Pit Production Options

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Congressional Research Service
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Outline

- Background
- Options
- Findings

History

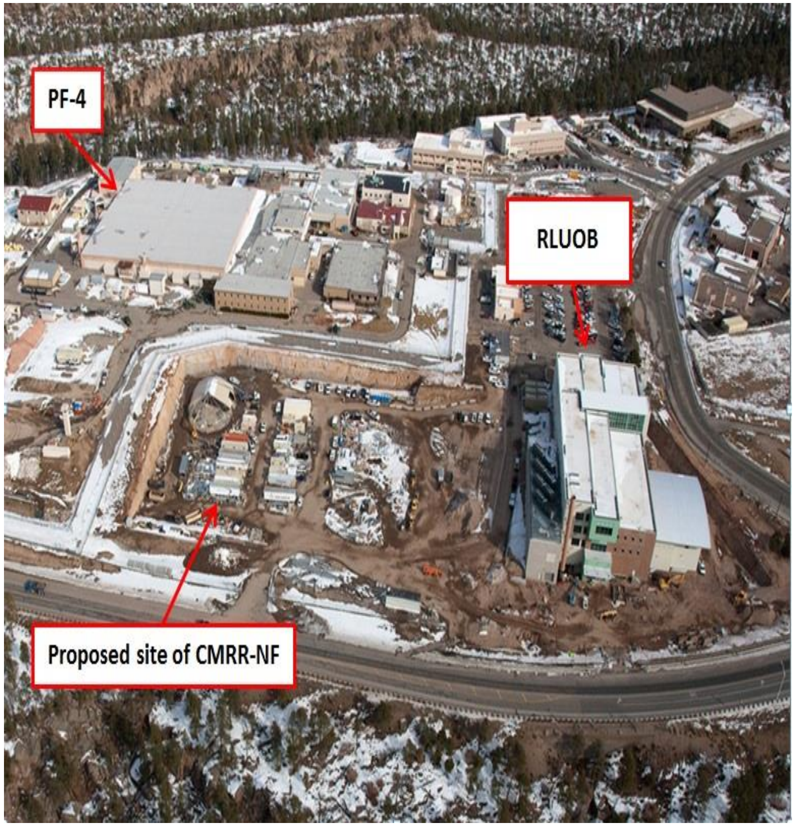
- U.S. has not produced >11 pits/year (ppy) for stockpile since Rocky Flats Plant closed (1989)
- U.S. has built no new Pu buildings for weapons work since 1978 (PF-4)
- Several Pu buildings have been proposed, planned, designed, or built, then canceled, deferred, ignored, or torn down
  - Nuclear Materials Storage Facility, Bldg. 371

Production Capacity

- Current capacity: ~10 pits per year (ppy)
- NWCouncil: 50-80 ppy by 2030
- UCS: 50 ppy max, possibly 10-20 ppy
- LASG: May need no new pits but some capability
- Congress: Assess requirements from 10 to 80+
- Depends on pit life, pit reuse, military requirements, stockpile size, etc.
- Briefing assumes requirement of 80 ppy by 2030
  – Focus: how to achieve 80, not need for 80

Existing Pu Buildings

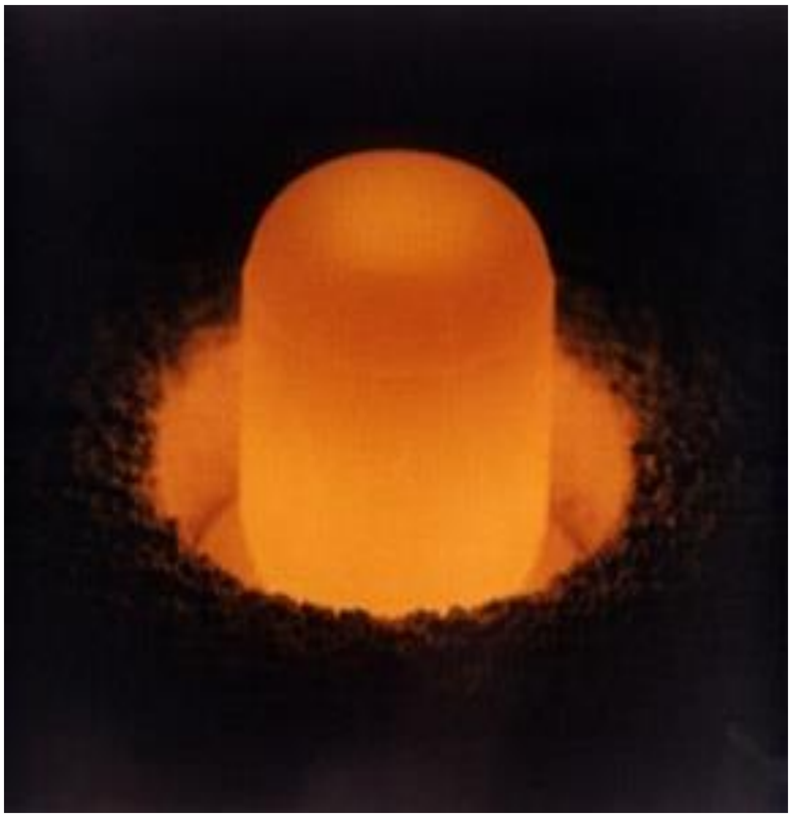
At Los Alamos National Laboratory



Chemistry and Metallurgy Research facility

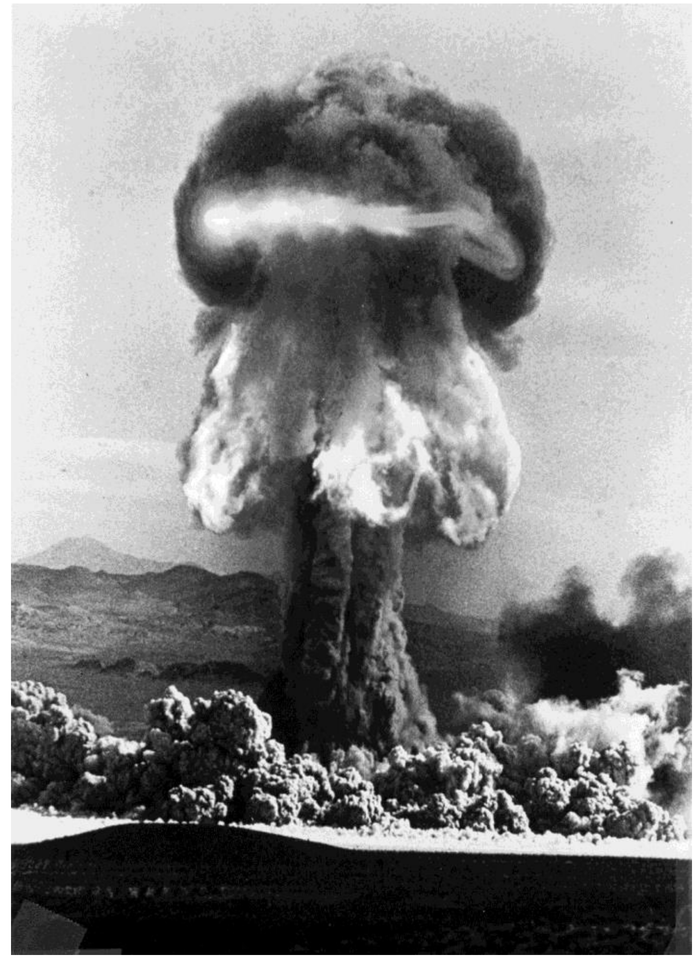
Source: Los Alamos National Laboratory

Pu-238 and Pu-239



Not for pits; high radioactivity

Source for both graphics: DOE



For pits; much lower radioactivity (before detonation)

Regulatory Terms: The Key to Understanding Options

- Dose
  - Units: rem
    - 1-25 rem: no detectable clinical effects*
    - 25-100 rem: serious effects improbable*
- Material At Risk (MAR)
  - Units: grams Pu-239 equivalent
- Hazard Category, Radiological Facility
- Documented Safety Analysis: limits MAR
- Security Category

*Dade Moeller, *Environmental Health,* revised edition, Cambridge, Harvard University Press, 1997, p. 250.

Some Options

- Pit production & supporting work only in PF-4
  - Would have to move out many other tasks to release space and MAR
  - Where would they go? Conseqs for ctr of excellence?
- Build CMRR-NF
  - Deferred; cost, schedule would increase
- New PF-4 + CMRR-NF combo
  - High cost, not designed, long time to design & build
  - Exits PF-4 before end of useful life
- Refurbish CMR
  - Decrepit; 1/36 chance of collapse in 10 yrs in quake

A Structured Approach to Options

	Hazard Category (HC)	
Security Category (SC)	**High (HC-2)**	**Low (HC-3)**
High (SC-I/II)	**Task:** Pit destruction (ARIES) and casting **Buildings:** PF-4 or module (new)	**null set** (no Pu tasks require this combination of attributes)
Low (SC-III/IV)	**Task:** Pu-238 work **Buildings:** HB Line, H Canyon, PTPF (new) at SRS; Building CPP-1634 (expanded) at INL; module at LANL (new)	**Task:** AC **Buildings:** RLUOB with 1 kg WGPu, Building 332 at LLNL*

Source: CRS

*Building 332 is SC-III/HC-2. It is included in this box because the AC tasks discussed here are only HC-3.

Key Point:

Moving MAR & AC out of PF-4

& Keeping Added AC out

May Enable PF-4 to Produce 80 ppy

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Task: Pit Casting & Destruction

- Need high MAR and high security
- PF-4
  - Has needed combination
  - Must reduce other MAR for 80 ppy to stay within DSA limit
  - Must free up space
- Modules: another possibility

Task: Pit Work Outside PF-4

- Modules
  - Description
    - 3,000-5,000 sq ft reinforced-concrete structures
      - Vs. 60,000 sf for PF-4, 19,500 sf for RLUOB
    - Buried near PF-4 and RLUOB
    - Connected to them by tunnel
    - Would use PF-4 infrastructure
    - Each for a single purpose
    - In preliminary planning stage only

Module Pros

- Pros
  - "Big box" approach has proven unsustainable
    - Too ambitious AND too cautious, and too expensive
  - Could build "small boxes" faster, cheaper, as needed
  - Each module would draw on lessons learned from previous modules, saving time and cost
  - Would permit a steady level of funding
  - With each module single-purpose, could match requirements for HC, SC, etc. to the purpose
  - Avoid replacing PF-4

Module Cons

- Are they needed?
  - Could other options do the needed tasks?
    - E.g., moving Pu-238 and Analytic Chem (AC) out of PF-4
- Are they needed now?
- Would they be expensive?
  - Would it be faster and less costly to upgrade PF-4 and move Pu-238 and AC to existing buildings?
- Can Congress have confidence in forthcoming cost and schedule projections?

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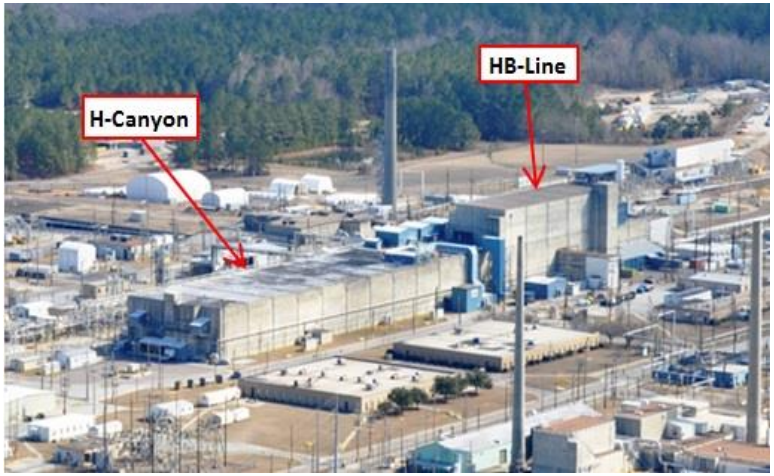
Task: Pu-238 Work Outside PF-4

- Used for RTGs, not pits; low security
- 275x as radioactive as Pu-239; 40% of PF-4 MAR
- Now done in PF-4
  - Moving it out would save space, reduce MAR
- Options: INL , SRS, Module
- Considered earlier; weapon program involvement might change calculus

Source: Idaho National Laboratory



Source: Savannah River Site

A Structured Approach to Options

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Task: Analytic Chemistry (AC)

- Examines composition of Pu in pits
  - Check quantities of trace elements and alloys
  - Check isotopic composition of Pu
  - AC used for all Pu programs, not just pits
- Done at all stages of manufacturing
- Typically uses tiny samples (mg) of Pu
- Low security and low MAR
- But space-intensive
  - Increases (not linearly) with ppy

Building 332 at LLNL

Source: Lawrence Livermore National Laboratory

AC Option: Building 332

- Has ample space suitable for AC
- Could probably do AC for 80 ppy
  - Samples would be sent from LANL
  - AC not time-critical
  - But need steady flow of samples to stay within SC limits
- But would sample flow be steady?
- LLNL would add Pu analytic chemists; it has 4
- Having LLNL do all AC would increase expertise at LLNL at expense of LANL; is that a + or - ?

Radiological Laboratory-Utility-Office Building (RLUOB) at LANL

Source: Los Alamos National Laboratory

AC Option: RLUOB As Is

- RLUOB is well configured for AC
- Ample floor space, excellent ventilation sys

- But it is a Radiological Facility
  - Can hold 26 grams of weapons-grade Pu

Source: Los Alamos National Laboratory

Volume of 26g Weapons-Grade Pu

Not nearly enough to do AC for 80 ppy

Source: CRS

AC Option: RLUOB as HC-3

- RLUOB with 1,000 g WGPu could almost certainly do AC for 80 ppy
- To comply with regs, would convert to HC-3
- This is effectively impossible
  – Many compliance tasks (~100) … see next slides
  – Many are "paperwork"
  – But many "paper" tasks lead to physical tasks

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Approved for public release; distribution is unlimited.

Title: Preliminary Outline of Potential Tasks Required for RLUOB to Exceed Hazard Category-3 Nuclear Facility Threshold Quantity

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Intended for: Preliminary Planning and Discussions with NNSA and other Customers

September 2013

Preliminary Outline of Potential Tasks Required for RLUOB to Exceed Hazard Category-3 Nuclear Facility Threshold Quantity

I. Purpose

This document is to provide a high level outline of the activities required to upgrade Radiological Laboratory Utility/Office Building (RLUOB) to a hazard category-3 (HC-3) nuclear facility (>38.6 grams up to 2,600 grams of ^{239}Pu equivalent).

II. Scope

The outline of tasks listed below is drawn from Codes of Federal Regulations (CFR), Department of Energy (DOE) Orders (DOE O), Standards (DOE STD) and Guides (DOE G), and Los Alamos National Laboratory (LANL) internal procedures. It is aligned to functional organizations to facilitate review by line organizations and eventual scheduling.

III. Potential Tasks

<u>Hazards Analysis</u>

- Define source term in sufficient detail to support the hazards analysis.
- Perform hazard categorization per DOE-STD-1027, *Hazard Categorization and Accident Analysis*, and LANL safety basis procedure (SBP) 114-2, *Hazard Evaluation and Accident Analysis*.
    - Perform initial hazards screening
    - Develop hazards analysis to finalize the hazard categorization.

<u>External Stakeholders</u>

- National Nuclear Security Administration (NNSA) and Department of Defense (DoD)– program customers
- NNSA/Los Alamos Field Office (LAFO)
- NNSA/Chief of Defense Nuclear Safety (CDNS)
- Defense Nuclear Facilities Safety Board (DNFSB)
- Interested Parties (public)

<u>National Environment Policy Act (NEPA)</u>

- Develop an environmental assessment per 40CFR1508.9, *Environmental assessment.*
- Develop an environmental impact statement if required by 40CFR1501.4 (*Whether to prepare an environmental impact statement*) in accordance with 40CFR1502 (*Environmental Impact Statement*) and DOE O 450 (*Environmental Protection Program*) and O 451.1B (*National Environmental Policy Act Compliance Program*)
- Review and update the Air Emission and Rad-NESHAP [1] Permit

<u>Safety Analysis</u>

- Develop safety design strategy per SBP 114-1, *Safety Basis Development for Projects*
- Develop conceptual safety design report per SBP 114-1
- Develop preliminary safety design report per SBP 114-1

[1] EPA National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad-NESHAP)

- Develop documented safety analysis (DSA) and technical safety requirements (TSR)[2] per DOE- STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis* and per SBP 114-1

  Note: These documents are not different documents, but evolutionary stages in the documentation of the safety basis.

Engineering

- Develop system adequacy analysis per Engineering Administrative Procedure (AP)-341-515
- Develop safety design report per DOE-STD-1189, *Integration of Safety into the Design Process.*
- Develop preliminary safety design report per DOE STD 1189.
- Identify vital safety systems per AP-341-101
- Determine critical characteristics for design of safety related items per AP-341-607
- Perform commercial grade dedication per AP-341-703
- Develop functions and requirements documents per AP-341-601
- Develop requirements and criteria document per AP-341-602
- Identify and procure critical spare parts per AP-341-521
- Develop instrument set point calculations per AP-341-613
- Develop software change packages per AP-341-507
- Develop management level determinations per AP-341-502
- Update master equipment list per AP-341-404
- Maintain technical baseline per AP-341-616
- Develop system procurement specifications per AP-341-609 and 610 as required
- Develop design and analysis for seismic upgrades as required. RLUOB safety Structure, System and Components (SSCs) are not currently required to be operational following a seismic event per LAFO direction.
- Develop design and analysis for fire protection upgrades as required
- Develop design, analysis and procurement documentation for building out new laboratory modules (i.e. gloveboxes and hoods) as required
- Review and approve detailed system and equipment design
- Develop test procedures to re-commission existing systems and commission new systems Per Engineering Standard Manual (ESM) chapter 15
- Implement International Building Code (IBC) per ESM chapter 16 for required modifications
- Update pressure safety certifications per ESM chapter17 for new or upgraded systems
- Identify new component labels and tags
- Update record drawings/develop as-built drawings

Fire Protection

- Identify major fire scenarios and special fire considerations for input to likely SSC designation

[2] TSR is the ~~minimum set of requirements to~~ keep nuclear facility in safe operations based on each nuclear facility's documented safety analysis.

- Develop updated Fire Hazards Analysis per DOE G 151.1-1 *Emergency Management Guide*, DOE O 420.1, *Facility Safety*, DOE O 440.1, *Worker Safety and Health Program for DOE*, DOE G 420.1-3, *Implementation Guide for DOE Fire Protection and Emergency Services Programs for Use with DOE O 420.1B, Facility Safety*, and 10CFR851, *Worker Safety and Health Program.*
- Update fire barrier design and fire areas if needed
- Determine required fire protection system modifications such as a diesel driven fire pump and fire water storage tank.
- Perform Fire Marshall reviews and inspections

Criticality Safety

- Determine criticality potential and develop input to hazard categorization per DOE O 420.1B, DOE STD-3007, *DOE Standard Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Nonreactor Nuclear Facilities*, and DOE G 421.1-1, *Criticality Safety Good Practices Program Guide for DOE Nonreactor Nuclear Facilities.*
- Develop criticality control philosophy and criticality guidance for design
- Develop updated criticality design requirements during preliminary design
- Update criticality limits and controls during detailed design
- Incorporate criticality controls into TSRs and operating procedures.
- Develop critical safety evaluation document and safety limits for operations

Radiation Protection

- Develop As Low As Reasonably Achievable (ALARA) strategy per 10CFR835, *Occupational Radiation Protection* and DOE G 441.1-1B, *Radiation Protection Program Guide*
- Perform preliminary shielding analysis considering material location and quantity
- Develop ALARA considerations in design
- Identity contamination control upgrades and zoning
- Develop final shielding analysis
- Develop final ALARA review
- Develop final monitoring plan and procure required monitoring equipment

Quality Assurance (QA)

- Update QA Plan per 10CFR830, *Nuclear Safety Management*, DOE O 414.1C, *Quality Assurance*, and NQA-1, *Nuclear Quality Assurance.*
- Implement added QA requirements
- Perform QA assessments and audits

Security

- Determine and convert uncleared lab area to a secured area is necessary
- Develop draft safeguards requirements identification per DOE O 470.3 *Graded Security Protection Policy* and O 470.4, *Safeguards and Security Program*
- Develop final material control and accountability (MC&A) plan

Training

- Perform job task analyses and establish training implementation matrix for RLUOB as a nuclear facility per DOE O 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities*
- Implement appropriate Conduct of Training
- Establish Operator's qualification requirements for HC-3 Nuclear Facility in RLUOB
- Qualify personnel for the qualified nuclear facility positions such as Nuclear Facility Manager, Nuclear Facility Operator, Cognizant System Engineer, etc.
- Certify fissile material handlers and glovebox workers

Operations

- Revise operations protocol process to support construction
- Implement appropriate Conduct of Operations
- Update operations procedures as required

Maintenance

- Upgrade preventive and predictive maintenance instructions as required
- Upgrade maintenance program for full compliance to DOE O 433.1B, *Nuclear Maintenance Management Programs (NMMPs) Guide* for nuclear facilities
- Install new component labels and tags

Environmental

- Update Permits & Requirements Identification (PRID) for RLUOB facility operations, analytical chemistry operations and supporting functions

Emergency Preparedness

- Develop emergency preparedness hazard survey and screen per 29CFR1910.119, *Occupational Safety and Health Standards*, 40CFR68, Chemical Accident Prevention Provisions, and DOE O 151.1C, *Comprehensive Emergency Management*
- Update to the emergency plan and training

Radiological and Hazardous Waste Management

- Update primary waste streams and waste profiles
- Update chemical management plan
- Design and install additional waste management capabilities in RLUOB
- Update waste procedures and waste profiles

Industrial Hygiene and Safety

- Update RLUOB chemical management plan
- Update other industrial hygiene and safety requirements

Construction Planning

- Develop construction safety plans
- Develop construction cost and schedule
- Develop construction quality assurance plan
- Develop construction procurement plan
- Develop construction document control plan
- Develop construction inspection and testing plan
- Develop equipment and materials storage and staging areas
- Perform construction to outfit lab and upgrade facility systems if needed

Commissioning

- Develop commissioning plan
- Execute test and balance
- Execute commissioning
- Construction turnover to operations

Operational Readiness Review (ORR)

- Personnel training, equipment and operational dry runs
- Preparation and conduct Management Self-Assessment
- Preparation and conduct Contractor Readiness Review
- Preparation and conduct DOE Operational Readiness Review (per DOE O 425.1D, *Verification of Readiness to Start up or Restart Nuclear Facilities*)

Materials and Supplies

- Stock laboratories with necessary materials and supplies

Personnel Relocation

- Relocate critical staff into RLUOB as required

External Reviews

- DOE, DNFSB, Project Reviews

Next Steps

1. Safety Basis scoping study for RLUOB to exceed HC-3 nuclear facility threshold quantity
2. Review and comment of required tasks by functional organizations.
3. Facility scoping review
4. System adequacy assessment
5. Parse activities into project management phases
6. Create logic network and milestones
7. Develop schedule and cost estimate

AC Option: RLUOB with Regulatory Relief

- RLUOB is newest Pu building (2009)
  - Built to higher std than PF-4 (1978) or CMR (1952)
  - Seismic analysis not required for Rad Facility, so no such study has been done
- First floor (lab) is heavily reinforced concrete
- 3 office floors are built to standards of emerg. response bldgs (hospitals, fire stations)
- What dose released if quake collapsed it?

Dose from a Pu Spill and Fire in RLUOB

Type and Quantity (grams) of Pu		Dose (rem) to:	
Pu-239E	WGPu	MOI*	CW*
38.6	26	0.01	0.27
750	505	0.25	5.20
1,500	1,010	0.49	10.41
2,610	1,760	0.86	18.11
Dept. of Energy standard*		5-25	100

Source: Calculations by Los Alamos National Laboratory

*MOI: maximally exposed offsite individual (at site boundary). CW: collocated worker, 100 meters from building that has released plutonium. Dose standards are from U.S. Department of Energy, DOE Standard: Integration of Safety into the Design Process, DOE-STD-1189-2008, March 2008, pp. A-5, A-6.

Pros

- Reduce risk of design errors (UPF) or cancellation
  - It’s already built
- Reduce risk of schedule slippage, cost growth
- Could be implemented quickly
  - Bldg is outfitted for AC; no rad material yet
- Could exit CMR early
- Cost << new bldg like CMRR-NF ($4B-$6B+)
- Match tasks to buildings
  - Could free up space in PF-4
  - Even with modules, most efficient use of space for AC is in low-SC, low-HC bldg
- Modifying existing bldg minimizes envir. impact

RLUOB Could Be Made More Robust

Source: Stanford Linear Accelerator Center

Source: Los Alamos National Laboratory

Cons

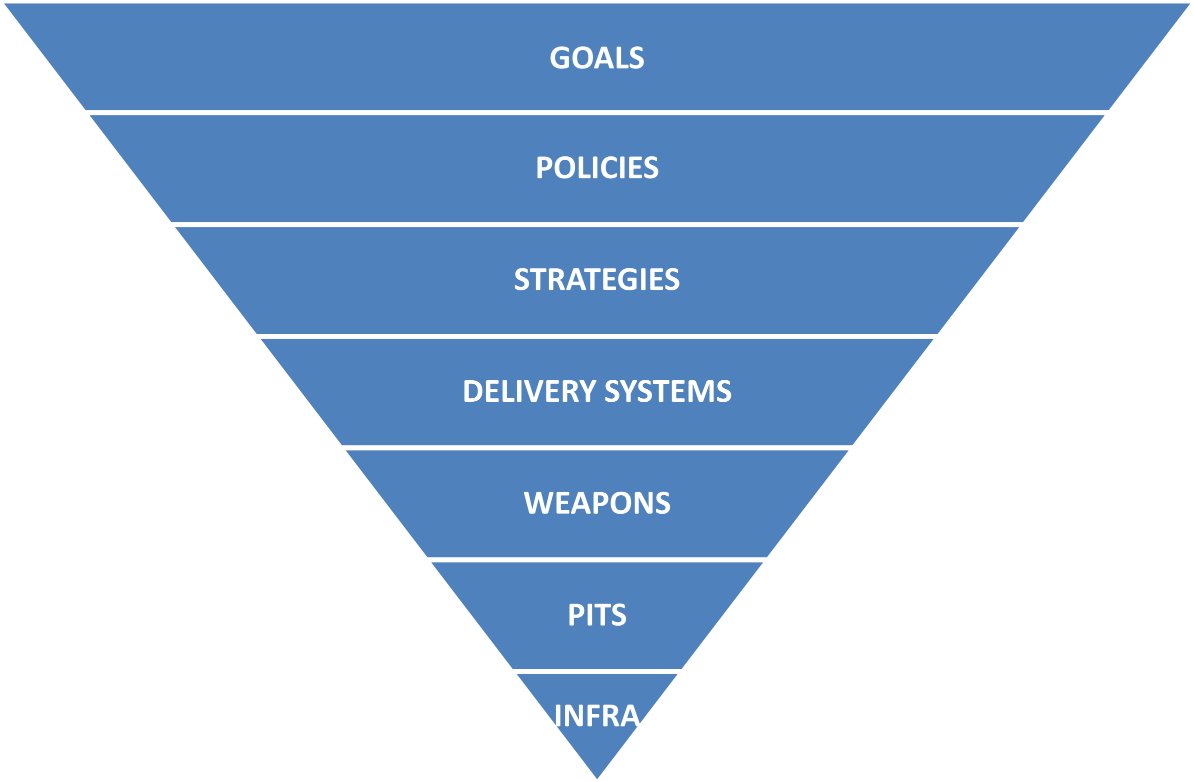
- Office component might collapse in a quake
- Public concern about relaxing nuclear facility standards
- Relaxing standards for one bldg could set precedent for doing so for other projects
- EIS might be inadequate
  - Would it include just RLUOB/PF-4, or also modules, facilities at INL, LLNL, SRS?
- Lab space at LANL for unclassified research on Pu probably disappears

Findings

- There are multiple paths by which NNSA might reach 80 ppy by 2030
- Some paths use existing buildings
  - Likely to reduce risk, cost, delays
- Key: align tasks with buildings
- Doing nothing has costs and risks (CMR)
- Solving 24-year-old pit prod’n problem would enable related programs to move forward

Backup Material

Relationship Between National Goals and Pit Production Infrastructure



Source: CRS

Security and Hazard Categories for Plutonium

Security Category (SC)	SC for Pu Material Limits		Hazard Category (HC)	HC for Pu-239 Equivalent Material Limits
I	Assembled weapons/test devices; ≥2,000 g pure products*; ≥6,000 g high-grade materials**		(1)	N/A (Nuclear Reactor)
II	Less than SC I, but ≥400 g pure products; ≥2,000 g high-grade materials; ≥16,000 g low-grade materials***		2	>2,610 g Pu-239 Equivalent
III	Less than SC II, but ≥200 g pure products; ≥400 g high-grade materials; ≥3,000 g low-grade materials		3	Less than HC 2, but >38.6 g Pu-239 Equivalent
IV	Less than SC III		(Radiological)†	Less than HC 3

Source: DOE O 474.2 (order), DOE SD G 1027 (supplemental guidance for DOE-STD-1027-92)

A Gas Gun in PF-4

Source: Los Alamos National Laboratory

Sample Calculation for Deriving Dose Values for RLUOB

Factor	Maximally Exposed Offsite Individual (MOI)	Collocated Worker (CW)
MAR (g PE)	500	500
Damage Ratio, DR	1	1
Airborne Release Fraction, ARF*	0.002	0.002
Respirable Fraction, RF	1	1
Leak-Path Factor	1	1
Source Term (g Pu-239 equiv)	1.00	1.00
"Chi over Q," X/Q (s/m^3)	8.77E-05	0.0035
Breathing Rate, BR (m^3/s)	0.00033	0.00033
Specific Activity, SA (Ci/g) for Pu-239 equiv	0.0622	0.0622
Dose Conversion Factor, DCF (rem/Ci)	5.92E+07	3.07E+07
Dose (rem)	0.107	2.21
Dose limit (rem) per DOE regulations	5-25	100

Calculation by Los Alamos National Laboratory. Factors are based on DOE rules except Chi over Q, which is specific to TA-55 (main plutonium area at LANL). Chi over Q includes such factors as distance, wind speed, wind direction, and deposition rate.

*ARF is specific to material form and accident scenario. This factor assumes that all plutonium is in solution, which would be typical of AC material, and a fire. Assuming all plutonium is in solution is conservative, as some material would be in less-vulnerable forms. Source for the factor of 0.002: DOE-Hdbk-3010-94, pg. 3-1.