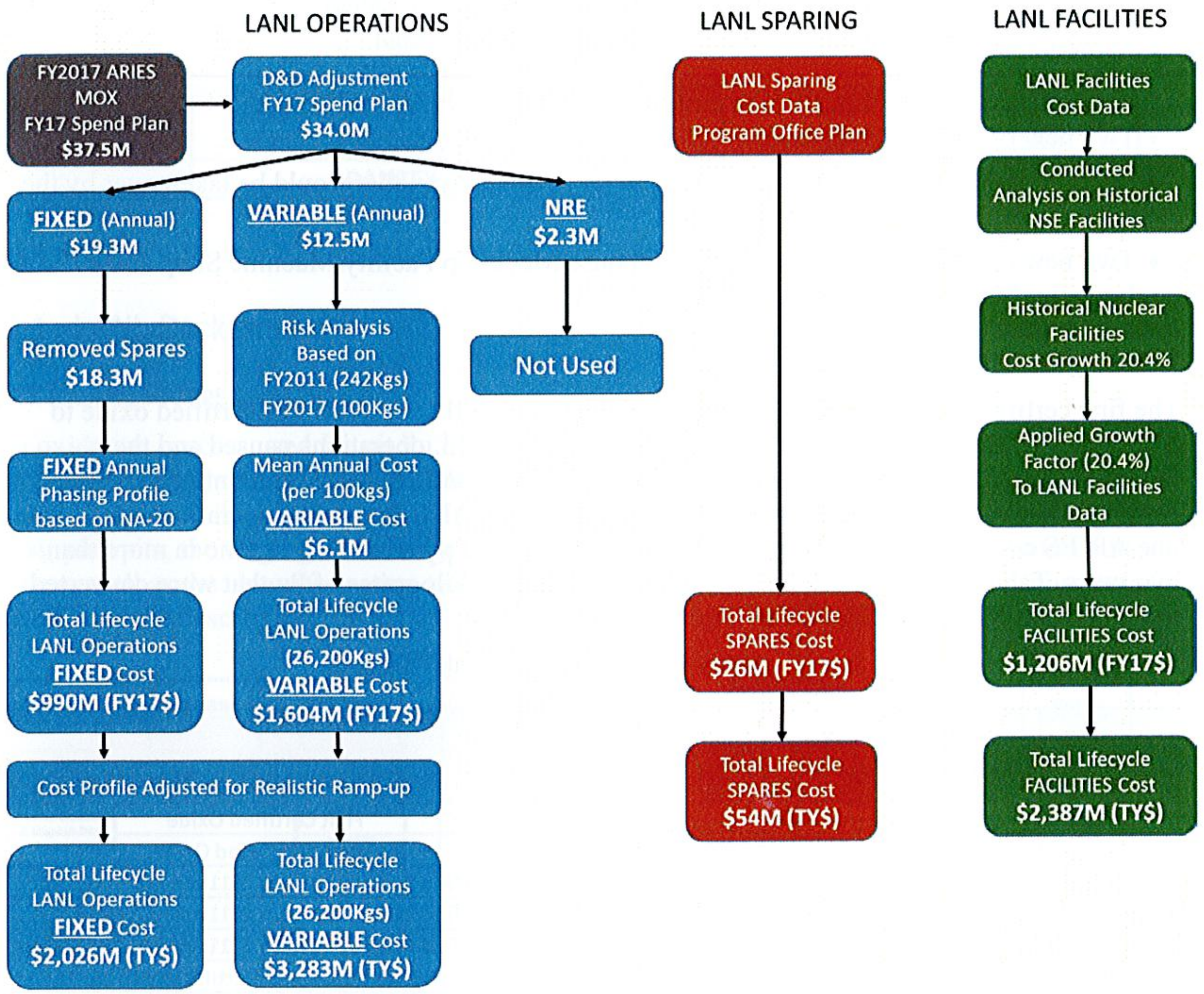
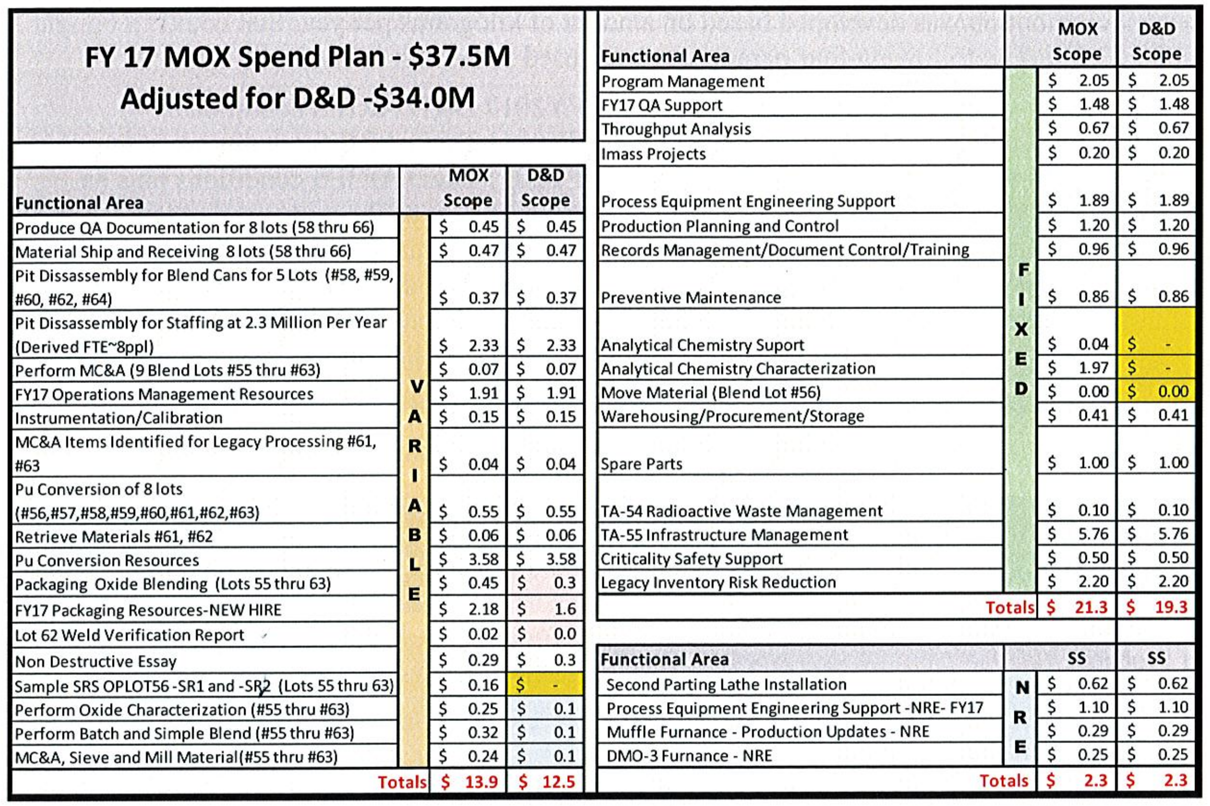


Figure 10 – LANL Cost Estimating Process Flow

3.3.2.2 LANL Operations Cost Estimate Development

3.3.2.2.1 LANL Operations Cost Starting Point

The primary data source for the LANL operations cost was the FY2017 spend plan summarized in the ARIES Oxide Production Program Management Plan (PMP) issued on March 24, 2017. The PMP was for the ARIES Oxide Production Program in FY2017, which aimed to support the NA-23 program by disassembling and converting 100 kg of Pu metal to certified Pu oxide for the initial operations of the MFFF for the current MOX project and process. The FY2017 spend plan for the MOX program for FY2017 totaled $37.5M. In order to develop the ICE, the spend plan data point had to be adjusted for D&D scope. This was accomplished by removing analytic chemistry, which is a MOX unique operation, taking an assumed 75% of the MOX cost for packaging and 25% of the MOX cost for D&D. This resulted in an adjusted spend plan total of $34.0M for D&D broken out by fixed ($12.5M), variable ($19.3M) and Non-Recurring ($2.3M) cost. This is summarized in Figure 11 below:



FY 17 MOX Spend Plan - $37.5M
Adjusted for D&D -$34.0M

Functional Area		MOX Scope	D&D Scope
Produce QA Documentation for 8 lots (58 thru 66)	VARIABLE	$ 0.45	$ 0.45
Material Ship and Receiving 8 lots (58 thru 66)		$ 0.47	$ 0.47
Pit Dissassembly for Blend Cans for 5 Lots (#58, #59, #60, #62, #64)		$ 0.37	$ 0.37
Pit Dissassembly for Staffing at 2.3 Million Per Year (Derived FTE~8ppl)		$ 2.33	$ 2.33
Perform MC&A (9 Blend Lots #55 thru #63)		$ 0.07	$ 0.07
FY17 Operations Management Resources		$ 1.91	$ 1.91
Instrumentation/Calibration		$ 0.15	$ 0.15
MC&A Items Identified for Legacy Processing #61, #63		$ 0.04	$ 0.04
Pu Conversion of 8 lots (#56,#57,#58,#59,#60,#61,#62,#63)		$ 0.55	$ 0.55
Retrieve Materials #61, #62		$ 0.06	$ 0.06
Pu Conversion Resources		$ 3.58	$ 3.58
Packaging Oxide Blending (Lots 55 thru 63)		$ 0.45	$ 0.3
FY17 Packaging Resources-NEW HIRE		$ 2.18	$ 1.6
Lot 62 Weld Verification Report		$ 0.02	$ 0.0
Non Destructive Essay		$ 0.29	$ 0.3
Sample SRS OPLOT56 -SR1 and -SR2 (Lots 55 thru 63)		$ 0.16	$ -
Perform Oxide Characterization (#55 thru #63)		$ 0.25	$ 0.1
Perform Batch and Simple Blend (#55 thru #63)		$ 0.32	$ 0.1
MC&A, Sieve and Mill Material(#55 thru #63)		$ 0.24	$ 0.1
	Totals	$ 13.9	$ 12.5

Functional Area		MOX Scope	D&D Scope
Program Management	FIXED	$ 2.05	$ 2.05
FY17 QA Support		$ 1.48	$ 1.48
Throughput Analysis		$ 0.67	$ 0.67
Imass Projects		$ 0.20	$ 0.20
Process Equipment Engineering Support		$ 1.89	$ 1.89
Production Planning and Control		$ 1.20	$ 1.20
Records Management/Document Control/Training		$ 0.96	$ 0.96
Preventive Maintenance		$ 0.86	$ 0.86
Analytical Chemistry Suport		$ 0.04	$ -
Analytical Chemistry Characterization		$ 1.97	$ -
Move Material (Blend Lot #56)		$ 0.00	$ 0.00
Warehousing/Procurement/Storage		$ 0.41	$ 0.41
Spare Parts		$ 1.00	$ 1.00
TA-54 Radioactive Waste Management		$ 0.10	$ 0.10
TA-55 Infrastructure Management		$ 5.76	$ 5.76
Criticality Safety Support		$ 0.50	$ 0.50
Legacy Inventory Risk Reduction		$ 2.20	$ 2.20
	Totals	$ 21.3	$ 19.3

Functional Area		SS	SS
Second Parting Lathe Installation	NRE	$ 0.62	$ 0.62
Process Equipment Engineering Support -NRE- FY17		$ 1.10	$ 1.10
Muffle Furnance - Production Updates - NRE		$ 0.29	$ 0.29
DMO-3 Furnance - NRE		$ 0.25	$ 0.25
	Totals	$ 2.3	$ 2.3

Figure 11 – FY 2017 LANL Spend Plan (100 kgs) for MOX
Contractor Proprietary Data Source: FY2017 Spend Plan of $37.5M (March 2017)

3.3.2.2.2 LANL Operations Variable Cost Starting Point

As discussed in the LANL Operations History (Section 3.3.1.2), the two best data points for ARIES history are the first year of operations (FY2011) and the most recent year as of this analysis (FY2017). The FY2017 adjusted variable cost of $12.5M per year represents the high cost because it included restarted operations with unoptimized processes and limited equipment upgrades to produce 100 Kgs of Pu oxide. The FY2011 actuals with realized efficiencies would allow 100 Kgs of Pu oxide to be produced using D&D operations for $5.2M, which provides a lower cost than the FY2017 scenario. This is summarized in Table 8 below:

Table 8 – FY2017 LANL Cost per 100 Kgs

Data Type	FY2011 Actuals	FY2017 Actuals
Efficiency Level	Realized Efficiencies	Inefficient Processes
Kgs of Pu Oxide Produced	242 Kgs	100 kgs
Total Variable Cost ($M)	$12.5	$12.5
Cost per 100 Kg ($M)	**$5.2**	**$12.5**

The 2011 scenario yields $5.2M per 100Kgs and the 2017 scenario yields $12.5M per 100Kgs. These data points were used as the basis for the analysis.

3.3.2.2.3 LANL Operations Variable Cost Risk Analysis

Risk analysis for the LANL operations is based on realized actuals from the ARIES program, a predecessor to the operations that will take place to support either MOX or D&D operations. A normal distribution was developed based on amount of kilograms per year that could be bought with $12.5M. The following four parameters were used in the risk analysis:

(1) $12.5M will produce 100 Kgs based on the FY2017 D&D ARIES conditions.
(2) $12.5M will produce 242 Kgs based on the FY2011 D&D ARIES conditions.
(3) $12.5M will produce 278 Kgs based on the FY2011 D&D ARIES conditions plus an efficiency of 15% realized yielding an additional 36 Kgs of Pu oxide production.
(4) $12.5M will produce an assumed 194 kgs based on a failure to meet full efficiency target for the FY2011 Scenario. This is due to an assumed fifth day labor shift to meet the 242 kgs target. The additional funding would be based on an additional 10 hour shift of labor which would total $3.1M ($12.5 x 25%) to meet the 242 kgs target.

The summary of the aforementioned parameters are summarized below in Table 9:

Table 9 – Scaling Parameters for Oxide Production Normal Distribution

Data Type	FY2011 15% New Efficiencies	FY2011 Actuals	FY2011 Adding Funding For Extra Shift	FY2017 Actuals
$12.5M Dollars will Produce:	278Kgs	242 kgs	194Kgs	100Kgs
Cost per 100 Kg ($M)	$4.5	$5.2	$6.4	$12.5
	Normal Parameters:		Mean: 204 kgs Standard Deviation: 4.1 kgs Mean Scaling produces 100Kgs for $6.1M	

Since it is not yet known how much MOX-specific operations will be reduced in the transition from ARIES to D&D, the team applied also applied a uniform distribution to a scaling factor in the adjusted D&D spend plan (Figure 11). The factors are based on Subject Matter Expert (SME) input from performing LANL personnel. Table 10 shows the ranges used within the risk analysis.

Table 10 – ARIES Operations Uniform Distribution

Operation	Uniform Range	Mean
Packaging	50%-100% of ARIES cost	75% of ARIES cost
Pu Characterization	0%-50% of ARIES cost	25% of ARIES cost

3.3.2.2.4 LANL Operations Variable Cost Estimate

The result of the normal distribution is that 100Kgs of Pu oxide could be produced for $6.1M of variable cost on average. Based on this parameter, the total variable operations cost per 100kgs of Pu oxide is $6.1M per year from FY18 to FY22 and $68.4M per year from FY23 to FY45. This is illustrated in the LANL throughput table, Figure 12 below.

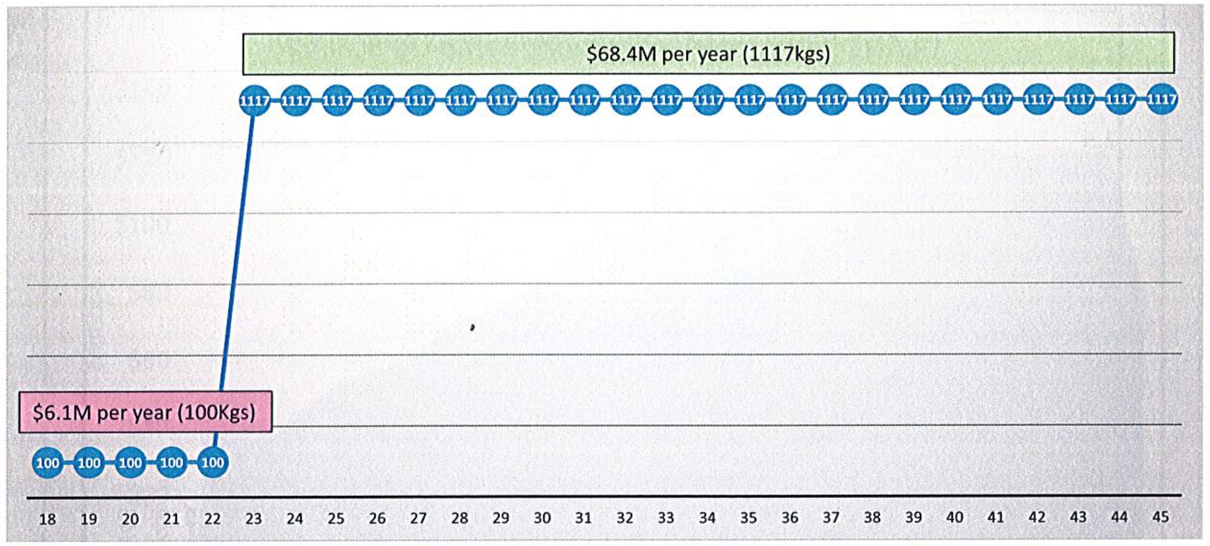


Figure 12 – LANL Operations Variable Cost per Year

As a result, the total variable operations cost estimate is $31M from FY18 to FY22 and $1,573M from FY23 to FY45 in FY2017 dollars. These calculations are displayed in Table 11 below.

Table 11 – LANL Operations Variable Cost Total (FY17$)

Timeline	Total Years (A)	Planned Kgs per Year	Total Kgs	Factor (B)	Annual Variable Cost ($M) (C)	Total Variable Cost ($M) (A)*(B)*(C)
FY18 to FY22	5	100	500	1.00	$ 6.1	$ 31
FY23 to FY45	23	1117	25700	11.17	$ 6.1	$ 1,573
					Total	$ 1,604

3.3.2.2.5 LANL Operations Fixed Cost Estimate

Fixed costs were phased and calculated based on the LANL program management phasing plan showing fixed costs ramping up from a factor of 1X to 2.5X, as seen in Figure 13. The FY2017 spend plan shown in Figure 11 breaks out a fixed cost of $21.3M for MOX ARIES operations. Processes that will be reduced or removed for D&D were remove from the fixed cost estimate, and sparing is broken out separately in Section 3.3.2.2.6. This adjustment resulted in a total fixed cost of $19.3M as the fixed cost basis. Applying the annual scaling factor to the annual FY2017 fixed cost of $19.3M results in a total cost of $990M in FY2017 dollars over the D&D lifecycle.

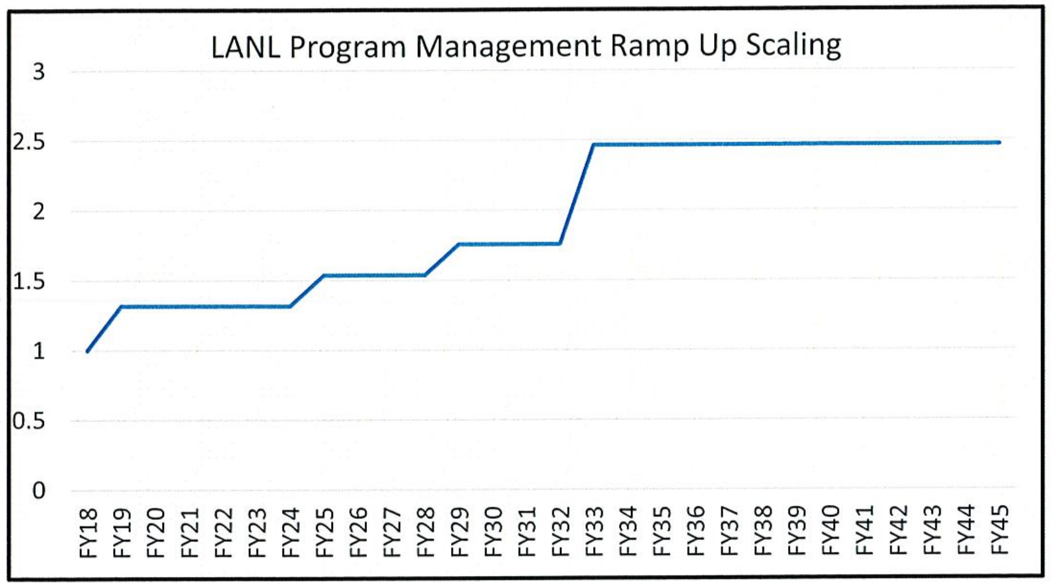


Figure 13 – Scaling Profile Based on LANL Program Management Phasing Plan

3.3.2.2.6 LANL Spares Cost Estimate

The cost from FY18 to FY22 are $750K per year in FY2017 dollars. The cost from FY23 to FY45 are $1,000K per year in FY2017 dollars. The total cost over the lifecycle is $26M in FY2017 dollars and $54M in Then Year dollars. The year-to-year cost is displayed in Figure 14 below:

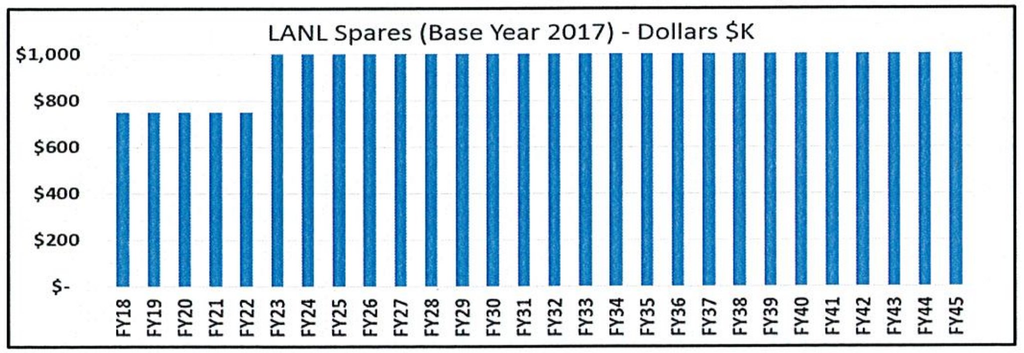


Figure 14 – LANL Operation Spares Phasing Profile

3.3.2.2.7 LANL Operations Cost Profile Adjustment

The assumption of constant throughput for the variable cost does not represent a realistic ramp-up of LANL operations. To ensure a defensible escalation and cost profile, the resulting base year cost for LANL operations (consisting of LANL Variable, LANL Fixed and LANL Spares) was re-profiled based on a costing profile provided by NA-23; this avoids classification issues caused by using the true throughput plan. This results in the annual cost profile shown in Figure 15.

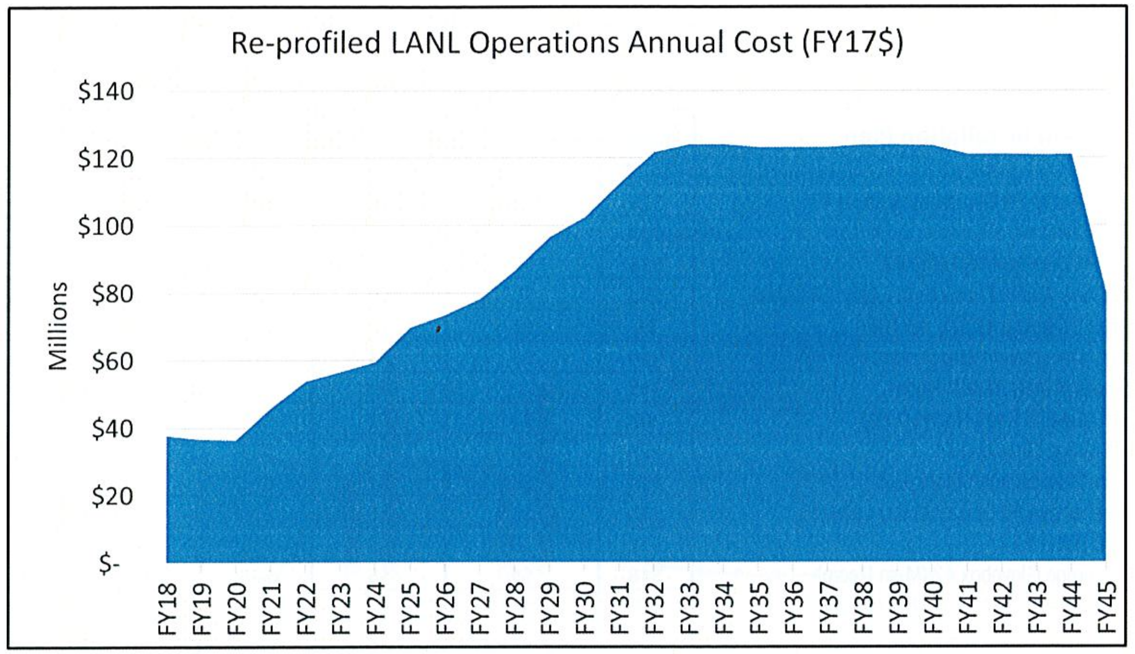


Figure 15 – LANL Operations Annual Cost after Re-profiling (FY17$)

Table 12 below shows the resulting total cost for LANL Operations.

Table 12 – LANL Operations Total Cost

	Cost Summary	FY2017 ($M)	Then Year ($M)
LANL Operations	LANL Variable Cost	$ 1,604	$ 3,283
	LANL Fixed Cost	$ 990	$ 2,026
	LANL Spares Cost	$ 26	$ 54
	Total LANL Operations Cost	**$ 2,620**	**$ 5,363**

3.3.2.3 LANL Facilities Cost Estimate Development

3.3.2.3.1 LANL Facilities Starting Point

Table 13 below shows the plan that identifies PF-4 equipment modifications and upgrades required to meet the desired throughput requirements based on the classified feed table. All planned costs include material, labor, and other direct costs needed to accomplish project needs from FY2021 to FY2026.

Table 13 – LANL Equipment and Facility Modification List (FY2017 dollars)
Contractor Proprietary

Equipment Installation Plan (MILLIONS OF DOLLARS)	**Totals ($M)**	**Technical & Programmatic Contingency**	**Management Reserve**	**Totals Cost (Before Growth)**	**Cost Growth Application**	**Totals Cost (After Growth)**
Comprehensive Pit Disassembly Lathe #2	$25	$6	$6	$37	$7	$44
New Pu DMO #4	$20	$5	$5	$30	$6	$37
Simple Pit Disassembly Lathe #2	$26	$6	$6	$39	$8	$47
Install 2 new Muffle Furnaces in a New Glovebox	$20	$5	$5	$30	$6	$36
New can Crimper and Bag out GB	$6	$2	$2	$9	$2	$11
Uranium Decontamination System #2	$10	$3	$3	$16	$3	$19
Trunklines in New ARIES Room	$45	$11	$11	$68	$14	$82
Install 4 Material Entry Hoods (XBs)	$8	$2	$2	$12	$3	$15
Inline Storage Glovebox #1	$23	$6	$6	$35	$7	$42
Uranium Precipitation/Staging GB	$14	$4	$4	$21	$4	$26
Comprehensive Pit Disassembly Lathe #3	$25	$6	$6	$38	$8	$46
New Pu DMO #5	$21	$5	$5	$31	$6	$37
Inline Storage Glovebox #2 (Main Room)	$18	$5	$5	$28	$6	$33
New Blending Glovebox #2 (New Room)	$9	$2	$2	$13	$3	$16
Transfer Glovebox for DMO 5	$9	$2	$2	$13	$3	$16
Engineering Support During Design Construction	$23	$6	$6	$34	$7	$41
SPD Warehouse	$17	$4	$4	$26	$5	$31
Logistics Support Center	$49	$12	$12	$74	$15	$89
LANL Deactivation	$183	$46	$46	$275	$0	$275
D&D Gloveboxes (Design, PM, Demo & Removal)	$43	$11	$11	$65	$0	$65
Other Major Equipment Replacement	$132	$33	$33	$199	$0	$199
			Totals ($M)	$1,093	$113	$1,206

3.3.2.3.2 LANL Facilities Cost Risk

Based on the seven data points that were pulled out of the Project Assessment and Reporting System II (PARS II) database, the analysis shows that nuclear facilities costs have grown around 20.4%. This increase was determined by taking the average cost growth of seven nuclear facilities projects (as a percentage) and testing them against a number of potential curves and curve shapes to determine the best fit to predict equipment/installation cost growth. The seven nuclear facilities are summarized in Table 14.

Table 14 – Completed Facilities and Realized Growth

Historical Facility or Subproject	Original Estimate ($K)	Cost Actuals ($K)	Cost Delta ($K)	% Difference
Nuclear Facility Risk Reduction	$ 75,790	$ 70,190	$ (6)	-7.4%
Low Liquid Waste Facilty	$ 82,694	$ 90,000	$ 7	8.8%
Tritium Extraction Facility	$ 506,439	$ 709,307	$ 203	40.1%
Waste Solidification Building	$ 278,187	$ 384,000	$ 106	38.0%
Sodium Bearing Waste Treatment Facility	$ 461,600	$ 663,311	$ 202	43.7%
Chemistry and Metallurgy Research Replacement Facility Radiological Laboratory, Utility, and Office Building (RLUOB) and Rad Lab Equipment Install (REI)	$ 363,000	$ 396,400	$ 33	9.2%
TRU Waste Facility Staging Facility Phases A and B	$ 106,864	$ 106,864	$ 0	0.0%

The cost growth of 20.4 % in the historical facilities was then determined by taking the average actual cost growth for each project as a percentage, and testing the data against a number of potential curves and curve shapes to determine the best fit for the data. The best fit (based on minimizing Sum of Squared Error, or SSE) was a Weibull curve, as shown in Figure 16. This methodology was also applied to facility upgrade projects for SRS K-Area as described in Section 0 and SRS E-Area as described in Section 3.4.2.6.2.

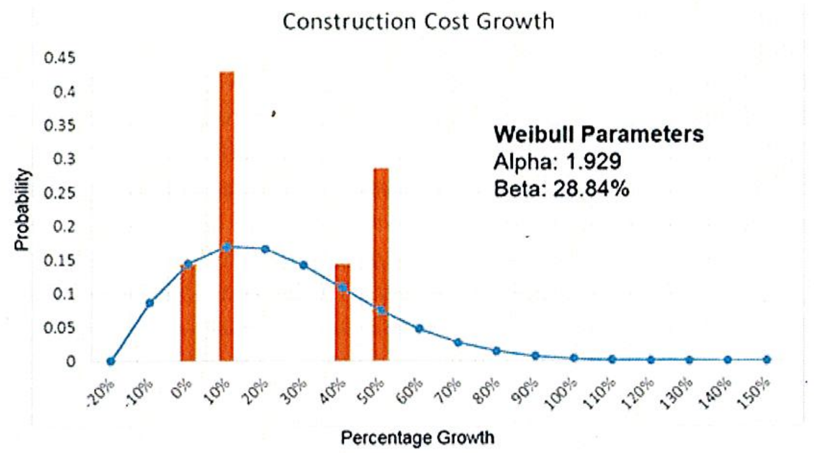


Figure 16 – Construction Cost Growth Actuals and Fitted Weibull

3.3.2.3.3 LANL Facilities Cost Estimate

The growth factor was applied to the major equipment purchases within PF-4, the SPD Warehouse, and the Logistics Support Center projects, which originally had an FY2017 cost of $554M. This resulted in a total cost of $667M. The 20.4% growth factor was not applied to LANL deactivation, planned major equipment upgrades and the design, program management, demo and removal of the D&D gloveboxes which totaled $539M in FY2017 dollars. A comprehensive breakdown of this cost breakdown is shown in Table 13. Adding the unadjusted and adjusted items results in total cost for LANL facility upgrades of $1,206M in FY2017 dollars and $2,387M in Then Year dollars.

3.3.2.4 LANL Total Costs (Operations, Spares, and Facility Upgrades)

The costs for LANL operations, sparing and equipment installation total $7.8B in Then Year dollars from FY2018 to FY2046, as shown in Table 15.

Table 15 – LANL Total Cost

	Cost Summary	FY2017 ($M)	Then Year ($M)
LANL Total	LANL Operations	$ **2,620**	$ **5,363**
	LANL Facilities	$ **1,206**	$ **2,387**
	Total LANL Cost	$ **3,826**	$ **7,750**

3.4 SRS

3.4.1 SRS Background

3.4.1.1 SRS Scope

SRS provides D&D operations necessary to facilitate disposition of all 34 MT of surplus Pu oxide material with inert materials, packaging the diluted material into approved shipping containers, and transporting the shipping containers to WIPP, where they would be placed in the underground panels for permanent disposal. NNSA would be responsible for processing 26.2 MT of pit Pu oxide in K-Area and managing E-Area characterization and packaging for all 34MT of surplus Pu. DOE-EM would be responsible for conversion of remaining non-pit Pu metal to oxide in H-Canyon or at an alternative site, processing 7.8 MT of non-pit Pu materials within the K-Area Interim Surveillance (KIS) infrastructure, and cost of E-Area characterization and packaging for 7.8MT of DOE-EM material. Figure 17 illustrates the responsibilities.

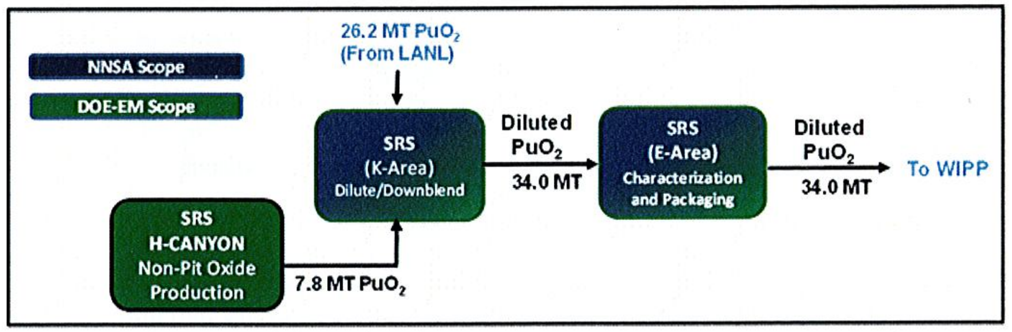


Figure 17 – NNSA and DOE-EM SRS Scope

DOE-EM would be responsible for:

- All current and future operations, maintenance, infrastructure, and security costs of EM-owned facilities in HB-Line, K-Area, and E-Area to support EM missions at SRS
- Oxide conversion, down-blending (i.e., dilution) and waste characterization of non-pit materials at SRS

NNSA (NA-23) would be responsible for:

- New equipment installed in K-Area and E-Area via line item construction projects and general plant projects
- Incremental labor and non-labor to operate, maintain, and support down-blending, interim storage, and waste characterization of pit materials
- Third-party infrastructure and verification costs for K-Area and E-Area (pit and non-pit materials)
- Performance-based security upgrades at E-Area, demolition removal of NA-23-installed equipment in E-Area and K-Area, and return to current state

3.4.1.2 SRS D&D Process

1. The Pu oxide shipping containers would be brought out of storage into the process room and opened; the cans containing the Pu oxide would be removed and transferred into a glovebox in K-Area.

2. Once in a glovebox, the cans would be opened. A can puncture device would vent the cans and enable gas sampling for certain cans in the Pu container surveillance program.
3. The Pu oxide would be placed in the new can along with the dry inhibitor material used to dilute the Pu. The cans would be sealed in vented cans and then mechanically manipulated to further homogenize their contents.
4. The cans would be removed from the glovebox, assayed, and then packaged into a Criticality Control Over-Pack (CCO), with two cans in each CCO.
5. The CCO would be transferred to an area for final characterization and certification for disposal at a geologic repository.

The D&D process at SRS is illustrated in Figure 18.

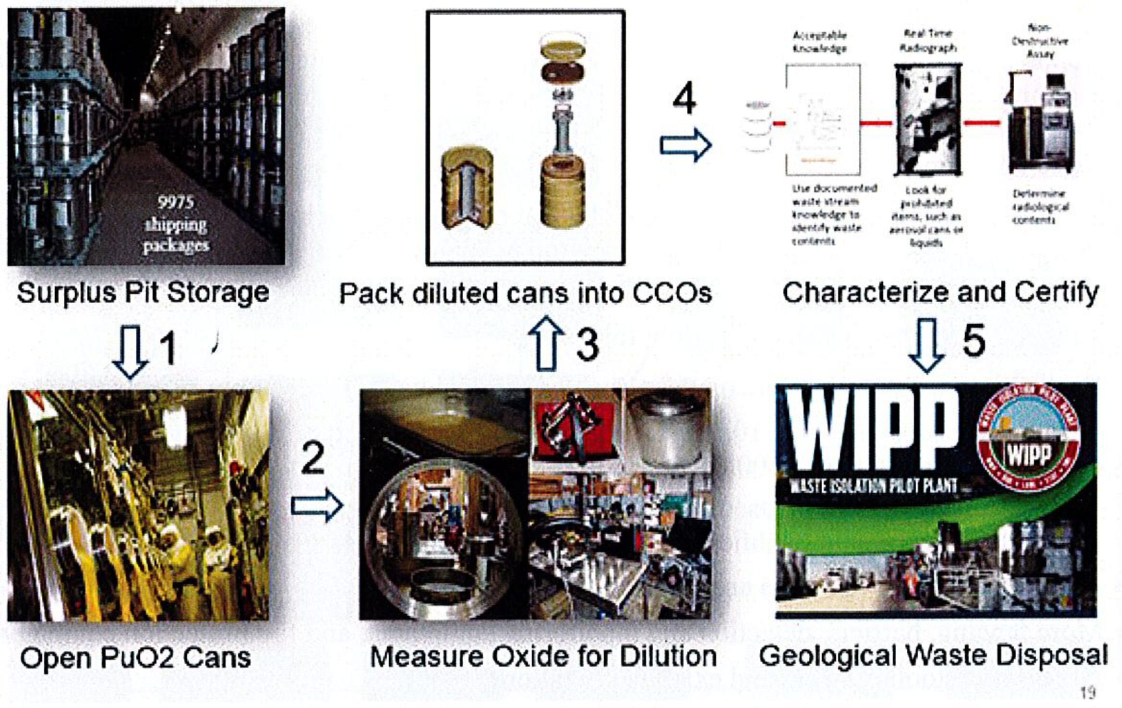


Figure 18 – SRS Dilute and Dispose Process Flow

3.4.1.3 SRS Equipment Installation Requirements

NNSA plans to install three gloveboxes located inside of the final storage area, a continuous air monitoring system, a nuclear incident monitoring system, an active confinement ventilation system, a gaseous suppression system, fire protection/detection equipment, a staging room, and other miscellaneous equipment upgrades. These equipment upgrades are needed to meet desired throughput.

3.4.1.4 K-Area (SRS) Complex

The K-Area Complex (KAC) provides operations for the handling and interim storage of the surplus Pu and other special nuclear materials (SNM) as well as fulfills the US commitment to international nonproliferation efforts in a safe and environmentally sound manner. Pu materials shipped to KAC are sealed inside DOE standard 3013 containers that are nested in robust, state-of-the-art, certified shipping packages called 9975s and 9977s. Prior to being packaged at the other sites, the Pu is stabilized in accordance with established standards for safe transportation and storage.

For D&D operations, K-Area will include two separate lines for dilution of Pu Oxide; DOE-EM material will run through the existing KIS line, while 26.2MT of pit Pu will run through a new NNSA K-Area line.

3.4.1.5 E-Area (SRS) Complex

E-Area at SRS is used for the storage and disposal of waste materials. The SRS solid waste facility in E-Area has routinely processed transuranic (TRU) waste for WIPP, but additional staffing and retooling are required to expand upon the operations to dilute Pu contents.

The fundamental process requires nondestructive assay (NDA) measurement by certified instruments, procedures, and personnel to demonstrate that the diluted Pu contents meet Environmental Protection Agency (EPA) and New Mexico Environment Department (NMED) criteria for disposal at WIPP. If all regulatory requirements are met, the diluted Pu will be received to E-Area in CCOs, characterized to meet the WIPP Waste Acceptance criteria, then packaged and shipped to WIPP.

Three primary activities included as part of characterization and packaging operations are (1) interim storage, (2) certification and (3) packaging & shipping. Each of these activities is proposed to be conducted in E-Area at SRS.

Additional E-Area scope will include the following:

- Expand interim storage to encompass seven additional waste pads within E-Area perimeter:
  - Increased scope to stage 10,000-12,000 CCO containers and provide services necessary for processing 6,000-7,000 CCO containers per year at peak rate
  - Five to six pads will be used for characterization and packaging operations, and an additional pad would modified to add characterization and packaging equipment
- Additional storage structure and security system
- More fencing, barriers, detection and monitoring equipment, and fire protection equipment
- Necessary retooling to expand existing operations
- Additional staffing, trucks, and forklifts

3.4.1.6 H-Canyon/HB-Line (SRS) Complex

H-Canyon processes liquid waste streams associated with HB-Line operations. HB-Line is located on top of H-Canyon and is the only chemical processing facility of its kind in the DOE Complex. The facility was built in the early 1980s to support the production of Pu-238, which is a power source for the nation's deep space exploration program, and to recover legacy materials stored in H-Canyon.

HB-Line has three process lines. Phase I is the scrap recovery processing line. Phase II is the production line for Pu and neptunium oxides. Phase III was originally the Pu-238 oxide production line, but is now used to prepare surplus Pu and U materials for disposition.

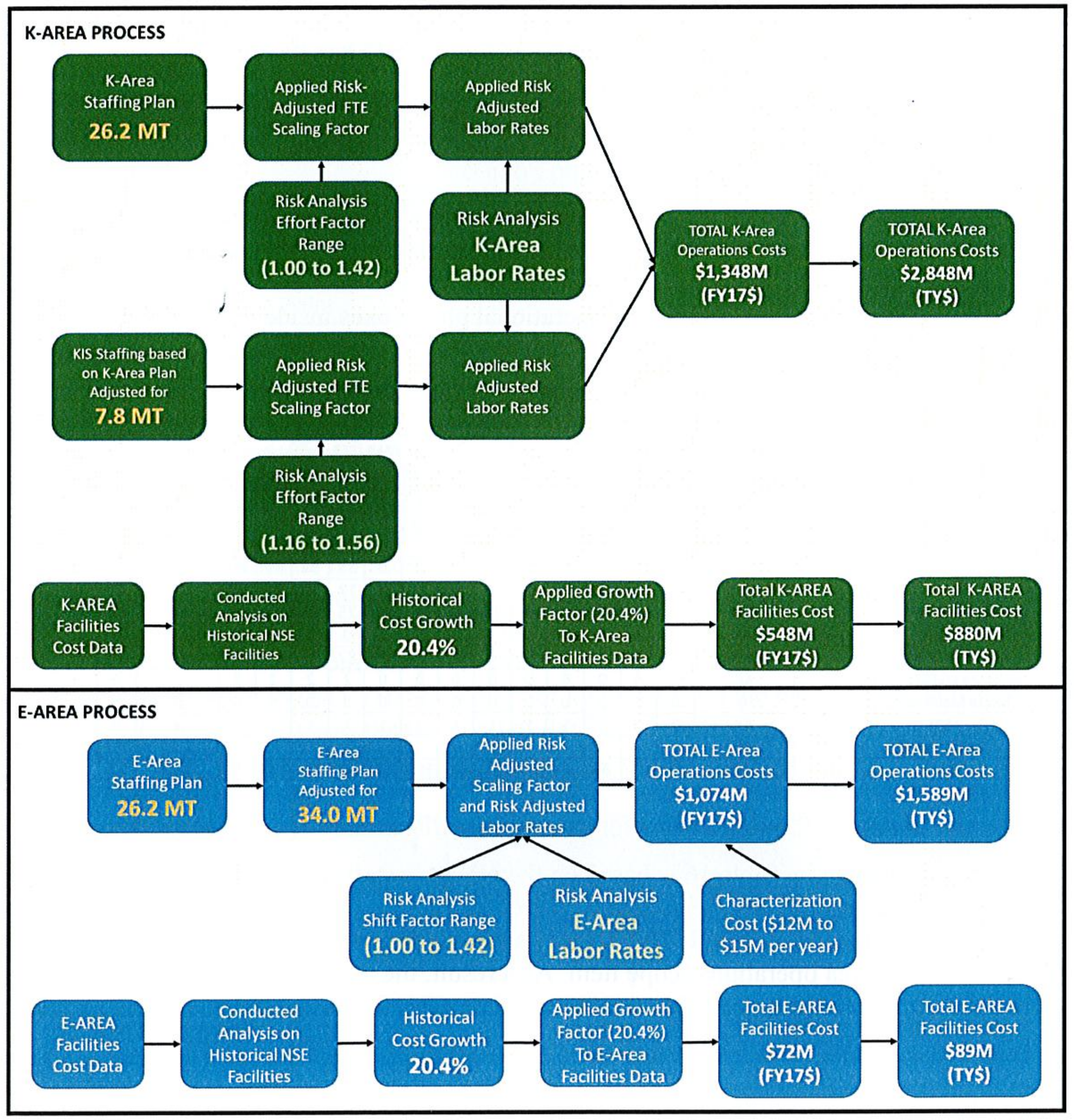
For D&D, H-Canyon supports non-pit production by dissolving Pu metal and by processing liquid waste streams generated by HB-Line aqueous operations. The HB-Line facility provides the capability for producing Pu oxide from the Pu solution that results from the dissolution in H-Canyon. Once sampled and packaged for storage, the HB-Line Pu oxide product is transferred to K-Area. Cost scope will include:

- Continuous preparation of Pu oxide in H-Canyon and HB-Line
- Annual maintenance for 9975 and 9977 shipping packaging
- Additional scope of work centered on capacity, reliability, packaging improvements, and emergent process requirements

3.4.2 SRS Cost Estimate Development and Results

3.4.2.1 SRS Cost Estimating Process

Figure 19 below provides a process flow illustrating how the SRS operations cost estimates were developed:



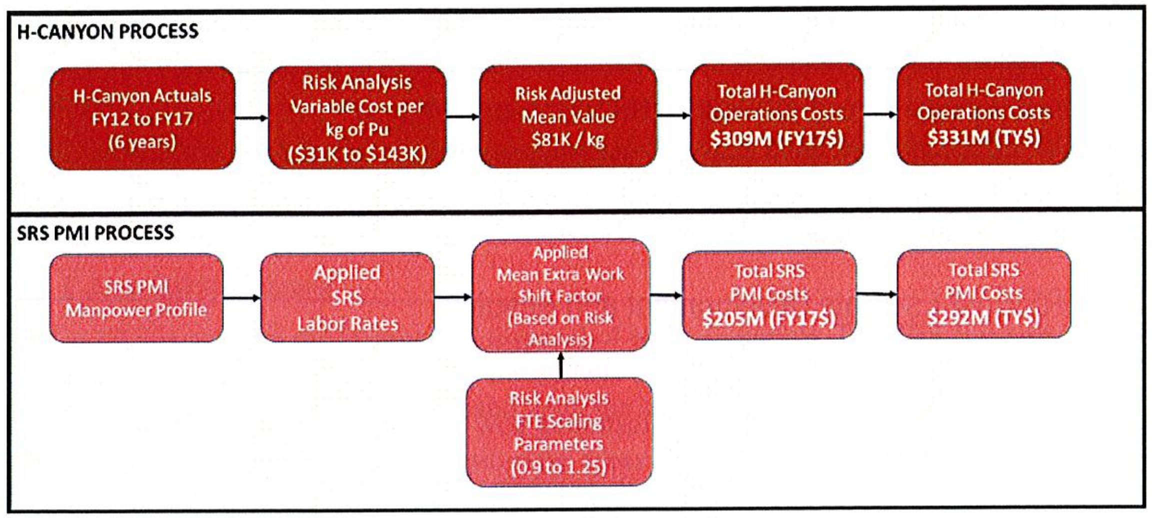


Figure 19 – SRS Dilute and Dispose Cost Estimating Process Flow

3.4.2.2 K-Area Operations (SRS)

3.4.2.2.1 K-Area (SRS) Operations Starting Point

The primary data source for the K-Area operations estimate was the staffing profile required for NNSA to dilute and dispose 26.2 MT of Pu oxide transported from LANL to SRS. This staffing profile was provided by the NA-23 program office and is based on 3 eight hours shifts, operating 24 hour a day, 7 days per week, using two operational gloveboxes inside K-Area. Table 16 shows the staffing profile.

Table 16 – K-Area Staffing Profile 26.2 MTs (October 2017)

		FISCAL YEAR (FTE Staffing Profile)																	
K-Area Operations Scope	**Total**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31 to 46**	**47**	**48**	**49**	**50**
Program Management	48	6	7	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SPD Project Support OPEXP	152	4	8	17	23	20	23	23	35	0	0	0	0	0	0	0	0	0	0
Receive	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Downblend	1151	0	0	0	0	0	0	0	0	0	34	34	60	60	60	0	0	0	0
Assay	547	0	0	0	0	0	0	0	0	0	14	14	29	29	29	0	0	0	0
Packaging and Shipping	958	0	0	0	0	0	0	0	0	0	25	25	48	48	48	48	0	0	0
Staging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Facility Support	1301	5	8	8	8	8	0	66	66	128	87	87	44	49	44	44	0	0	0
Surveillance and Maintenance	40	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0
Major Maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IAEA	48	0	0	2	5	1	1	1	1	1	1	1	2	2	2	0	0	0	0
Deactivation	0																		0
Total	4245	15	22	33	36	29	25	91	103	129	164	164	185	191	185	92	1	1	0

3.4.2.2.2 K-Area (SRS) Adjustment for DOE EM Material in KIS

The raw data set shown in Table 16 is based on the NNSA's staffing profile to dilute and dispose of 26.2 MT with a ramp-up to a steady-state FTE count of 185. In order to estimate staffing for KIS operations for disposal of DOE-EM 7.8MT, a scaling factor of 0.30 (7.8 MT/26.2 MT) was applied to each K-Area operations scope item. As a result, the adjusted FTE profile for NNSA and KIS operations shows a steady state starting point of 241 FTEs prior to risk adjustments.

3.4.2.2.3 K-Area and KIS (SRS) Operations Risk

K-Area operations risk is driven by personnel required for D&D operations and labor costs. The risk estimate for FTEs is based on scaling factors from the SRS-provided staffing profile and its variable cost, as shown in Table 17. The contingency-based estimate from the SRS program office includes two fully staffed gloveboxes running 24 hours a day and 7 days per week (including a training shift) with a third glovebox in reserve for surge capacity; this is the starting point (scaling factor of 1.0); the variable cost per kilogram of Pu in this estimate is $27K per kg (FY2017 dollars). If the third glovebox is also fully staffed, it would add 30 FTEs and result in a 16% increase in K-Area personnel (generating a scaling factor of 1.16). KIS has already performed small-scale down-blending within an existing glovebox using excess staff when available. The program office projected that the current ad hoc operation could be scaled up to down-blend 150 kgs per year at an estimated cost of $13M in FY2017. Stripping out $7.3M in fixed cost leaves $5.7M in variable cost, or $38K per kg of Pu; this variable cost is 42% higher than the D&D K-Area base operation variable cost (generating a scaling factor of 1.42).

Table 17 – K-Area FTE Normal Distribution Parameters (applied to 26.2MT)

	SRS-provided Variable Cost and FTEs (Starting Point)	Starting Point plus Third Glovebox FTEs	KIS Variable Costs
Variable Cost/kg (FY2017$)	$26,544	N/A	$37,778
Base FTEs	185	215	N/A
Scaling from Starting Point	1.00	1.16	1.42
Normal Parameters:		Mean: 1.194 Standard Deviation: 0.214	

The resulting scaling factors as determined above were used to develop a normal distribution for FTE scaling. The mean staffing factor of 1.194 was then applied to the 26.2MT staffing profile.

KIS staffing is based on the initial K-Area staffing profile in Table 16 with a scaling factor of 0.30 (7.8 MT/26.2 MT). However, a separate risk profile was applied for FTE scaling, as shown in Table 18. The low estimate is based on the 1.16 midpoint from NNSA K-Area operations as shown in Table 17. The same scaling factor based on KIS variable costs (1.42) also applies to continued KIS operations. NA-23 provided a revised estimate for KIS operations that shows a total cost of $323M for down-blending of 7.8MT; this implies a variable cost of $41,410 per kg and a scaling factor of 1.56 ($41,410 / $26,544 per kg taken from the base K-Area staffing). The mean scaling factor of 1.381 was then applied to the 7.8MT staffing profile

Table 18 – KIS FTE Normal Distribution Parameters (applied to 7.8MT)

	K-Area est. w/ Third Glovebox Operations	KIS Variable Costs	NA-23 Program Office Estimate
Variable Cost/kg (FY2017$)	N/A	$37,778	$41,410
Scaling from K-Area Staffing	1.16	1.42	1.56
Normal Parameters:		Mean: 1.381 Standard Deviation: 0.203	

This results in a DOE/NNSA total of 298 FTEs required to operate K-Area and KIS operations to dilute and down-blend 34MT of Pu oxide.

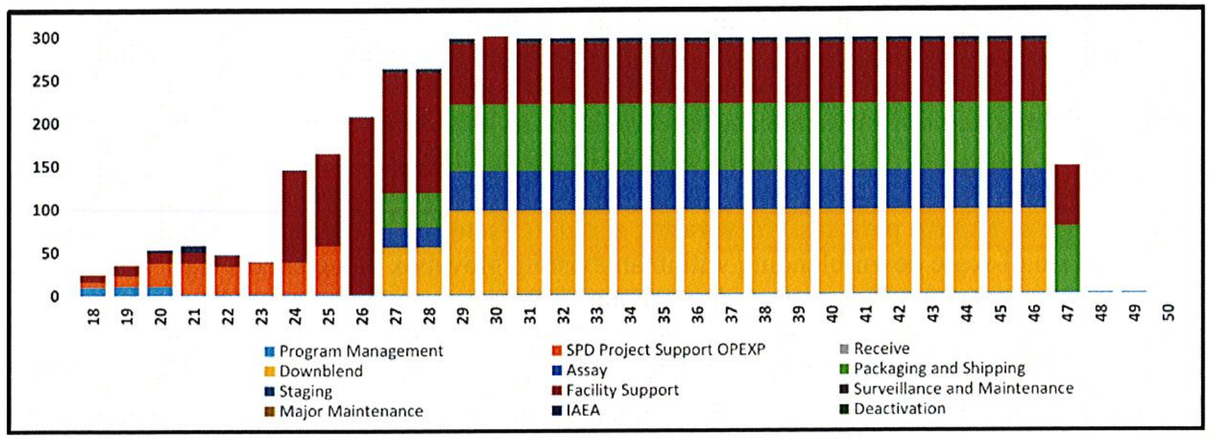


Figure 20 – K-Area 34 MT (50% CL) Staffing Profile

In addition, there is risk in the K-Area labor cost per FTE. The estimates shown in the SRS contractor estimate are often lower than the Forward Pricing Rates with NNSA, and realized rates for actual NNSA operations at SRS during the B61-12 program (with comparable labor mixes) are higher than both. Therefore, a triangular distribution was created for K-Area labor rates, shown in Table 19. A similar adjustment was applied to E-Area labor rates, as described in Section 3.4.2.5.3. The concern with labor rates did not apply to operations at other sites, where provided labor rates were comparable to realized history and agreements. The labor rates from the 50% confidence level are shown in the fifth column of Table 19.

Table 19 – K-Area Labor Rates Triangular Distribution Parameters by Operations
Contractor Proprietary

SRS Operation	Low (FPRA Low) (FY2017$)	Point (FPRA Average) (FY2017$)	High (B61-12 SRS Actuals) (FY2017$)	50% Confidence (FY2017$)
Program Management	$255,254	$310,000	$439,430	$330,256
D&D Project Support OPEXP	$143,121	$223,589	$358,220	$237,889
Down Blend	$124,174	$137,398	$240,543	$163,074
Assay	$124,174	$126,760	$224,159	$154,379
Packaging and Shipment	$117,762	$134,713	$245,458	$161,370
Facility Support	$124,283	$196,824	$316,327	$209, 206
Surveillance and Maintenance	$161,519	$165,268	$224,159	$181,212

3.4.2.2.4 K-Area Operations (SRS) Cost Estimate

Overall, the staffing profile provided by NA-23 was scoped out to dilute 26.2 MT of diluted Pu oxide over the lifecycle. After applying the extra effort factor, adding costs for KIS operations for DOE-EM 7.8MT, and applying the 50% confidence level labor rates, this resulted in a cost estimate of $1,348M in FY2017 dollars, including $115M for materials and non-labor. The cost in Then Year dollars over the lifecycle is $2,848M (FY2018 to FY2049).

3.4.2.3 K-Area (SRS) Equipment and Installation

3.4.2.3.1 K-Area (SRS) Equipment and Installation Starting Point

Appendix D shows the K-Area upgrade plan identifying equipment modifications and upgrades required to meet the desired throughput requirements for 26.2MT based on the classified feed table. All planned costs include material, labor and other direct costs to accomplish project needs from FY2018 to FY2027. The summary of planned equipment installations is shown in Table 20.

Table 20 – K-Area Summary of Planned Equipment Installations

Cost Elements	Cost (FY17$M)
TEC Direct & Burden	$211
TEC Contingency	$126
OPC Direct & Burden	$30
OPC Contingency	$18
Total (TEC+OPC)	**$385**

For the DOE-EM material, the existing KIS line will be used for ramped-up operations to dilute 7.8MT of non-pit Pu as well as 6MT of additional Pu for a separate DOE EM project.

3.4.2.3.2 K-Area (SRS) Facilities Cost Risk

The assumption is that K-Area facilities will have a 20.4% cost growth based on the analysis summarized in Section 3.3.2.3.2 – LANL Facilities Cost Risk. This increase was determined by taking the average cost growth of seven nuclear facilities projects (as a percentage), and testing them against a number of potential curves and curve shapes to determine the best fit to predict equipment/installation cost growth. Section 3.3.2.3.2 explains the derivation in further detail.

3.4.2.3.3 K-Area Facilities Cost Estimate

After applying this 20.4% factor to the planning value ($385M), removing the sunk costs ($8M) and adding the costs for demolition and deconstruction of $90M in FY2017 dollars, the K-Area Equipment upgrade estimate resulted in a total of $548M in FY2017 dollars and $880M in Then Year dollars.

3.4.2.4 K-Area Total Cost Summary

The costs for K-Area operations and equipment installation total $3.7B in Then Year dollars for the most likely cost scenario from FY2018 to FY2049. This is broken down in Table 21 below.

Table 21 – K-Area Cost Summary

	Cost Summary	FY2017 ($M)	Then Year ($M)
K-Area	K-Area Operations	**$ 1,348**	**$ 2,848**
	K-Area Facilities	**$ 548**	**$ 880**
	Total K-Area Cost	**$ 1,896**	**$ 3,728**

3.4.2.5 E-Area (SRS) Operations

3.4.2.5.1 E-Area (SRS) Operations Starting Point

The primary data source for the E-Area operations estimate was the staffing profile required for NNSA to characterize and package 26.2 MT of Pu oxide from K-Area. This staffing profile was provided by the NA-23 program office and is based on one ten-hour shift and four days per week. The FTE staffing profile is shown in Table 22 below:

Table 22 – Source Data: E-Area Staffing Profile for 26.2 MT (March 2018)

		FISCAL YEAR (FTE Staffing Profile)																		
E-Area Operations Scope	**Total**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31-45**	**46**	**47**	**48**	**49**	**50**
Program Management	94	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Characterization & Packaging	1547	0	0	0	0	0	1	47	48	49	69	67	67	67	67	67	67	0	0	0
OPEXP	18	0	1	1	0	2	3	3	3	3	1	0	0	0	0	0	0	0	0	0
Ops Proj	50	0	0	1	6	7	6	3	5	1	1	1	0	1	1	4	1	0	0	0
Deactivation	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	16	16	0
Total	**1752**	***3***	***4***	***5***	***9***	***12***	***13***	***56***	***59***	***55***	***74***	***71***	***70***	***71***	***71***	***76***	***75***	***19***	***19***	***3***

3.4.2.5.2 E-Area (SRS) Adjustment to 34MT of Manpower

The raw data set shown in Table 22 is based on the NNSA's staffing profile to package 26.2 MT ramping up to a steady-state of 71 FTEs. This staffing profile is also based on ten hour shifts and four days per week. In order to account for the DOE-EM's portion of the estimate, a scaling factor of 1.30 (34 MT/26.2 MT) was applied to two categories of the data set only: program management and characterization & packaging. As a result, the adjusted FTE profile for E-Area operations to D&D 34 MT of Pu oxide for the base case is a steady state of 91 FTEs.

In addition, WIPP will provide on-site characterization support at E-Area. This was estimated to cost $12M per year in FY2017 dollars based on current characterization operations to support WIPP disposal.

3.4.2.5.3 E-Area (SRS) Operations Risk

E-Area operations are sensitive primarily to the personnel required to perform packaging and shipment operations. A triangular distribution was applied to the FTE estimate, as shown in Table 23. The low is based on realization of opportunities for efficiency from the initial PM staffing estimate. The most likely requires the addition of a fifth day of shift work (adding 25% to the initial estimate). The high applies the same scaling factor as K-Area (adding 42% to the initial estimate).

Table 23 – E-Area FTE Triangular Distribution

Triangular Parameter	Scaling Factor
Low	0.9
Point	1.25
High	1.42
50% Confidence	1.23

The resulting scaling factors as determined above were used to develop a triangular distribution for FTE scaling. The mean staffing factor of 1.23 was then applied to the 34MT staffing profile. This resulted in a DOE/NNSA total FTE steady state of 112 FTEs, as displayed in Figure 21.

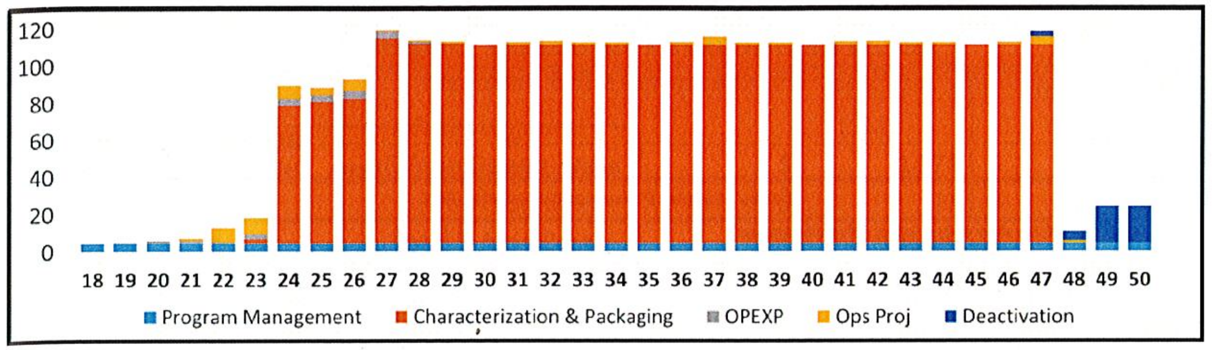


Figure 21 – SRS E-Area Staffing Profile for 34MT (Base Case w/ Extra Shift)

Like K-Area, E-Area costs will be sensitive to labor costs. Given conflicting data on labor costs (as discussed Section 3.4.2.2.3) the triangular distribution of labor costs shown in Table 24 was applied to E-Area FTEs.

Table 24 – E-Area Labor Cost Triangular Distribution
Contractor Proprietary

Triangular Parameter	Cost per FTE (FY2017$)
Low (FPRA Low)	$206K
Point (FPRA Most Likely)	$257K
High (Based on NNSA Actuals)	$282K
50% Confidence	$250K

In addition, the $12M per year characterization cost is affected by the number of shipments per week sent to WIPP; in accordance with the sensitivity analysis described in Section 3.9.2, if shipments per week exceed 3.5, an additional shift of characterization staff is added at a cost of $3M per year.

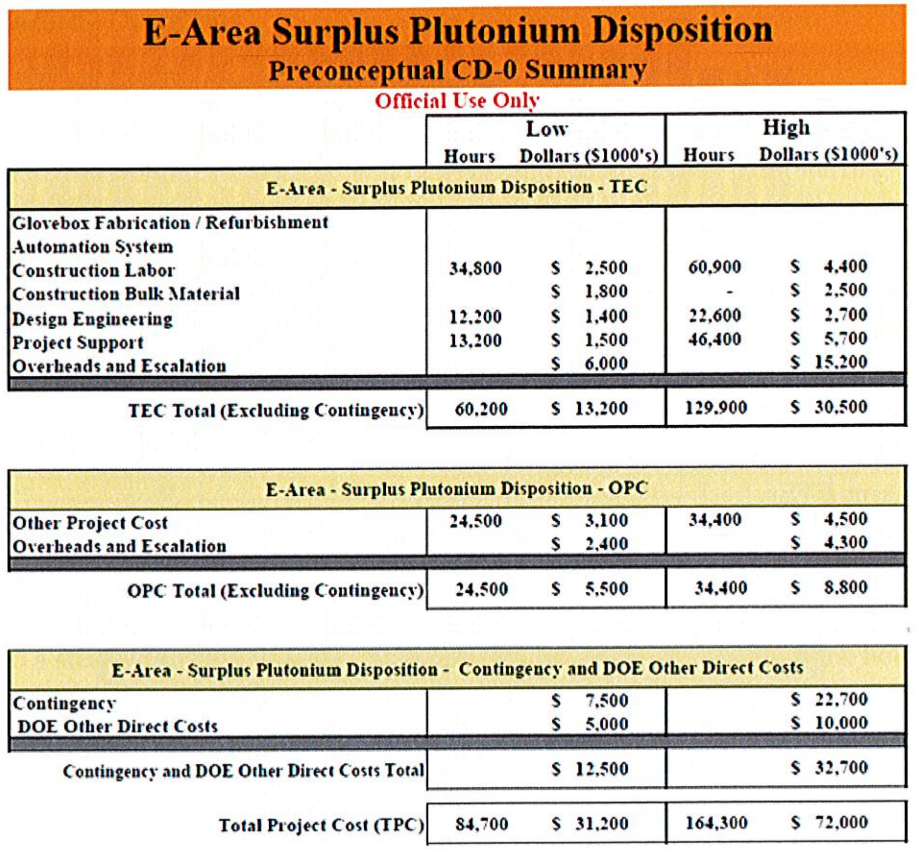
3.4.2.5.4 E-Area Operations (SRS) Cost Estimate

Overall, the staffing profile provided by the NA-23 program office was scoped out to characterize and package 26.2 MT of diluted Pu oxide over the lifecycle. After adjusting to account for the 34 MTs, applying the extra shift factor and applying the 50% confidence level labor rates, this resulted in a cost estimate of $1,074M in FY2017 dollars, which also includes $358M for WIPP characterization support, materials and non-labor cost. The Then Year total is $1,589M over the lifecycle (FY2018 to FY2050).

3.4.2.6 E-Area (SRS) Equipment and Installation

3.4.2.6.1 E-Area (SRS) Equipment and Installation Starting Point

The E-Area plan identifying equipment modifications and upgrades required to meet the desired throughput requirements is shown in Figure 22 below, as provided by NA-23 CD-0 estimates. This includes all planned costs, including material, labor, and other direct costs to accomplish project needs from FY2018 to FY2026.



E-Area Surplus Plutonium Disposition
Preconceptual CD-0 Summary
Official Use Only

	Low Hours	Low Dollars ($1000's)	High Hours	High Dollars ($1000's)
E-Area - Surplus Plutonium Disposition - TEC				
Glovebox Fabrication / Refurbishment				
Automation System				
Construction Labor	34,800	$ 2,500	60,900	$ 4,400
Construction Bulk Material		$ 1,800	-	$ 2,500
Design Engineering	12,200	$ 1,400	22,600	$ 2,700
Project Support	13,200	$ 1,500	46,400	$ 5,700
Overheads and Escalation		$ 6,000		$ 15,200
TEC Total (Excluding Contingency)	60,200	$ 13,200	129,900	$ 30,500
E-Area - Surplus Plutonium Disposition - OPC				
Other Project Cost	24,500	$ 3,100	34,400	$ 4,500
Overheads and Escalation		$ 2,400		$ 4,300
OPC Total (Excluding Contingency)	24,500	$ 5,500	34,400	$ 8,800
E-Area - Surplus Plutonium Disposition - Contingency and DOE Other Direct Costs				
Contingency		$ 7,500		$ 22,700
DOE Other Direct Costs		$ 5,000		$ 10,000
Contingency and DOE Other Direct Costs Total		$ 12,500		$ 32,700
Total Project Cost (TPC)	84,700	$ 31,200	164,300	$ 72,000

Figure 22 – SRS Summary of Planned Equipment Installations for E-Area
Contractor Proprietary

3.4.2.6.2 E-Area (SRS) Facilities Cost Risk

The assumption is that E-Area facilities will have a 20.4% cost growth based on the analysis summarized in Section 3.3.2.3.2 – LANL Facilities Cost Risk. This increase was determined by taking the average cost growth of seven nuclear facilities projects (as a percentage), and testing them against a number of potential curves and curve shapes to determine the best fit to predict equipment/installation cost growth. Section 3.3.2.3.2 explains the derivation in further detail. The 20.4% factor was applied to the planning value of the average of total project costs (TPC: Low – $31.2M; High – $72.0M; Average – $51.6M) shown in Figure 22, excluding a sunk costs of $2.1M. This resulted in a total cost of $60M in FY2017 dollars.

$$E - Area\ Equipment\ Upgrade\ Cost = (\$51.6M - 2.1M)\ x\ 1.204 = \$60M$$

A cost for demolition and deconstruction ($12.4M) was also added, resulting in a total cost of $72M in FY2017 dollars and a total cost of $89M in Then Year dollars.

3.4.2.7 E-Area (SRS) Total Cost Summary

The costs for E-Area operations and equipment installation total $1.7B in Then Year from FY2018 to FY2048, as illustrated in Table 25.

Table 25 – Total E-Area (SRS) Cost Summary

	Cost Summary	FY2017 ($M)	Then Year ($M)
E-Area	E-Area Operations	$ 1,074	$ 1,589
	E-Area Facilities	$ 72	$ 89
	Total E-Area Cost	**$ 1,146**	**$ 1,678**

3.4.2.8 H-Canyon/HB-Line Operations (SRS)

3.4.2.8.1 H-Canyon/HB-Line Operations (SRS) Starting Point

The starting point for oxide production of Non-Pit Plutonium operations were the H-Canyon/HB-Line historical actuals from FY2012 to FY2017 and the NA-23 planning values provided in the D&D basis-of-estimates data. Actual costs in Then Year dollars and FY2017 dollars are summarized in Table 26 below:

Table 26 – H-Canyon/HB-Line Actuals and Planned Costs (FY2011 to FY2017)
Contractor Proprietary

H-Canyon Actuals ($M)	FY12	FY13	FY14	FY15	FY16	FY17	Total
Oxide Production	$ 20.5	$ 21.0	$ 19.9	$ 21.2	$ 22.0	$ 21.3	**$ 125.8**
Program Management	$ -	$ -	$ -	$ -	$ 0.40	$ 0.27	**$ 0.7**
Capacity & Reliability	$ -	$ 0.22	$ 1.63	$ 1.90	$ 3.07	$ 0.05	**$ 6.9**
Then Year (Total)	$ 20.5	$ 21.2	$ 21.5	$ 23.1	$ 25.5	$ 21.6	**$ 133.4**
Oxide Production	$ 22.2	$ 22.5	$ 21.0	$ 22.0	$ 22.4	$ 21.3	**$ 131.4**
Program Management	$ -	$ -	$ -	$ -	$ 0.40	$ 0.27	**$ 0.7**
Capacity & Reliability	$ -	$ 0.22	$ 1.63	$ 1.90	$ 3.07	$ 0.05	**$ 6.9**
Base Year 2017 (Total)	$ 22.2	$ 22.7	$ 22.6	$ 23.9	$ 25.9	$ 21.6	**$ 139.0**

The actual variable cost to convert 4.3MT of Pu to oxide from FY2012-FY2017 is $31K / kg ($131M / 4.3MT).

3.4.2.8.2 H-Canyon Operations Risk Summary

The base case assumes H-Canyon operations for D&D will be a continuation of existing processes and operations to convert 3.5MT of remaining Pu to Pu oxide. However, NA-23 has indicated that existing HB Line resources might be overtaken by other operational priorities, so prior costs might not be representative of the future cost. Alternatives proposed (but not yet down-selected) include continuing HB line operations at a higher costs as resources are rebalanced, or moving oxide production for non-pit Pu to LANL in the same line as NNSA's pit Pu. To capture this uncertainty, a normal distribution was built based on variable cost per kg for the following options: H-Canyon actuals from FY12-17; NA-23 estimate of updated HB Line operations ($303M / 3.5MT = $85K per kg); LANL FY11 actuals ($62K per kg) and FY17 actuals ($143K per kg), using the data described in the LANL variable cost Section 3.3.2.2.3. The results of the normal distribution are summarized in Table 27.

Table 27 – H-Canyon Normal Distribution Parameters

Normal Distribution Data	Variable Cost per kg (FY17$)
H-Canyon Actuals (FY12-17)	$31K
NA-23 Updated HB Line Estimate	$85K
LANL FY11 Actuals	$62K
LANL FY17 Actuals	$143K
Normal Parameters:	Average: $80K; Standard Deviation: $48K

This normal distribution captures the actual costs to-date as well as the upside risk of potential operational options. Based on the average variable cost of $80K per kg, the total variable cost at the 50th percentile is $285M in FY2017 dollars.

In addition, a sensitivity analysis was performed to determine the cost impact of delaying the dilution of remaining non-pit Pu until FY2030 rather than the original schedule of FY2018 to FY2023; the results of this analysis are not included in the base model but are shown in Section 3.9.2.

3.4.2.9 H-Canyon/HB-Line Total Cost Summary

Based on the resulting 50% confidence level of the variable cost, and after adding $24M in fixed costs, the total cost from FY2018 to FY2023 for conversion of the remaining non-pit Pu to oxide is $309M in FY2017 dollars and $331M in Then Year dollars. Table 28 shows the result.

Table 28 – Total H-Canyon (SRS) Cost Summary

H-Canyon Operations	Cost Summary	FY2017 ($M)	Then Year ($M)
	H-Canyon Operations	**$ 309**	**$ 331**

3.4.2.10 SRS Project Management and Integration (PMI)

3.4.2.10.1 SRS PMI Starting Point

The primary data source for the SRS PMI estimate was the staffing profile provided by the NA-23 program office for planning, program planning and integration, and technical support functions, as illustrated in Table 29.

Table 29 – Staffing Profile [Data Source: SRS PMI Data]

	Fiscal Year																			
Scope	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31 to 45**	**45**	**46**	**47**	**48**	**49**	**50**
SRS - PMI	10	15	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
SRS - Technical Support	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SRS - D&D Planning	4																			

3.4.2.10.2 SRS PMI Base Estimate

The SRS FPRAs were used to determine the composite fully burdened labor rates. These labor rates were then used to cost out the base case optimal staffing profile illustrated in Table 29. This

resulted in a total base estimate cost of $198M in FY2017 dollars of which also include $23M of materials and non-labor cost.

3.4.2.10.3 SRS PMI Risk

SRS PMI is a relatively small cost and low risk to the program; the base estimate is based on realized actuals from the MOX program. A triangular distribution was applied to the base PMI estimate, as shown in Table 30.

Table 30 – SRS PMI Triangular Distribution

Triangular Parameter	Scaling Factor
Low	0.9
Point	1.0
High	1.25
50% Confidence	1.04

The results of the triangular simulation would provide a 50% percentile confidence level of 1.04 to use as a scaling factor to apply to the FTEs.

3.4.2.11 SRS PMI Total Cost Summary

Based on the 1.04 scaling applied to the staffing profile, the estimate for SRS PMI totals $206M in FY2017 dollars, which also includes $23M of materials and non-labor cost. The Then Year total for SRS PMI is $293M as shown in Table 31:

Table 31 – SRS PMI Staffing Total Cost

SRS PMI	Cost Summary	FY2017 ($M)	Then Year ($M)
	SRS PMI	**$ 206**	**$ 293**

3.5 WIPP

3.5.1 WIPP Background

3.5.1.1 WIPP Site Description

The WIPP was authorized by Congress in 1979 is located near Carlsbad, New Mexico. It was certified for long-term storage of TRU waste disposal by the EPA in 1998. The TRU waste is stored in underground salt repositories at a depth of 2,150 feet, as shown in Figure 23 below.

Figure 23 – WIPP Underground Repository

The WIPP Land Withdrawal Act (LWA) is the federal law that sets the geographical boundaries for WIPP, along with limits to the waste capacity, radioactivity, and types of waste stored in WIPP. The total capacity of WIPP for TRU waste by volume is 6.2 million cubic feet, which is equivalent to 175,564 cubic meters.

WIPP is regulated by both the EPA and NMED. Under the Resource Conservation and Recovery Act (RCRA), the State of New Mexico is authorized to administer the state hazardous waste program in lieu of the federal program. The Hazardous Waste Permit for WIPP covers the terms and conditions to protect human health and the environment in the operation of WIPP and contains a detailed synopsis of WIPP and activities that occur in support of the safe operation of the site. This includes the specification of how waste is accounted for against the LWA limit. The WIPP permit is updated by NMED as the requirements for operating WIPP change. A special view of the site, extracted from the WIPP Hazardous Waste Permit, is shown in Figure 24.

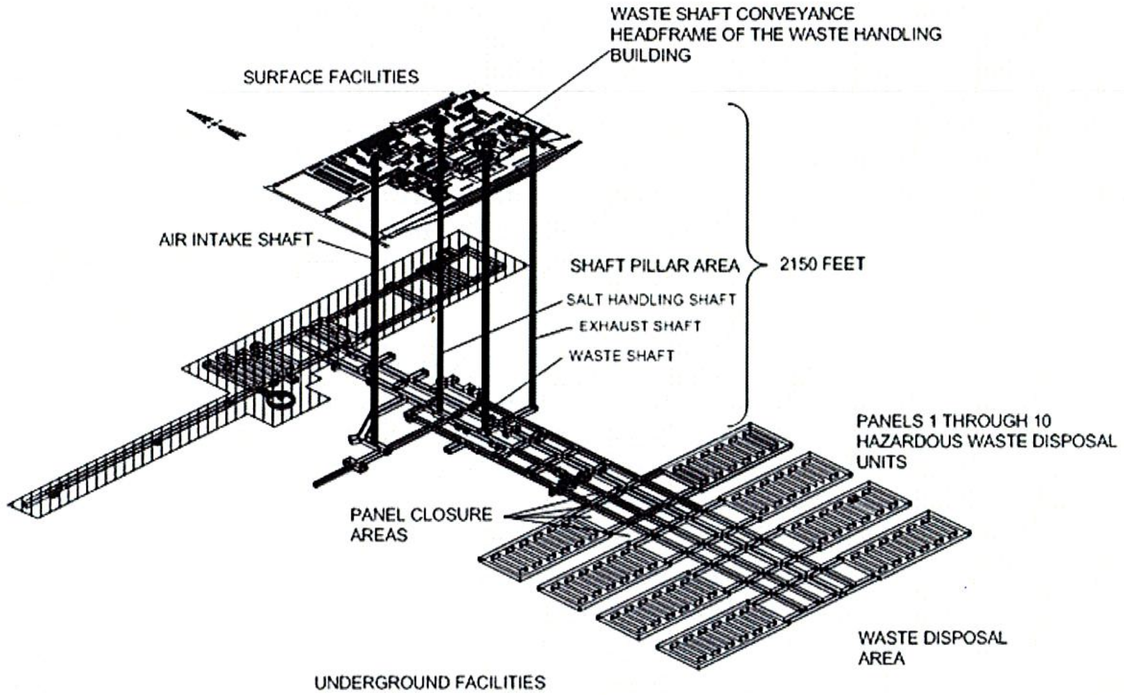


Figure 24 – WIPP Underground Repository Spatial View

3.5.1.2 WIPP Expected Changes

On September 5, 2017, the GAO published its review of the D&D approach (GAO-17-390), which recommended that DOE develop a plan for expanding space at WIPP. During November 28-30, 2017 the National Academy of Sciences (NAS), under its statutory authority in the WIPP LWA, held a series of meetings to discuss the disposal of surplus Pu at WIPP. During the public session, the representative from DOE-EM briefed the NAS that part of the capacity issue at WIPP is that historically the site has included the volume of over-pack material and even unused air space in packaging containers when determining stored volume under the LWA. This is an accounting artifact which is not a requirement under the LWA. By modifying the Hazardous Waste Permit so that only the volume specifically associated with the waste material is accounted as TRU waste under the LWA, the remaining statutory capacity at WIPP can be used more efficiently without direct legislative action. The effect is that the 8,035 cubic meters of capacity currently set aside at WIPP for TRU waste from MOX operations would be sufficient for the accountable TRU waste generated by D&D under the planned waste accounting change.

CEPE calculates that 113,000 55-gallon sized storage containers will be used to store waste from D&D at WIPP, equivalent to 23,611 cubic meters. The diluted Pu oxide is held in a smaller container inside the larger storage container, typically 12-24 liters (3.2 – 6.4 gallons) in size. For D&D, the bulk of the 23,611 cubic meters is air volume, and roughly 1,400-2,800 cubic meters is the volume associated with the diluted plutonium oxide.

Given that these changes can be made without legislative action, CEPE evaluated whether these and similar administrative changes to required environmental documents could be made before the first expected shipment in 2026. Conversations with the NNSA program office and the Carlsbad Field Office (CBFO) revealed the general planning expectation that changes to any environmentally related document take 18-24 months from initiation to final decision; this includes public comment periods. To evaluate whether this estimate of time was reasonable, CEPE used data regarding durations of changes to environmental documents and discovered that the DOE maintains a public-facing website with detailed information on its initiation, changes, and updates to its Environmental Impact Statements (EIS), as available from the Office of NEPA Policy and Compliance. The time to Record of Decision, along with a fitted Weibull model, is shown in Figure 25. CEPE decided that this data could be used as an analogous representation of risk associated with administrative environmental action since the general processes for those actions are similar to changes to the Hazardous Waste Permit and could serve the purpose of explaining impacts of any potential changes to any environmental documents for this effort.

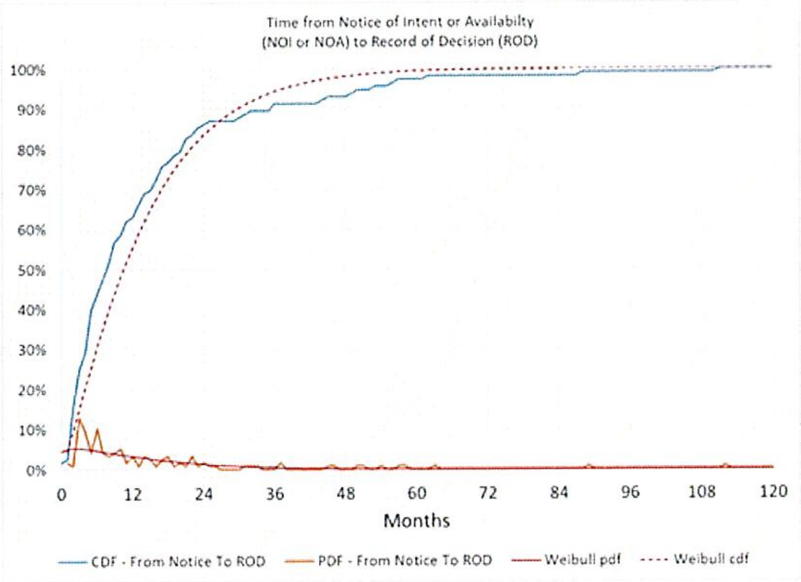


Figure 25 – Distribution of Months to Complete Environmental Actions
Data Source: Office of NEPA Policy and Compliance public material

An analysis of the data available from NEPA revealed that 32 months or less time was needed in 90% of actions requiring a Notice of Intent (NOI) or Notice of Availability (NOA) where a Record of Decision (ROD) was made. While this is longer than projected by the program and the CBFO, the impact is not sufficient to drive the critical path unless there are direct legal challenges leading to lengthy court injunctions. Since such court action is difficult to predict, it was not explicitly modeled but was considered to be captured as part of the overall risk range for the estimate.

3.5.2 WIPP Cost Estimating Development and Results

3.5.2.1 WIPP Operations Cost Estimating Process

Figure 26 provides a process flow illustrating how the WIPP operations cost estimates were developed:

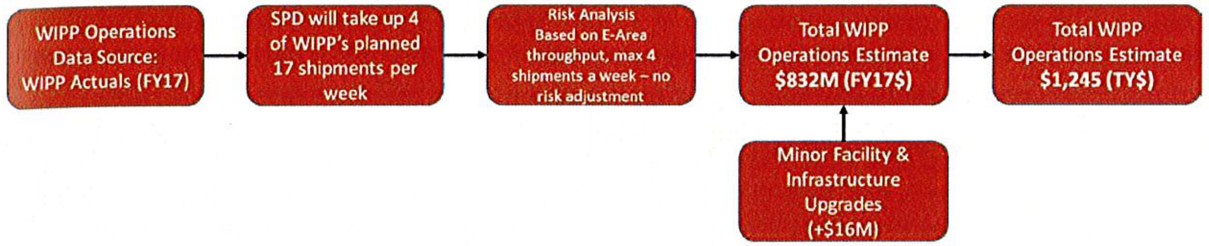


Figure 26 – WIPP Cost Estimating Process Flow

3.5.2.2 WIPP Starting Point

Because WIPP has a long-established history, a reconstruction of WIPP's funding history from 1977 through 2017 was developed based on budget documents and compared to Standard Accounting and Reporting System (STARS) when practicable. This data was used to compute an inflation-adjusted cost for operations per cubic meter of waste stored. This was done by taking the total history of operations and excluding construction, transition, and testing costs. Since WIPP operations had stopped effectively from the middle of FY2014 and restarted at limited capacity in FY2017, costs and shipments after the middle of FY2014 were excluded. The remaining cost includes the cost to operate the site, safeguards and security costs, the central characterization project cost, and the WIPP transportation program cost (which is separate from shipping costs). This led to an initial estimate of $45K per cubic meter in FY2017 dollars. Regression analysis comparing emplaced volume to cost did not lead to a strong cost correlation, so this approach was abandoned. Further research of the EISs for WIPP revealed that operations costs are largely determined by the staffing requirements of the site. In 2017, WIPP restarted operations and it was assumed that staffing requirements to ensure safe operation were largely stable because of the intensive review needed to achieve approval to restart operations. This led to the conclusion that the non-construction budget in FY2017 during the continuing resolution gave a real representation of baseline operations cost for the site.

Discussions with the CBFO indicated that a better methodology for determining cost would be to consider that funding for WIPP must ensure the processing of a certain number of shipments per week. Once WIPP has completed construction of its upgraded ventilation system, the site will be able to return to receiving 17 shipments per week by 2026. Further, the total number of shipments from D&D operations will be limited to four per week. This is dictated by the need to only have one vehicle in transit to WIPP while there is another vehicle offloading at WIPP. This requirement also drives the need for a temporary parking location and associated security upgrades at WIPP in the event an offloading vehicle cannot depart before a transiting vehicle arrives.

Based on this information, the best methodology was determined to be allocation of WIPP operational costs based on the number of shipments per week relative to the total number of shipments WIPP could process during normal operations.

In FY2017 WIPP funding totaled $304M; excluding one-time recovery costs and characterization costs, the cost for operations, safeguards and security, and transportation infrastructure was $200M. Throughput scenarios showed an average of 2.96 to 3.72 shipments of D&D material to WIPP per week depending on the CCO capacity (see Sensitivity Analysis in Section 3.9.2). While the shipment rate might vary, the maximum throughput shown in the model fits within WIPP's plan for 4 D&D shipments per week from FY2028 through FY2047; therefore those 4 shipments per week were used as the portion of WIPP costs attributable to

D&D. CEPE used the general relationship of 4 shipments per week out of 17 and adjusted it to account for D&D only shipping for 40 weeks per year. CEPE also noted variability in the costs for transportation infrastructure costs based on the volume of waste and made adjustments by using FY15 actual costs as a baseline since no shipments were made to WIPP that year. This resulted in an allocated cost of $39M (FY2017 dollars) per year for WIPP storage during normal operations. In addition, a one-time cost of $16M (FY2017 dollars) for upgrades to create the temporary parking area is directly attributable to the D&D program.

Costs for excavation are already included in the WIPP base operating cost and therefore should not be explicitly estimated to avoid double counting. However, CEPE performed an excursion, as shown in Appendix E, on the requirements for and potential cost of additional panels in case these costs are later charged to D&D, though the CBFO has consistently stated they will maintain excavation costs in the base budget.

3.5.2.3 WIPP Risk Adjustment

Given that WIPP is sensitive to the number of shipments per week and that the total number of shipments will be at or under the 4 D&D shipments per week in WIPP's planning assumptions, no additional risk analysis was performed on the WIPP estimate.

3.5.2.4 WIPP Cost Results

Based on the expected shipments per year, the allocated operating costs for storage of D&D waste at WIPP, which excludes characterization costs captured in E-Area operations, ramps up to approximately $39M per year; when the $16M in upgrades is added, the WIPP operations cost totals of $832M in FY017 dollars. Inflating this cost during the expected period of operation leads to an estimate of $1,245 in Then Year dollars for WIPP storage costs. Table 32 summarizes the results.

Table 32 – WIPP Total Cost

WIPP Operations	Cost Summary	FY2017 ($M)	Then Year ($M)
	Waste Isolation Pilot Plant (WIPP)	**$ 832**	**$ 1,245**

3.5.2.5 WIPP Cross Check

A cross-check of this estimate can be performed. The cost allocated to D&D for WIPP operations totals $816M (which excluded upgrades cost), and the characterization costs performed at E-Area total $264M, both in FY2017 dollars. If the sum of these, $1,080M, is divided by the total waste volume of 23,611 cubic meters, the result is a cost of $46K per cubic meter in FY2017 dollars. This is slightly higher than the average cost of $45K per cubic meter from historical WIPP operations as discussed in Section 3.5.2.2; the CEPE ICE therefore provides a slightly more conservative estimate.

3.6 Transportation and Packaging

3.6.1 Transportation and Packaging Background

The D&D program uses an iterative transportation procedure for processing, characterization, and storage capabilities for disposition and permanent disposal of 34 MT of weapons-usable Pu. After nuclear weapons are removed from service and dismantlement programs are completed, the surplus pits are staged at PANTEX until required for Pit Disassembly and Processing. The surplus pits are transported by OST to LANL using the MD-2 shipping packages. Once received, the surplus pits are unpackaged and placed into interim storage until required for disassembly operations. LANL receives and unpacks surplus pits for disassembly, then processes and analyzes Pu oxide in preparation for packaging into 9977 containers for delivery to SRS by OST. The delivery of Pu oxide from processing of both pit and non-pit Pu materials is managed as part of the K-Area base operation at SRS for the dilute process. E-Area at SRS is responsible for interim storage, characterization, and packaging for delivery to WIPP. The diluted Pu is packaged into CCOs; these are placed into TRU Packaging Transporter Model II (TRUPACT II) and managed by the DOE-EM to be commercially transported to WIPP. Figure 27 shows a map of the sites involved.

Figure 27 – Map of Sites

3.6.1.1 Transportation Responsibilities

The NNSA Office of Secure Transportation will be responsible for transportation and cost for all material being moved from PANTEX to LANL to SRS. DOE-EM will be responsible for all material being transported from SRS to WIPP. Table 33 below provides a summary including type of vehicle transport:

Table 33 – Transportation Responsibilities

TRANSPORTATION			
Travel	**Vehicle Use**	**Transport Responsibilty**	**Cost Responsibilty**
PANTEX to LANL to SRS	FY23 - FY27 Safeguard Guardian Transporter FY28 - FY45 Mobile Guardian Transporter	NNSA Office of Secure Transportation	NNSA Office of Secure Transportation
SRS to WIPP	Commercial Transportation	DOE-EM	DOE-EM

3.6.2 Transportation and Packaging Cost Estimate Development and Results

3.6.2.1 Transportation and Packaging Cost Development Process

Figure 28 provides a process flow illustrating how the Transportation and Packaging cost estimates were developed:

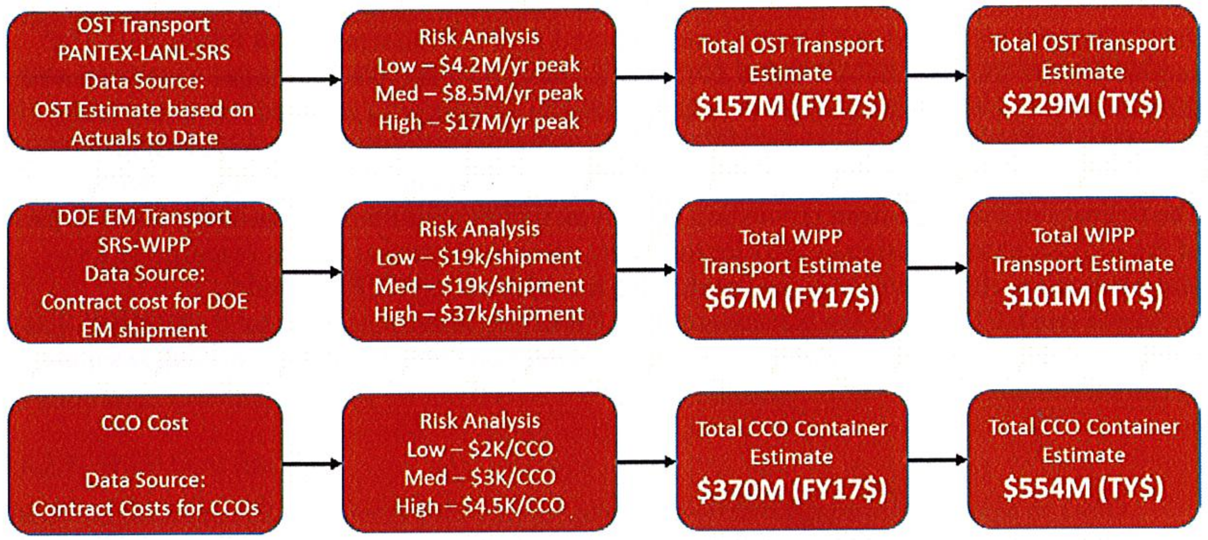


Figure 28 – Transportation and Packaging Cost Estimating Process Flow

3.6.2.2 Transportation and Packaging Starting Point

OST provided estimated costs for transportation from PANTEX to LANL to SRS. OST transportation costs fall within the ongoing budget for OST operations. However, transportation of the TRU waste to WIPP is based on a commercial contract calculated average rate over the estimated operational duration.

OST Transportation used actual costs to provide an estimate for D&D transport operations from PANTEX to LANL to SRS. The transportation costs include salary, fringe benefits, overtime, and night differential, travel, per mile maintenance, fuel charge, meals, and other incidental expenses. Table 34 shows the lifecycle estimate for OST transportation in FY2017 dollars and Then Year dollars.

Table 34 – Office of Secure Transportation Costs

	FY26 - FY45 ($M)	
	FY17	Then Year
FY2023		
FY2024		
FY2025		
FY2026	$5.8	$6.9
FY2027	$5.8	$7.0
FY2028	$5.8	$7.2
FY2029	$5.8	$7.3
FY2030	$8.5	$11.0
FY2031	$8.5	$11.2
FY2032	$8.5	$11.4
FY2033	$8.5	$11.6
FY2034	$8.5	$12.0
FY2035	$8.5	$12.1
FY2036	$8.5	$12.3
FY2037	$8.5	$12.6
FY2038	$8.5	$12.9
FY2039	$8.5	$13.1
FY2040	$8.5	$13.4
FY2041	$8.5	$13.6
FY2042	$8.5	$14.0
FY2043	$8.5	$14.2
FY2044	$8.5	$14.5
FY2045	$5.8	$10.0
Total	$157	$228

For transportation from SRS to WIPP, based on the contract and input from the CBFO, the average cost is $18.7K per trip. Based on vendor quotes and research provided by NA-23, the costs of CCOs are $3K per unit. The team considered the annual number of CCOs needed to determine the approximate total lifecycle costs for packaging and shipping from SRS to WIPP. (NA-23 assumes a schedule of approximately four trips per week for 40 weeks per year, on par with the team's analysis.)

3.6.2.3 Transportation and Disposal Cost Risk

Packaging and transportation costs are dependent on cost per shipment and number of CCOs per year. Packaging and transportation cost risks are described below. The number of CCOs (and resulting number of shipments) are explored in sensitivity analysis, Section 3.9.2.

3.6.2.3.1 Packaging Cost Risk

CCO cost is based on an existing contract. However, since CCOs are a significant cost driver for the program, a triangular distribution was applied to container cost as shown in Table 35.

Table 35 – CCO Container Cost

Triangular Parameter	Cost per Container (FY2017$)
Low	$2,000
Most Likely	$3,000
High	$4,500
50% Confidence Level	$3,131

The result of the triangular distribution at the 50% confidence level is $3,131 in FY2017 dollars for CCOs.

3.6.2.3.2 Shipping Cost Risk (PANTEX to LANL to SRS)

Shipping from PANTEX to LANL to SRS will be performed by NNSA OST, which provided a number of scenarios for transport cost based on existing operations. These scenarios, captured in Table 36, were applied to the low and most likely of a pert analysis (1/6 probability of low, 2/3 probability of point estimate, and 1/6 probability of high). The high parameter was simply double the most likely, intended to capture the upside risk of the future cost changing.

Table 36 – OST Transportation Cost (PANTEX to LANL to SRS) Risk Parameters

PERT Parameter	Average Cost per Year (FY2017$)
Low (OST Low)	$4.2M
Point (OST base)	$8.5M
High (2x Point)	$17M
Most Likely is the Point	$8.5M

The result of this modified triangular distribution at the 50% confidence level $8.5M in FY2017 dollars for OST transport.

3.6.2.3.3 Shipping Cost Risk (SRS to WIPP)

The shipping costs from SRS to WIPP, shown in Table 37, are based on existing contracts managed by WIPP. The number of shipments will be driven by the total number of CCOs, which is explored in the Sensitivity Analysis, Section 3.9.2. Cost per shipment is based on the existing WIPP contract (as both low and most likely), with a high estimate based on that cost doubling to capture upside risk of the future cost changing.

Table 37 – Risk Parameters for Average CCO costs

Triangular Parameter	Average Cost per Shipment (FY2017$)
Low	$18,700
Point	$18,700
High (2x Most Likely)	$37,400
50% Confidence Level	$24,177

The result of the triangular distribution at the 50% confidence level for the average shipment cost to WIPP is $24,177 in FY2017 dollars for DOE EM transport.

3.6.2.4 Transportation and Packaging Cost Estimate

Based on the risk analysis, the 50% confidence levels for transportation are $3,131 for the CCO container cost, $8.5M for annual OST transportation costs from PANTEX to LANL to SRS and $24,177 per trip for the transportation costs from SRS to WIPP. Based on these parameters the cost estimates for transportation and packaging across the D&D lifecycle are as follows:

1. The total cost of the CCOs is $370M in FY2017 dollars and $554M in Then Year dollars. (FY26 to FY48)
2. The cost to transport the CCOs from SRS to WIPP are $67M in FY2017 dollars and $101M in Then Year dollars. (FY26 to FY48)

3. The cost of CCOs over the lifecycle are $366M in FY2017 dollars and $548M in Then Year dollars. (FY26 to FY48)

The total overall cost of transportation and packaging is $594M in FY2017 dollars and $884M in Then Year dollars. Table 38 provides the cost summary.

Table 38 – Transportation and Packaging Total Cost

	Cost Summary	FY2017 ($M)	Then Year ($M)
Transportation and Packaging	Transportation (PANTEX to LANL to SRS)	$ 157	$ 229
	Transportation (SRS to WIPP)	$ 67	$ 101
	Criticality Control Over-Pack (CCOs)	$ 370	$ 554
	Total Transport and Packaging Cost	**$ 594**	**$ 884**

3.7 NNSA Program Management and Integration

3.7.1 NNSA PMI Background

NNSA Program Management and Integration (PMI) provides overall program management and integration functions for execution of the D&D Program. NNSA PMI also provides detailed planning and integration, technical support, and National Environmental Policy Act (NEPA) functions for ongoing D&D program activities, including execution planning, program lifecycle management, integrated program scheduling, and technical baseline and risk management.

3.7.2 NNSA PMI Cost Estimate Development and Results

3.7.2.1 NNSA Process Flow

Figure 29 provides a process flow illustrating the NNSA PMI cost estimate:

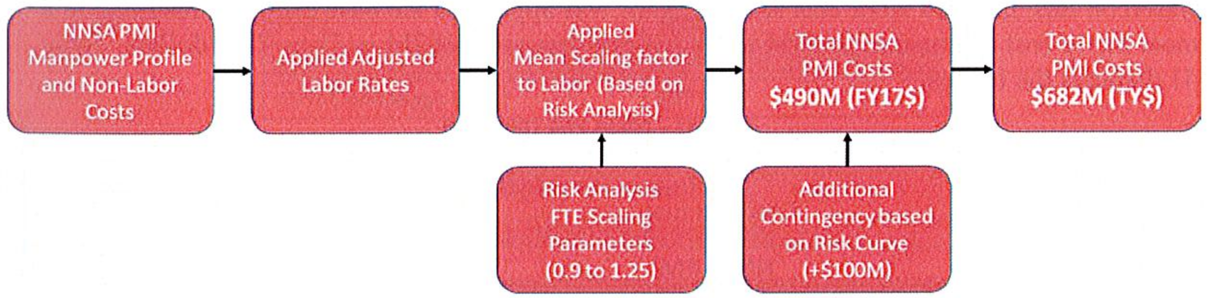


Figure 29 – NNSA PMI Cost Estimating Process Flow

3.7.2.2 NNSA PMI Starting Point

The primary data source for the NNSA PMI estimate was the staffing profile provided by the NA-23 Program Office as illustrated in Table 39. Additional projections for NEPA planning, program planning and integration, and technical support functions were also provided, based on realized actuals from the MOX program.

Table 39 – Staffing Profile [Data Source: NNSA PMI Data]

	Fiscal Year																			
Scope	18	19	20	21	22	23	24	25	26	27	28	29	30	31 to 45	45	46	47	48	49	50
NNSA PMI Staffing	10	18	18	18	18	18	18	18	18	15	15	15	15	15	15	15	8	8	8	8

3.7.2.3 NNSA PMI Risk

To capture risk in NNSA PMI, a triangular distribution was applied to the base PMI estimate, as shown in Table 40.

Table 40 – NNSA PMI Triangular Distribution

Triangular Parameter	Scaling Factor
Low	0.9
Point	1.0
High	1.25
50% Confidence Level	1.04

The results of the triangular distribution show a 50 percentile confidence level of 1.04 for the cost scaling factor.

Additional non-labor PMI costs include clearance costs ($3M in FY2017 dollars), Support Contracts, Other Program Money (OPM), and NA-20 Taxes (all totaling $207M in FY2017 dollars). These are based on actuals from MOX ramp-up, with costs irrelevant to D&D removed.

In addition, the Monte Carlo Simulation described in Section 3.9.3 demonstrates additional risk that is not captured in the 50th Percentile of each individual cost element. Therefore, an additional contingency of $3M per year (for a total of $100M in FY2017 dollars) was added within the NNSA PMI element to ensure this risk is captured.

3.7.2.4 NNSA PMI Cost Estimate

Based on this, the 1.04 labor cost scaling factor was applied to the base estimate, resulting in a most likely cost estimate of $490M in FY2017 dollars and $682M in Then Year dollars. Table 41 displays the results.

Table 41 – NNSA PMI Total Cost

NNSA PMI	Cost Summary	FY2017 ($M)	Then Year ($M)
	NNSA PMI	$ 490	$ 682

3.8 MOX Closure

3.8.1 MOX Closure Background

MOX contract termination and construction close-out is defined as DOE directing the MOX prime contractor to develop a plan within 90 days to terminate the project and begin to secure information, materials, and equipment at the job site to protect government assets and ensure the safety of workers. The disposition of temporary and permanent facilities would be planned and equipment prepared for storage or disposition as appropriate. In general, the contractor would begin termination of the sub-contracts and leases.

General activities anticipated in this scope are as described below, but subject to change: The project will facilitate future occupancy. Permanent buildings will be environmentally sealed and some form of condition ventilation installed to minimize mold and mildew. Temporary buildings and structures will only be environmentally sealed and secured. In-process construction activities will cease and be secured and laid-up to protect people, equipment and materials while minimizing deterioration from the environment. Equipment and materials will be stored in an appropriate location to protect and maintain intended performance requirements with minimum refurbishment costs. All documents associated with planning, design, construction and operational paperwork for the structures, systems and components, including all nuclear quality paperwork, shall be suspended in an organized fashion to allow a restart with minimum delay and risk of rework. Subcontracts that are 70% or greater will be completed and contract deliverables received and inspected. All contracts less than 60-70% complete will be terminated for convenience and bi-lateral settlements reached. A complete government property inventory will be taken and decisions made on release of certain property due to obsolescence. Recurring maintenance and utilities will be required to maintain the permanent facilities, equipment and stored government property.

3.8.2 MOX Cost Estimate Development and Results

The cost to close the MOX facility is a large cost driver for the program; however, the cost is unknown due to uncertainty of closure scope. Therefore, a wide-range triangular distribution, captured in Table 42, was developed to allow for a number of potential closure scenarios and costs.

Table 42 – MOX Closure Cost Risk Parameters

Triangular Parameter	MOX Closure Cost (TY$M)
Low	$500M
Point	$880M
High	$1,600M
50% Confidence Level	$971M

The MOX closeout cost estimate at the 50% confidence level is $906M in FY2017dollars and $971M in Then Year dollars. Table 43 displays the results.

Table 43 – MOX Closure Total Cost

MOX Closeout	Cost Summary	FY2017 ($M)	Then Year ($M)
	MOX Closeout	$ 906	$ 971

3.9 Program-Level Risk Analysis

3.9.1 Schedule Risk

The ICE allows for schedule risk within operations as the program has deliberate material queues at each step of the operation to absorb operational delays. The model and risk assumptions also allow for increased capacities to recover from delays. Therefore, no additional schedule risk was applied to the program schedule. Schedule sensitivity is explored below in the Sensitivity Analysis, Section 3.9.2.

3.9.2 Sensitivity Analysis

Three primary avenues for sensitivity analysis were identified: the number of grams of Pu allowed within a CCO (which affects a number of other costs within the program), schedule for converting 7.8MT of non-pit Pu from DOE-EM, and the D&D Schedule.

The shipping costs for waste from SRS to WIPP are sensitive to the Fissile Gram Equivalent (FGE) loading per CCO that is generated by dilution processes. The FGE per CCO limit is a function of environmental permitting and other processing factors and can vary based on planning assumptions. This directly affects the total number of CCOs that must be purchased, shipped, and ultimately stored. The base number of FGE per CCO is 300; if allowed, the contractor states they could pack up to 330 grams in each CCO, which would reduce the number of CCOs to be purchased and shipped. The high estimate is based on a worst-case limit of 250 FGE per CCO, which would increase the number of CCOs and shipments. This sensitivity analysis was folded into the risk estimate using a triangular distribution, with parameters shown in Table 44.

Table 44 – CCO FGE Sensitivity Parameters

	g/CCO	CCOs/Year	Shipments/Year
Low	330	4,970	118
Medium	300	5,467	130
High	250	6,560	156
50% Confidence Level	295	5,628	134

The resulting number of CCOs per year affects CCO acquisition cost and shipments per year affects shipping cost to WIPP and E-Area characterization costs. The 50% confidence level is used for all estimates above, and the parameters of this sensitivity are included in the Monte Carlo Simulation described in Section 3.9.3.

As described in Section 3.4.2.8.2, there is still uncertainty as to when the remaining non-pit Pu will be converted to oxide if current H-Canyon operations are not used. CEPE performed an additional analysis on the cost of delaying this operation. The sensitivity estimate is based on a variable cost of $85K per kg and fixed cost of $4M per year in FY2017 dollars. If conversion begins in FY2030 instead of FY2018, costs may increase by $100M for 6 years of operations or $150M for 10 years of operations; this is due to increased escalation costs and addition fixed costs incurred for extending operations.

Sensitivity analysis on the schedule assumed a two-year schedule slip of the most likely scenario to complete the entire D&D process, which includes potential delays for: pit oxide production at LANL; non-pit oxide production at HB-Line; dilution operations at K-Area and E-Area; and transporting diluted Pu oxide to WIPP. The sensitivity of this scenario falls within the anticipated cost risk range from the Monte Carlo Simulation (Section 3.9.3).

3.9.3 Monte Carlo Results

After each risk and sensitivity driver was assessed independently, relationships were developed between those dependent on each other; the primary inter-dependency is packaging and shipping, which are each tied to the number of CCOs. The remaining operations and costs were deemed to be independent from one another given existing operations, queuing and storage capabilities, and independence of operations. All risk and sensitivity parameters were applied in a Monte Carlo risk simulation, resulting in the Confidence Interval and Risk Range shown in Figure 30 and Table 45 below.

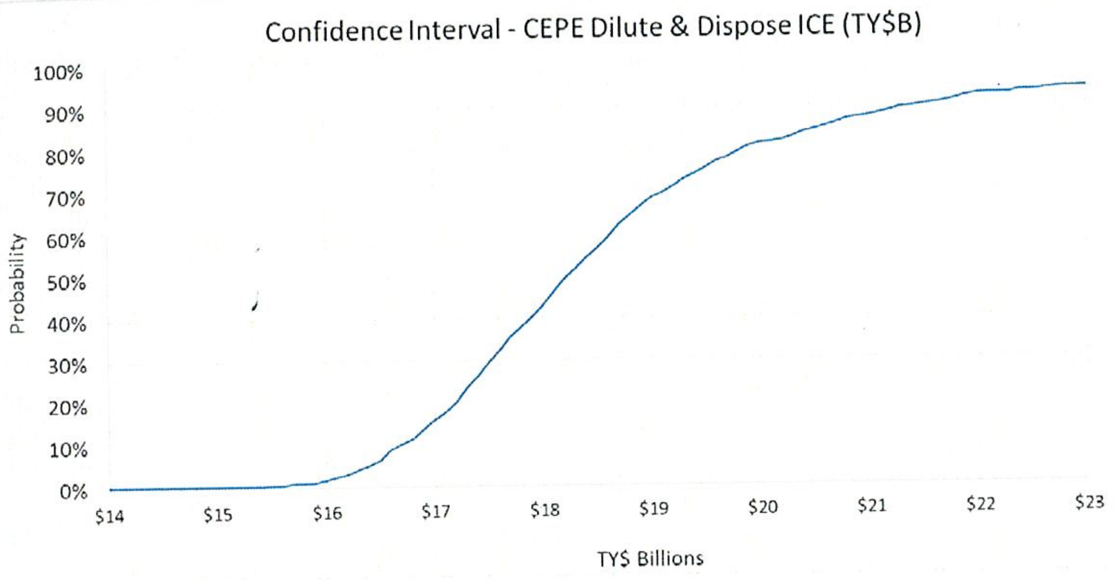


Figure 30 – CEPE ICE Confidence Interval

Table 45 – CEPE Confidence Interval 20%, 50%, 80%

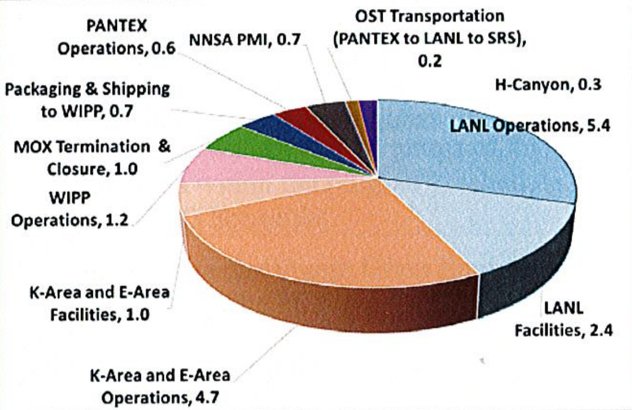
Percentile	Total Cost (TY$B)
20th Percentile	$17.2B
50th Percentile	$18.2B
80th Percentile	$19.9B

4 Conclusion

With sunk costs of $20M, the total D&D ICE cost range is $17.2B to $19.9B, with a most likely cost of $18.2B in Then Year dollars. The D&D ICE summary of the most likely cost is shown in Table 46.

Table 46 – D&D ICE Summary

Scope	D&D ICE (TY$B)
Sunk Costs	0.02
PANTEX Operations	0.6
OST Transportation (PANTEX to LANL to SRS)	0.2
LANL Facilities	2.4
LANL Operations	5.4
H-Canyon Operation	0.3
K-Area and E-Area Facilities	1.0
K-Area and E-Area Operations	4.7
Packaging and Shipping to WIPP	0.7
WIPP Operations	1.2
NNSA Program Management & Integration	0.7
MOX Termination & Closure	1.0
Totals "To-go"	**18.2**



The September 2016 MOX fuel program lifecycle cost estimate is $56.0 billion in Then Year dollars, of which $7.6 billion are sunk costs by FY2017 and $48.4 billion are costs remaining to-go in FY2018 and beyond. The GAO notes, however, in their report "Plutonium Disposition: Proposed Dilute and Dispose Approach Highlights Need for More Work at the Waste Isolation Pilot Plant" (GAO-17-390) that the 2016 MOX fuel program lifecycle estimate does not exhibit the characteristics of an estimate developed in alignment with GAO best practices (and was never intended as such). CEPE found that the 2016 MOX lifecycle estimate omits costs funded outside of the MOX program, such as transportation costs, decontamination and decommissioning of the MOX facility, and operations of the WIPP facility. After including these costs and correcting other issues in the estimate, the remaining cost of the adjusted MOX fuel program lifecycle is $49.4 billion in Then Year dollars.

The remaining D&D lifecycle cost is therefore 35%–40% of the remaining MOX fuel program lifecycle cost.

Appendix A Team Members

The Dilute and Dispose Lifecycle Cost Estimate team included the individuals from the Office of Cost Estimating and Program Evaluation (CEPE) listed in Table 47 below.

Table 47 – D&D ICE Team Members

Team Member	Role
Steve Ho	Director, CEPE
William Banks	Dilute and Dispose ICE Lead
Harlan Swyers	Red Team Review
Tyrone Smith	Operations Research Analyst
Mike Metcalf (Contractor)	Operations Research Analyst
Rob Kepner (Contractor)	General Engineer
Jill Maloney	NNSA Graduate Fellow
Lee Solomon	AAAS Post-Doctoral Fellow

Appendix B Data Sources

Sub-Category	Data Sources	Data Source Raw Name	Dated
LANL Variable Cost	FY17 Program Management Plan	LANL Operations FY17 Actuals	May 2017
LANL Fixed Cost	FY17 Program Management Plan	LANL Operations FY17 Actuals	May 2017
LANL Spares Cost	FY17 Program Management Plan	LANL Operations FY17 Actuals	May 2017
LANL Cost Profile	LANL Operations Basis of Estimates	Various; one per operation	September 2017
Total LANL Facilities Cost	LANL Equipment Scoping and Quantity Development Packages	LANL Equipment List	September 2017
PANTEX Operations	PANTEX Task Analysis Sheets	PANTEX Staffing Profile	May 2017
K-Area Operations	K-AREA Operations Task Analysis Sheets	K Area Operations Staffing Profile	August 2017
E-Area Operations	E-AREA Operations Task Analysis Sheets	E Area Operations Staffing Profile	August 2017, updated March 2018
SRS PMI	SRS Task Analysis Sheets with Manpower Breakout	SRS PMI Staffing Profile	November 2017
K-Area Facilities	SPD AoA K-Area Final Storage Vault Glove Box - Costs Breakout	K-Area Equipment/ Upgrade List	August 2016
E-Area Facilities	SPD AoA E-Area Upgrade High and Low Range Summary	E-Area Equipment List	August 2016
H-Canyon Operations	Non-Pit Oxide Production Costs Actuals (FY12 to FY17)	H-Canyon Actuals	August 2017
H-Canyon Operations	Non-Pit Plutonium Scope and Estimate Update	Draft LCCE Summary Report, Addendum	March 2018
WIPP Operations	FY 2017 WIPP Operations Budget	WIPP Budget	FY 2017
WIPP Operations	WIPP Hazardous Waste Permit on WIPP public website http://www.wipp.energy.gov	WIPP Hazardous Waste Permit	January 2016
WIPP Operations	NEPA Environmental Impact Statements history on NEPA public website, http://www.energy.gov/nepa	NEPA Environmental Impact Statements (EIS) history	October 2017
NNSA PM & Integration	NNSA PMI Task Analysis Sheets with Manpower Breakout	NNSA PMI Staffing Profile	November 2017
MOX Closeout	AREVA MOX Services Termination ROM Close-Out Quote	MOX Closeout AREVA ROM	June 2015
Transportation (PANTEX to LANL to SRS)	FY2017 NNSA OST Operations Budget	OST Budget	FY 2017
Transportation (SRS to WIPP)	Contracts Cost for DOE - EM Shipment	Discussion with Carlsbad Field Office	August 2017
Criticality Control Over-Pack (CCOs)	Vendor Quote	Discussions with NA-23	August 2017

Appendix C LANL Operations Scope Descriptions

LANL Program Management

The work in this WBS element is performed to maintain oversight of the ARIES Oxide Production program at LANL, including scope, schedule, and budget. Program Management (PM) personnel will ensure that all necessary activities and documentation for the program are approved and implemented. This will include directing work, financial tracking, project justification, regular reporting to NA-233, developing and maintaining schedules and budgets, tracking performance, technical reporting and analysis development, and updating the PMP, the Risk Management Plan, and other planning and program documents.

LANL Quality Assurance Support

The work performed under this WBS element provides quality control and quality engineering support in accordance with PA-PLAN-01016, Oxide Production Quality Assurance Project Plan. These activities include support to integrate the quality requirements for institutional and customer implementation and serve as the basis for LANL QA program acceptability. QA staff implement the full scope of requirements as defined in DOE O 414.1D, Quality Assurance, 10 CFR 830, Subpart A, Nuclear Safety Management Quality Assurance Requirements, and quality consensus standard ASME NQA-1. Although product may not be certified in FY17, which would normally be part of this WBS element, QA personnel will provide the following other types of support during the FY: perform oversight activities for oxide production tasks by spending time on the processing floor; develop, maintain a database, and verify implementation of corrective actions; initiate, revise, review, and/or approve quality-related procedures, operational procedures, work instructions, data sheets, travelers, and other documentation; establish and conduct training related to quality aware ness and implementation of quality procedures and practices; participate in and support audits and assessments; complete PFITS actions assigned by the program; and monitor operational travelers, data sheets, and hold points.

LANL Material Shipping and Receiving

The focus of this work includes maintaining capabilities for shipping, receiving, packaging and transportation of material to and from LANL to support the ARIES Oxide Production Program. The team will ensure containers are maintained as required. Additional responsibilities include the storage of the Eurofab lead test MOX fuel rod FS-65 canisters and cooperation on resolving classification questions in this area. This program is also cost-sharing with the Pu Sustainment Program to complete a Title II design for PF-4 shipping and receiving area upgrades to add capability to receive, pack, and unpack MD-2 Type B containers.

LANL Pit Disassembly

The focus of this work includes 1) Engineering associated with pit disassembly, 2) Operations and production, and 3) Fabrication and testing of a second ARIES parting lathe to serve as a fully operational source for spare parts and as a training platform for new disassembly personnel. The main focus will be meeting production milestones, schedules and deliverables defined in the pit disassembly work packages and this PMP. Operators will continue to maintain specific processing, fissile material handler, and glovebox certifications by performing required training and exercising their skills. Operators will participate with the operations responsible supervisor and process engineers to ensure that necessary documentation (Integrated Work Documents, Radiological Work Permits, Process Monitoring Flow Diagrams, Comprehensive Site Plan, Detailed Operating Procedures (DOP), and CSEDs) are updated and equipment maintenance is performed. In addition, the operators will assist in maintaining housekeeping requirements for the rooms and gloveboxes to ensure safety and combustible loading requirements are met.

LANL Operations Management

The focus of this work includes operations management, supporting both operations and engineering across all modules in ARIES operation while supporting the objectives of this PMP. Operations provides wing coordination, RCT support, classification, and software quality assurance (SQA) support, as well as interaction with facilities management and participation in work planning meetings. Operations efforts will focus on updating procedures as required, maintaining and ensuring activities follow established procedures for safety, security and quality, and maintaining up-to-date personnel training requirements. In addition, support for uncleared staff members, upgrading of the current LANMAS system for tracking accountable nuclear material through the iMass project, and revising flowsheets for ARIES operations and updating the ARIES throughput model are part of the FY17 work scope for this WBS element.

LANL Pu Conversion

Pu Conversion will focus in three areas of responsibility: 1) Completing deliberate operations on the DMO-2 furnace; 2) Engineering associated with direct metal oxidation furnaces DMO-2 and DMO-3; 3) Preparing the DMO-3 furnace for readiness; 4) Production operations associated with direct metal oxidation in the DMO-2 furnace; and 5) Engineering and Operations support for the use of muffle furnaces for Pu oxide production, including procedure revisions and completion of the installation of a new control system. Engineering will assist with equipment maintenance, ensure all documentation is updated as needed, and support the installation of the replacement LVCCWS for the DMO-2 furnace. The Operations work will include conducting operations, troubleshooting and ensuring maintenance is completed as required, and supporting the installation of the LVCCWS for the DMO-2 furnace.

LANL Packaging

Packaging will focus in two main areas of responsibility: 1) Engineering support for the production schedule; 2) Operations support for the production schedule; 3) Implementation electronic travelers being developed by Production Control; and 4) Supporting NCS in developing a Level 3 CSED for the ARIES Packaging line that will enable its removal from the ESS. The team will perform all aspects of packaging to meet milestones and schedule, implement equipment and process training to increase team capability and reduce risk, maintain training and certifications, maintain good housekeeping, perform system maintenance including software maintenance, and maintain controlled storage of 3013 containers. The team will also assist with installation of water diversion features on glovebox windows as needed.

LANL Nondestructive Assay

Nondestructive Assay will focus on performing all aspects of NDA to support ARIES operations and production to meet work package deliverables, schedule, and the deliverables identified in this PMP. NDA operations will maintain the NDA system certification for Material Control & Accountability (MC&A), perform system maintenance as required, perform measurements on existing certified packages to demonstrate compliance with ICD requirements, and implement the capability to perform prompt gamma on the ARIES NDA equipment when CSEDs and CSPs are in place. The team will also deliver a report on gamma spectroscopy measurements requested by MOX Services.

LANL Analytical Chemistry

The focus Analytical Chemistry is to maintain chemical analysis capabilities to support oxide certification for the Program, including the chemical analysis of product oxide to demonstrate conformance with the requirements of Section 4.2 of the ICD (ICD-08-025-02, G-ESR-K-00039). This scope requires the following elements:

- Sample eight blend lots produced during the FY and ship samples to SRNL for analysis;
- Ensure that LANL maintains SRNL's listing on the Institutional Evaluated Suppliers List (IESL) for the chemical analysis of oxide produced by LANL, including conducted a surveillance at SRNL F/H labs; and
- Maintain analytical chemistry data (control charts) and evaluate possible ways to qualify processes or reduce the frequency of analytical chemistry from the current requirement of 100% inspection for 44 elements.

LANL Pu Characterization

Pu Characterization will focus on performing all milling, blending, sieving, and plutonium characterization operations required to meet production goals with respect to engineering and operations. The team will maintain training and qualification requirements, assist with equipment maintenance, ensure all documentation is updated, provide operational and engineering support for production, perform MC&A activities, perform waste management, perform material moves, and ensure glovebox and room housekeeping is maintained. The team will also complete testing of the new surface area analyzer installed in FY16.

LANL Process Equipment Engineering Support

Process Equipment Engineering Support is technical and engineering support from AET division for all elements of the Oxide Production Program related to ARIES operating equipment. This effort will involve close integration between AET and MET-1 product and process engineers for each oxide production unit operation. For FY17, work scope will also include 1) completion of software upgrades for the DMO-3 furnace; 2) completion of the installation of the new muffle furnace control system; and 3) design, testing, and installation of new Conveyor-to-glovebox shuttles on the ARIES Conveyor system. Normal Engineering support is required to keep the Conveyor/SCADA system, NDA robot, disassembly lathe, DMO-2, DMO-3, muffle furnace, EDC and packaging systems operational. Engineering will also coordinate engineering tasks, serve on review boards, mentor and support students, and support NCO-4 and NPI-3 on all maintenance activities as needed, and provide overall support for the equipment listed above. Support for the DMO-2, DMO-3 and muffle furnaces includes maintenance and normal operational support.

LANL Production Planning and Control

Production Planning and Control is associated with maintaining an effective production planning and control team, particularly as the Program resumes normal production operations. The team will continue to provide support for the Program and ensure that personnel remain current on all training and other safety/security requirements associated with access to work inPF-4. Other responsibilities include the coordination the Measurement and Test Equipment (M&TE) calibration support for all production processes, continued work on the ARIES Working Database for electronic travelers, and management of classified parts and precious metals. In particular, this will include implementing the ARIES Packaging Module electronic traveler system on the PF-4 Floor in FY17.

LANL Records Management/Document Control/Training

Records Management/Document Control/Training is associated with providing subject matter expertise and application in the functional areas of Document Control, Records Management and Training. This includes controlling and processing of documents for issuance and management of records according to ADPSM, institutional, DOE and other program sponsor guidance to ensure compliant document and records management operations. It may also include technical editing of documents and forms where practical. Assistance with overall training coordination, training reports, assigning training, maintaining records, proctor required training support, and tracking of course credit is included. Classified and unclassified computer support is also included in this work package.

LANL Preventive Equipment Maintenance

The focus of this work is to perform preventive Equipment Maintenance to support the Program's maintenance needs as production resumes in FY17. This comprises performing routine glovebox maintenance, including surveillance, maintenance, and repairs to the following: (1) Support for the glovebox Glove Integrity Program; (2) Maintaining gloveboxes with facility authorized operating parameters; (3) Maintaining glovebox airlock doors; (4) Assisting in decommissioning and removal of inactive equipment efforts (e.g., IWDs, bag-outs); (5) Maintaining instruments and group-specific procedural documents, as applicable; (6) Torque maintenance of glovebox windows and service panels; (7) Maintaining additional equipment necessary for sustaining basic area operations; (8) Developing work orders requiring Integrated Work Packages; and (9) Providing regular room wipe-down activities and room decontamination services as required. For FY17, it also includes ranking systems for maintenance complexity and developing or updating maintenance plans and procedures.

Warehousing/Procurement/Storage

Warehousing/Procurement/Storage is a level of effort work package to support the ARIES Oxide Production Program and the FY17 Pu oxide production schedule. These support functions include TA55 warehouse and controlled storage inventory management, as well as procurement activities. NPI-8 shall comply with P330-12 (Establishing Controlled Storage Areas), P330-13 (Identification and Control of Items in Controlled Storage Areas), P-840-1 (Quality Assurance for Procurements), and all other applicable policies, procedures, and DOE Directives. In addition, storage and procurement activities will comply with PA-PLAN-01016 (ARIES Oxide Production Quality Implementation Plan), which invokes the ICD requirements of NQA-1-1994/95a. This compliance ensures that ML-1 through ML-3 Safety Class/Safety Significant/Quality related items are procured, stored, and managed in a compliant manner that meets programmatic needs.

LANL Radioactive Waste Management

Radioactive Waste Management covers the costs for disposal of waste generated by the production of oxide and related Program activities, including transuranic (TRU), Mixed, and Low-level Waste. The Program is responsible for the costs for storage and disposal of waste created from oxide production operations. Due to recent changes in LANL TRU waste management operations, including the split of newly-generated TRU waste operations funded by NNSA from legacy TRU waste operations managed by DOE-EM, per drum costs for this WBS element are to be determined.

LANL TA-55 Infrastructure

The work performed under TA-55 Infrastructure is associated with the infrastructure costs of performing oxide production at TA-55. The TA-55 business model provides the validated and formal methodology to support annual, recurring facility operating and infrastructure costs at TA-55. The facility costs are incorporated in one WBS element for facility tenants in order to manage scope and costs at a single location and distribute costs equitably to participating programs based on the square footage of PF-4 utilized by the programs. The work packages are developed utilizing the Readiness in Technical Base and Facilities (RTBF) National WBS categories (Facility Management and Support and ESH&Q) but are centralized for the full funding of the facility operations in the RTBF database and follow the RTBF change control processes. The funding model is based on the footprint utilized by programs working in PF-4. The space attributed to each program is reviewed and modified based on programmatic needs before validation and approval by the various programmatic organizations as part of the change control process. ARIES continues to occupy 7.5% of the facility space.

LANL Criticality Safety Support

This work supports non-readiness criticality safety tasks and perform the function of the Criticality safety Officer for the ARIES Oxide Production Program. Follow all internal LANL procedures to develop and implement criticality safety analyses, documentation, postings, procedure reviews, and other support for the program, including interfacing with LANL Operational Responsible Supervisors and PNNL Criticality Safety Analysts (CSAs) working under a separate contract with NA-23.

Appendix D K-Area Upgrades Planning Document

Contractor Proprietary

Vendor - GLOVEBOX Fabrication

Total Estimate Cost (TEC)	Hours	Dollars	Construction Equipment	Material	Engineered Equipment	Sub Contractor	Totals
Vendor Fab Three (3) Shielded Glove Boxes							$ 15,000,000
Change Orders							$ 500,000
Vendor Trips							$ 250,000
Expeditor	350	$ 43,750					$ 43,750
QA Support	350	$ 43,750					$ 43,750
Total Vendor - Glove Box Fabrication							$ 15,837,500

K- Area Construction Scope

Total Estimated Cost	Hours	Dollars	Construction Equipment	Material	Engineered Equipment	Sub Contractor	Totals
Install / Remove Temporary Security Mods	5,000	$ 300,000		$ 95			$ 300,095
D&R Contaminated Piping, Equipment, Platform, etc. Inside Gas Vent Rooms		$ -					$ -
Remove Hangers, Miscellaneous Steel, Lead & Install Lifting Eyes (15 ea.)		$ -					$ -
Glove Bags, HEPA Filter w/ Housing, Copus Blower, Plastic Suits & BA EO		$ -					$ -
Cut Concrete (4 locations), Remove Shield Walls, Sliding Doors & Exhaust Grills		$ -					$ -
Cut Concrete (3 locations), for Doors between Glove Box Rooms		$ -					$ -
Form and Pour Concrete for Door Opening and Exhaust Vent Opening		$ -					$ -
Remove Concrete Pads & Curbing, Fill Floor Openings & Repair Expansion Joint	1,250	$ 75,000	$ 3,000.00	$ 7,000			$ 85,000
D&R Miscellaneous Electrical Commodities in Rooms		$ -					$ -
D&R Pump Room, Control Room, Electrical Shop, Make-up Room & Transformer Room		$ -					$ -
D&R Distillation Tower & Install New Stairwell to Purification Roof		$ -					$ -
Install Supports on -14 (3 supports)		$ -					$ -
Install Airlocks and Fire Doors to Three (3) Glove Box Rooms	2,500	$ 150,000		$ 75,000			$ 225,000
Install Emergency Egress Doors for Three (3) Glove Box Rooms	2,100	$ 126,000		$ 50,000			$ 176,000
Install Emergency Egress Door for HEPA Room	-						$ -
Install Fire Doors at Gas Bottle Room, Staging and HEPA Room (4 total)	2,500	$ 150,000		$ 25,000			$ 175,000
Install 3-hour Fire Rated Sheetrock Walls for FM200, HEPA, Staging & GB 3 Rooms	8,000	$ 480,000		$ 250,000			$ 730,000
Electrical Installation - Lights, PA, Receptacles, etc.	4,000	$ 240,000		$ 100,000			$ 340,000
Scaffold Support - Temp Stairwell to Purification Roof	-						$ -
Install HVAC System, Duct Work and Associated Dampers	16,000	$ 960,000		$ 115,000	$ 90,000.00		$ 1,165,000
Install Active SC HEPA System - Pre-Filters, HEPA Filters, Fans and Stack	31,500	$ 1,890,000		$ 750,000	$ 2,550,000.00		$ 5,190,000
Install Breathing Air Compressor & Manifolds	7,000	$ 420,000		$ 150,000	$ 175,000.00	1,000	$ 746,000
Install SC Fire Suppression System	10,200	$ 612,000		$ 84,000	$ 1,100,000.00		$ 1,796,000
Install SC Diesel Generator - Two (2) Units	5,600	$ 336,000		$ 200,000	$ 200,000.00	1,000	$ 737,000
Install of Nuclear Incident Monitor System (NIMS)	8,400	$ 504,000		$ 450,000	$ 750,000.00		$ 1,704,000
Install Stack Monitoring Instrumentation	700	$ 42,000		$ 15,000	$ 25,000.00		$ 82,000
Install 2 AGOS, PCM-1Bs	640	$ 38,400		$ 5,000	$ 200,000.00		$ 243,400
Install Fire Detection System & Life Safety Modifications	2,500	$ 150,000		$ 9,000			$ 159,000
Install SC Nitrogen System - Bulk Storage Tanks, Tubing & Purification Units	6,500	$ 390,000		$ 62,500	$ 175,000.00		$ 627,500
Install Various Glove Box & Room Monitoring Instrumentation	2,600	$ 156,000		$ 34,000	$ 100,000.00		$ 290,000
Install Continuous Air Monitors (CAMS)	800	$ 48,000		$ 6,000	$ 75,000.00		$ 129,000
Install Three (3) Glove Boxes	9,400	$ 564,000		$ 30,000	$ 272,000.00		$ 866,000
Install Glove Boxes Electrical Components	3,000	$ 180,000		$ 75,000	$ 350,000.00		$ 605,000
Fab and Install Ventilation to Glove Boxes Hood	4,300	$ 258,000		$ 7,000	$ 60,000.00		$ 325,000
Glove Box & Hood Certification Testing	1,600	$ 96,000		$ 20,000			$ 116,000
Install VTR for CCO Staging Prior to Shipment	4,000	$ 240,000	$ 5,000.00	$ 45,000	$ 700,000.00		$ 990,000
Special Nuclear Material Vehicles (2)	-						$ -
Install IAEA Monitoring System	3,000	$ 180,000		$ 20,000			$ 200,000
Install Five MC&A Rooms w/ 3-Hours Sheetrock Walls & Fire Doors	6,000	$ 360,000		$ 125,000			$ 485,000
Install 3-hour Fire Rated Sheetrock Walls for MC&A FM200 System	2,100	$ 126,000		$ 75,000			$ 201,000
Install MC&A Assaying Equipment (1 Gamma Isotopic, 2 SWAS & 5 Calorimeters)	3,500	$ 210,000		$ 125,000	$ 500,000.00		$ 835,000
Install Security Cameras to Monitor all Doors (In and Out) Twenty (20) Doors	4,500	$ 270,000		$ 115,000			$ 385,000
Prep and Paint Floors, Walls and Ceilings	8,000	$ 480,000		$ 50,000		1,000	$ 531,000
Install and Entry Control Facility	5,000	$ 300,000		$ 300,000	$ 800,000.00		$ 1,400,000
Install Fighting Positions	5,000	$ 300,000		$ 75,000			$ 375,000
Relocate Assembly Area Computer Room, Sandboxes and Install Mantrap West Side	9,000	$ 540,000		$ 350,000	$ 200,000.00		$ 1,090,000
Install Concrete Pad and Cover for Exterior VTR for CCO Staging	8,000	$ 480,000		$ 150,000	$ 100,000.00		$ 730,000
Prep & Paint FSV Floors for New Array	2,000	$ 120,000		$ 3,000			$ 123,000
Remove and Relocate MC&A Cameras in FSV	2,400	$ 144,000		$ 3,000			$ 147,000
Cut Access Into and Remove Curtain in 910B Water Seal	4,000	$ 240,000		$ 30,000			$ 270,000
D&R Ductwork in 910B Staging Area	3,500	$ 210,000		$ 35,000			$ 245,000
Form and Pour Concrete for Water Seal Ductwork Opening	4,500	$ 270,000		$ 150,000		2000	$ 422,000
Prep and Paint Floors, Walls and Ceilings in Water Seal	3,000	$ 180,000		$ 7,000			$ 187,000
Subtotal Construction	213,590	12,815,400	8,000	4,177,595	8,422,000	5,000	$ 25,427,995

Contractor Proprietary

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Total Estimated Cost (TEC) (cont)	Hours	Dollars	Construction Equipment	Material	Engineered Equipment	Sub Contractor	Totals
Overtime	25,802	$ 1,548,120					$ 1,548,120
Construction Equip (PECMC)		$ -	$ 387,025.00				$ 387,025
Craft Support	44,427	$ 2,665,620					$ 2,665,620
QC Field Inspections	12,901	$ 1,612,625					$ 1,612,625
NonManual Construction Management	79,469	$ 9,933,625					$ 9,933,625
HRP Escorts (5 FTE for 4 years)	40,000	$ 2,400,000					$ 2,400,000
Scaffold Support	10,000	$ 600,000		50,000			$ 650,000
Subtotal Construction Support	**212,599**	**18,759,990**	**387,025**	**50,000**			**$ 19,197,015**
Total Construction	426,189	31,575,390	395,025	4,227,595	8,422,000	5,000	$ 44,625,010
Design Engineering - Title II	81370	$ 10,171,250					$ 10,171,198
Design Engineering - GB Specification	1500	$ 187,500					$ 187,500
Design Engineering - Bids, Award, Submittal Reviews	10500	$ 1,312,500					$ 1,312,500
Design Engineering - Title III	20342	$ 2,542,750					$ 2,542,800
Design Engineering - Structural Analysis	1000	$ 125,000					$ 125,000
Total Design Engineering	114712	$ 14,339,000					$ 14,338,998
Process Control & Automated Technology (PC&AT)	32454	$ 5,192,643					$ 5,192,643
Project Management - 2 FTEs @ 5 years	17500	$ 2,187,500					$ 2,187,500
Project Controls - 6 FTEs @ 5 years	52500	$ 6,562,500					$ 6,562,500
Project QA	10818	$ 1,352,251					$ 1,352,251
Procurement	10818	$ 1,135,891					$ 1,135,891
Site Estimating	750	$ 78,750					$ 78,750
System Engineering	5409	$ 676,125					$ 676,125
Design Safety Analysis	5409	$ 676,125					$ 676,125
Commissioning and Test Services	5409	$ 676,125					$ 676,125
VA Team	2000	$ 250,000					$ 250,000
Nuclear & Criticality Safety Engineering	15000	$ 1,875,000					$ 1,875,000
Total Project Support	158067	$ 20,662,910					$ 20,662,910
Subtotal Costs Direct	**703367.4**	**$ 67,367,761**	**395025**	**4257595**	**$ 8,422,000.00**	**15755000**	**$ 96,197,381**
Escalation							$ 2,885,921
Miscellaneous Equipment Adjustment							$ 2,614,921
LSS							$ 10,447,899
ESS							$ 21,241,689
G&A							$ 9,052,937
Site Legacy (Pension)							$ 54,988,122
FEE							$ 13,310,404
Sub Total Burdens							$ 114,541,897
Total Direct & Burdens							$ 210,739,278
Management Reserve							$ 105,369,639
Technical & Programmatic Risk Analysis (T&PRA)							$ 14,751,749
Schedule							$ 6,322,178
Total Contingencies							$ 126,443,567
TEC TOTAL							$ 337,182,845

Other Project Costs (OPC)	Hours	Dollars	Construction Equipment	Material	Engineered Equipment	Sub Contractor	Totals
Project Support (PM) - 2 FTEs @ 4 years	14000	$ 2,240,000					$ 2,240,000
Project Controls - 3 FTEs @ 4 years	21000	$ 2,625,000					$ 2,625,000
DE Testing & OPS Support after Turnover	9000	$ 1,125,000					$ 1,125,000
Conceptual Design	24000	$ 3,000,000					$ 3,000,000
Procurement	1500	$ 157,500					$ 157,500
Site Estimating	1000	$ 105,000					$ 105,000
Commissioning and Test Services	12689	$ 1,586,119					$ 1,586,119
Fire / HEPA System Testing	15227	$ 1,903,342					$ 1,903,342
Critical Spare Parts				1000000			$ 1,000,000
Training Development	1500	$ 187,500					$ 187,500
Total OPC	99916	$ 12,929,461					$ 13,929,461
Subtotal Cost Direct	99916	$ 12,929,461					$ 13,929,461
Escalation							$ 417,884
LSS							$ 1,473,965
ESS							$ 2,996,727
G&A							$ 1,277,167
Site Legacy (Pension)							$ 7,757,594
FEE							$ 1,877,800
Sub Total Burdens							$ 15,801,137
Total Direct & Burdens							$ 29,730,598
Management Reserve							$ 16,054,523
Technical & Programmatic Risk Analysis (T&PRA)							$ 891,918
Schedule							$ 891,918
Total Contingencies							$ 17,838,359
OPC Total							$ 47,568,957
Contract Price							$ 384,751,802

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Project Support OPEX	Hours	Dollars	Construction Equipment	Material	Engineered Equipment	Sub Contractor	Totals
Pre-Conceptual CD0/ Alternative Study							
Engineering - Facility Support - 5 FTEs @ 9 years	88200	$ 11,025,000					$ 11,025,000
Ops - Project Support - 2 FTEs @ 7 years	27440	$ 3,430,000					$ 3,430,000
Rad Con - Project Support - 1 FTEs @ 8 years	15680	$ 1,176,000					$ 1,176,000
Operations Support - 4 FTEs @ 7 years	54880	$ 4,116,000					$ 4,116,000
Training - 4 FTEs @ 4 years	31360	$ 3,920,000					$ 3,920,000
Safeguards & Security (S&S) - 1 FTEs @ 8 years	15680	$ 2,508,800					$ 2,508,800
Material Control and Accountability (MC&A) - 0.5 FTEs @ 9 years	8820	$ 926,100					$ 926,100
Procedures - 6 FTEs @ 5 years	58800	$ 7,350,000					$ 7,350,000
Maintenance - 0.25 FTEs @ 8 years	3920	$ 294,000					$ 294,000
Safety & Industrial Hygiene (IH) - 1 FTEs @ 5 years	9800	$ 1,029,000					$ 1,029,000
Quality Assurance / Quality Control (QA/QC) - 0.5 FTEs @ 8 years	7840	$ 980,000					$ 980,000
Readiness Assessment (RA)/ORR & CORR - 25 FTEs @ for 5 weeks x 3	14135	$ 1,766,827					$ 1,766,827
Program Management - 0.5 FTEs @ 9 years	8820	$ 1,411,200					$ 1,411,200
Nuclear Criticality & Safety Engineering (NC&SE) - 0.5 FTEs @ 9 years	8820	$ 1,102,500					$ 1,102,500
Total OPEX	354195	$ 41,035,427					$ 41,035,427
Subtotal Cost Direct	354195	$ 41,035,427					$ 41,035,427
Escalation							$ 1,231,063
LSS							$ 4,342,218
ESS							$ 8,828,194
G&A							$ 3,762,463
Site Legacy (Pension)							$ 22,853,445
FEE							$ 5,531,896
Sub Total Burdens							$ 46,549,280
Total Direct & Burdens							$ 87,584,707
Management Reserve							$ 19,268,636
Technical & Programmatic Risk Analysis (T&PRA)							
Schedule							$ 2,627,541
Total Contingencies							$ 21,896,177
							$ 109,480,884
							$ 494,232,686
Deactivation and Decommissioning							$ 7,500,000
Escalation							$ 10,174,241
LSS							$ 1,815,751
ESS							$ 3,691,615
G&A							$ 1,573,319
Site Legacy (Pension)							$ 9,556,443
FEE							$ 2,313,229
Sub Total Burdens							$ 29,124,599
Total Direct & Burdens							$ 36,624,599
Management Reserve							$ 15,382,332
Technical & Programmatic Risk Analysis (T&PRA)							$ -
Schedule							$ 1,098,738
Total Contingencies							$ 16,481,070
							$ 53,105,669
Total Project Cost (TPC) Inculding OPEX and D&D							$ 547,338,354
Total Project Cost (TPC) Inculding D&D							$ 437,857,471

Contractor Proprietary

Appendix E WIPP Panel Excavation Excursion

As part of its sensitivity analysis, CEPE reviewed the cost of excavation of additional panels at WIPP as an excursion to its D&D ICE and collected open source and site-generated cost information to support this analysis.

The following facts are relevant:

- Although D&D generated waste material will be a significant driver for storage needs, it is not the sole driver of future storage requirements at WIPP.
- Two capital asset projects, a new utility shaft and safety significant ventilation are approaching Critical Decision-2/3. These projects will provide the necessary access and underground conditions to allow continued mining expansion of the repository footprint.
- Mining activities are part of the base operations budget at WIPP and are incorporated in the annual budgets, thus the cost for mining is included already within CEPE's WIPP allocation estimate for D&D.
- The physical volume associated with stored waste is different than the physical volume of the WIPP mine, and if changes are made to the Hazardous Waste Permit as planned, the accountable volume tracked for compliance with the WIPP Land Withdrawal Act (LWA) will also be different.

In addition, the following published facts serve as benchmarks in analysis:

- Previously published data from mining operations in support of underground lab construction shows that drum miners can excavate up to 875 standard tons/shift[1] which clears a space of 4m x 8m x 15m = 480 m^3. More recent published numbers state that 10 tons/minute is achievable.[2]
- Total salt weight for a panel is >112,000 tons per panel.[3]
- Rooms generally hold about 10,395 55-gallon drum equivalents which equals 2,164 m^3 (based on 264 gal / m^3).

The expected volume of waste from D&D operations is 23,611 m^3 which will make use of the 8,035 m^3 already set aside for MOX; therefore slightly more than 7 rooms will be needed for the additional physical volume ([23,611 m^3 – 8,035 m^3]/ 2,164 m^3 per room = 7.2 rooms).

An analysis of the Hazardous Waste Permit for WIPP give the following general characteristics for a panel:

- It is comprised of 7 rooms and two drifts which supply access
- Each room is approximately 4m x 10m x 91m = 3,640 m^3
- Each drift is approximately 4m x 10m x 256m = 10,240 m^3
- The total volume for a panel is 45,960 m^3

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[1] Previously available at http://www.wipp.energy.gov/science/UG_Lab/PrecisionNew.html

[2] Available at https://miningconnection.com/longwall/news/article/miners_begin_drilling_rock_salt_at_waste_isolation

[3] https://www.energy.gov/em/articles/salt-mining-resume-wipp

The salt density derived from the published facts yields 1.8 standard tons per cubic meter (based on 875 tons / 480 m^3). This would yield a weight of 83,781 tons per panel. This is lower than the published number of >112,000 tons.

Assuming the salt density number is accurate, and using 112,000 tons as an accurate weight measurement, then the excavated volume for the panel is estimated at 61,440 m^3.

New panels starting with Panel 11 will require main access ways to be mined to access a new area of the WIPP. The Carlsbad Field Office (CBFO) provided the following ROM data for Panel 11 construction, including these 3 new main access ways:

- $7,765 per shift for mining (FY2018 dollars, unburdened)
- $285 per foot for bolting (FY2018 dollars, unburdened)
- Mining 3 main access ways requires 541 shifts
- Mining panel 11 requires 403 shifts
- Bolting length in the mains is 6,213.5 feet
- Bolting for cross cuts 2,904 feet
- Bolting for Panel 11 is 4,160 feet

This implies a cost of $4M for Panel 11 mining and bolting and $6M for mining and bolting of three main access ways (without labor cost burdening), for a total of $10M in FY2017. Applying a burdening to labor (based on SRS labor rates) and adding a 30% program management factor (based on CBFO SME input), this totals $18M in FY2017 dollars for Panel 11 and three access ways.

The CBFO also provided a more detailed estimate based on experience from Panels 3 through 7 excavation costs; this shows the total cost for a complete panel is $7M unburdened in FY2017 dollars. Using the same adjustment methodology as shown above yields a cost of $13M per panel and $17M for three access ways in burdened FY2017 dollars. The excavation cost range is therefore $18M for one panel and mains (based on the Panel 11 estimate) to $43M for two panels and three mains (based on Panels 3 to 7).

The CBFO estimates panel construction to take 2-3 years. The timing of panel construction affects escalation cost. Applying an escalation factor of 2% (as used for other WIPP activities), the low estimate becomes $20M in Then Year dollars for one panel and mains excavated from FY2023-2025. The high range is $65M in Then Year dollars for two panels and mains excavated from FY2035-2041. In either scenario these costs already included in the WIPP base budget and therefore are allocated to D&D in the WIPP estimate provided in Section 3.5.2.

Acronyms

ARIES	Advanced Recovery and Integrated Extraction System
AoA	Analysis of Alternatives
CBFO	Carlsbad Field Office
CCO	Criticality Control Overpack
CD	Critical Decision
CEPE	Cost Estimating and Program Evaluation
D&D	Dilute and Dispose
DMO	Direct Metal Oxidation
DOE-EM	DOE Office of Environmental Management
EPA	Environmental Protection Agency
ETC	Estimate To Complete
FPRA	Forward Rate Pricing Agreement
FTE	Full Time Equivalent
FY	Fiscal Year
GAO	Government Accountability Office
ICE	Independent Cost Estimate
Kg	Kilogram(s)
KIS	K-Area Interim Surveillance
LANL	Los Alamos National Laboratory
LCCE	Life Cycle Cost Estimate
LWA	Land Withdrawal Act
MFFF	Mixed Oxide (MOX) Fuel Fabrication Facility
MOX	Mixed Oxide
MT	Metric Ton
NA-23	NNSA Office of Material Management and Minimization
NAS	National Academy of Sciences
NDA	Nondestructive Assay
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act

NMED	New Mexico Environment Department
NNSA	National Nuclear Security Administration
NOA	Notice of Availability
NOI	Notice of Intent
NRE	Non-Recurring Equipment
OPC	Other Project Costs
OST	Office of Secure Transportation
PANTEX	Panhandle of Texas Site
PARS II	Project Assessment and Reporting System II
PMDA	Plutonium Management and Disposition Agreement
PMI	Program Management and Integration
PMP	Program Management Plan
Pu	Plutonium
RIPS	Robotic Integrated Packaging System
ROD	Record of Decision
ROM	Rough Order of Magnitude
SME	Subject Matter Expert
SPD	Surplus Plutonium Disposition
SRS	Savannah River Site
SSE	Sum of Squared Error
STARS	Standard Accounting and Reporting System
TEC	Total Estimated Costs
TPC	Total Project Costs
TRU	Transuranic
TRUPACT II	Transuranic Packaging Transporter Model II
TY	Then Year
U	Uranium
US	United States
WBS	Work Breakdown Structure
WIPP	Waste Isolation Pilot Plant