INL/EXT-12-26428
Revision 4

Advanced Post-Irradiation Examination Capabilities Alternatives Analysis Report

December 2012

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

DISCLAIMER

This information was prepared as an account of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness, of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trade mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

INL/EXT-12-26428
Revision 4

Advanced Post-Irradiation Examination Capabilities Alternatives Analysis Report

December 2012

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

This page intentionally left blank.

Advanced Post-Irradiation Examination Capabilities Alternatives Analysis Report

INL/EXT-12-26428
Revision 4

December 2012

Approved by:

William H. Landman
Project Engineer for APIEC

12/11/2012
Date

M. W. (Mike) Patterson
Project Manager for APIEC

12/11/2012
Date

Collin J. Knight
Scientific Coordinator for APIEC

12/11/2012
Date

Kemal O. Pasamehmetoglu
Associate Laboratory Director, Nuclear Science and Technology

12/13/2012
Date

This page intentionally left blank.

REVISION LOG

Rev.	Date	Affected Pages	Revision Description
0		All	PREDECISIONAL DRAFT – Issued to SRC in preparation for Workshop 1 review activities.
1	9/6/2012	All	PREDECISIONAL DRAFT – Issued to SRC in preparation for Workshop 2 review activities. This revision reflects changes identified during Workshop 1 as well as additional information on alternative scoring.
2	10/23/2012	All	PREDECISIONAL DRAFT – Issued to SRC in preparation for Workshop 3 review activities. This revision reflects changes identified during Workshop 2 as well as additional information on alternative scoring, risk, and sensitivity.
3	11/15/2012	All	PREDECISIONAL DRAFT – Issued to DOE for review and comment. This revision reflects minor changes identified during Workshop 3.
4	12/11/2012	All	Removed “PREDECISIONAL DRAFT” header; added header with title, date, and document number; and updated Appendix D to indicate the DOE had no comments.

This page intentionally left blank.

ABSTRACT

An alternatives analysis was performed for the Advanced Post-Irradiation Capabilities (APIEC) Project in accordance with the U.S. Department of Energy (DOE) Order DOE O 413.3B, "Program and Project Management for the Acquisition of Capital Assets". The Alternatives Analysis considered six major alternatives, with sub-alternatives for Alternatives 3 and 4:

1. No Action
2. Modify Existing DOE Facilities – capabilities distributed among multiple locations
3. Modify Existing DOE Facilities – capabilities consolidated at a few locations
    a. Modify Existing DOE Facilities at Idaho National Laboratory (INL) and Los Alamos National Laboratory (LANL)
    b. Modify Existing DOE Facilities at LANL and Oak Ridge National Laboratory (ORNL)
    c. Modify Existing DOE Facilities at INL and ORNL
4. Construct New Facility
    a. New Facility at Materials and Fuels Complex (MFC) at INL (close to the Advanced Test Reactor)
    b. New Facility at ORNL (close to the High Flux Isotope Reactor)
    c. New Facility at other DOE Laboratory
5. Commercial Partnership
6. International Partnerships.

Based on the alternatives analysis documented herein, it is recommended to DOE that world-leading advanced post-irradiation examination capabilities be provided by a new facility constructed at the MFC at the INL Site.

This page intentionally left blank.

EXECUTIVE SUMMARY

An alternatives analysis was performed for the Advanced Post-Irradiation Capabilities (APIEC) project in accordance with the U.S. Department of Energy (DOE) Order DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*. The Alternatives Analysis considered six major alternatives identified in the *Mission Need Statement for Advanced Post-Irradiation Examination Capability* (MNS) as well as three sub-alternatives each for Alternatives 3 and 4:

1. No Action
2. Modify Existing DOE Facilities – capabilities distributed among multiple locations
3. Modify Existing DOE Facilities – capabilities consolidated at a few locations
    a. Modify Existing DOE Facilities at Idaho National Laboratory (INL) and Los Alamos National Laboratory (LANL)
    b. Modify Existing DOE Facilities at LANL and Oak Ridge National Laboratory (ORNL)
    c. Modify Existing DOE Facilities at INL and ORNL
4. Construct New Facility
    a. New Facility at Materials and Fuels Complex (MFC) at INL (close to the Advanced Test Reactor)
    b. New Facility at ORNL (close to the High Flux Isotope Reactor)
    c. New Facility at Other DOE Laboratory
5. Commercial Partnership
6. International Partnerships.

Based on the alternatives analysis documented herein, it is recommended to DOE that advanced post-irradiation examination (PIE) capabilities be provided by a new facility constructed at the MFC at the INL Site.

Background

The demand for clean, sustainable energy will continue to increase in the United States, and nuclear energy will play a major role in fulfilling these demands. The DOE Office of Nuclear Energy (NE) needs world-leading advanced post-irradiation examination (PIE) capabilities for the United States to support a science-based approach to developing new fuels and materials. These capabilities will maintain and further a global leadership role in advancing safe and secure nuclear energy technology. In recognition of this need, DOE approved the MNS on January 31, 2011.

The APIEC project is a non-major capital acquisition project that will comply with the requirements of DOE O 413.3B. As part of the Definition Phase of the project, the conceptual design process must identify and evaluate alternatives that are responsive to the mission need. This report documents the results of this alternatives analysis.

Alternatives Analysis Overview

APIEC Scope

The APIEC scope includes thermal, micro-/nano-structural, micro-/nano-chemical, and mechanical properties characterization of highly irradiated nuclear fuels and materials, including samples of failed

fuels and samples from transient testing. To provide these primary examination and characterization functions, the APIEC will need to support the following activities:

- Shielded cask receiving/shipping
- Shielded source material storage
- Shielded source material sizing/capsule disassembly
- Shielded sample/specimen preparation
- Final prepared sample/specimen shielded storage and archive
- Shielded waste processing/packaging.

Stakeholder Review Committee

A group of experts, designated as the Stakeholder Review Committee (SRC), was commissioned from the DOE national laboratories, nuclear industry, and universities to support the APIEC project team by reviewing and offering feedback on intermediate and final alternative analysis results. In addition, the committee provided insights as to the state of advanced PIE in the United States and internationally, including current capability, conditions and limitations, programmatic directions/trends, user requirements, and various materials and fuels needing PIE. The SRC support augmented the APIEC project team role which was to manage the alternatives analysis process, gather and compile data, and to provide analysis. The SRC membership included representatives for the following organizations:

- U.S. Department of Energy, Office of Nuclear Energy
- Idaho National Laboratory
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Electric Power Research Institute
- Academia (i.e., Illinois Institute of Technology)/ATR National Scientific User Facility.

Three workshops were conducted with the SRC to obtain their review and feedback:

- Workshop 1 – This session included APIEC project team presentations on detailed descriptions of the alternatives, proposed decision goals, threshold requirements, evaluation criteria, and weighting factors. SRC comments from this workshop were captured and resolutions incorporated into the alternatives analysis report including revisions to goals/criteria and the adoption of the SRC-recommended goal and criteria weights.
- Workshop 2 – This session included APIEC project team presentations on detailed metrics for measuring alternative performance relative to each of the evaluation criteria and on analyses supporting quantitative criteria scoring. Also, scores for each alternative were collected from SRC members for measuring performance relative to the qualitative criteria. As in Workshop 1, comments from the SRC were collected and revisions made to the report, as appropriate.
- Workshop 3 – This session included APIEC project team presentations on the results of initial scoring as well as sensitivity and risk analyses. Feedback from the SRC was obtained and incorporated into the report.

Alternatives Considered

Six alternatives were identified in the MNS that span the range from no action to construction of a new facility. These alternatives formed the basis for this analysis, and additional sub-alternatives were identified to address the specific possibilities for some of the major alternatives. The alternatives considered in this report are as follows:

1. No Action

   This alternative reflects the status quo in that it relies on existing DOE facilities that have shielded hot cells in which structural, thermal, or mechanical examinations are carried out on irradiated fuels or materials. No capital expenditures for modifications to these facilities will be made. The facilities will be used "as is" with their currently installed PIE instrumentation.

2. Modify Existing DOE Facilities – Distributed

   This alternative considers modifying existing facilities across the DOE complex to provide the necessary APIEC. The sites considered for this alternative included Idaho National Laboratory (INL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Sandia National Laboratory (SNL), and Savannah River National Laboratory (SRNL).

3. Modify Existing DOE Facilities – Consolidated

   This alternative considers modifying existing facilities across the DOE complex but consolidates the capabilities at two sites (no single site was identified that could provide all the required space). A total of three sub-alternatives were identified for this alternative, namely:

   a. Irradiated Materials Characterization Laboratory (IMCL) at INL paired with the Chemistry and Metallurgy Research (CMR) Wing 9 Facility at LANL

   b. CMR Facility at LANL paired with the Radiochemical Engineering Development Center (REDC) 7930 and Irradiated Fuels Examination Laboratory (IFEL) at ORNL

   c. REDC 7930 and IFEL at ORNL paired with IMCL at INL.

4. Construct New Facility

   This alternative considers construction of a new, modern facility to provide the needed APIEC. Again, sub-alternatives were identified for this alternative and included the following:

   a. New facility sited at the MFC at the INL

   b. New facility sited at ORNL

   c. New facility sited at a DOE laboratory with only pre- and post-irradiation capabilities and no irradiation facility.

5. Commercial Partnership

   This alternative considers using (and potentially modifying) existing commercial facilities within the United States.

6. International Partnerships

   This alternative involves establishing partnerships with the leading international PIE facilities located around the world.

Alternatives Analysis Process

As described in the *Plan for Advanced Post-Irradiation Examination Capabilities Alternatives Analysis* (PLN-4187), the analysis process identified a hierarchy of goals, requirements, and criteria against which the alternatives were measured. Goals are statements of desired states, responses, or outcomes relative to the alternatives being evaluated. Requirements are conditions that any acceptable solution to the problem must meet. Criteria are related to the goals and defined to objectively measure how well each alternative achieves the project goals. The five major goals and their associated requirements are shown in Figure ES-1.

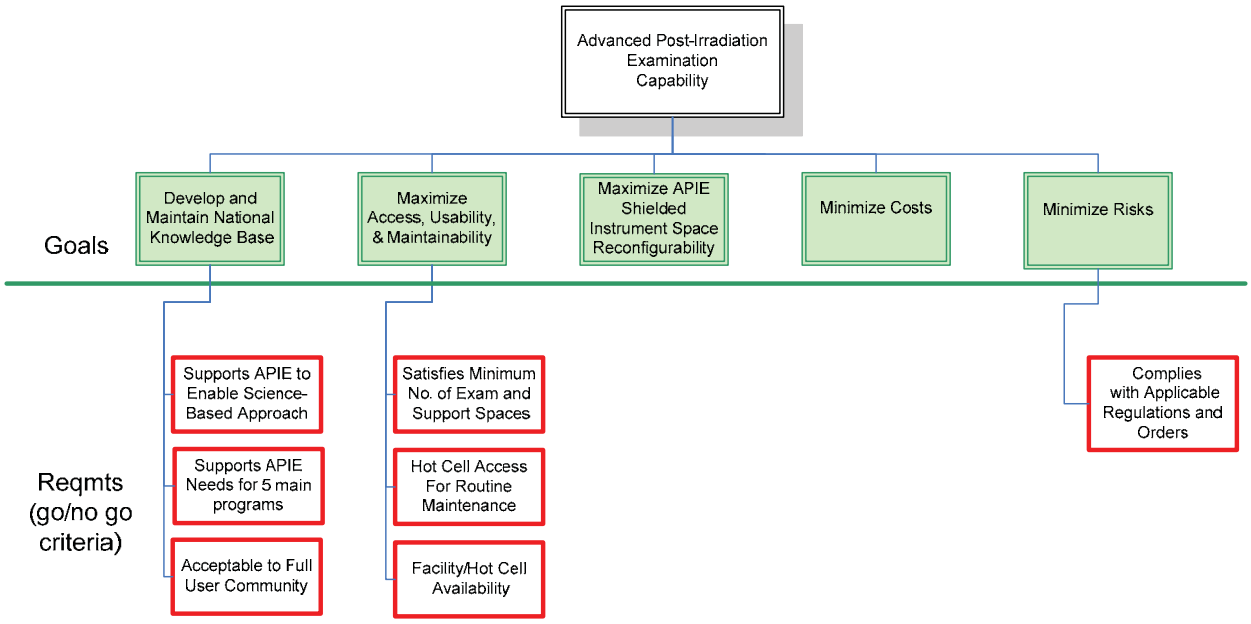


Figure ES-1. Goals and Requirements for APIEC Alternatives Analysis

The requirements identify threshold levels of performance that the alternatives must meet to be considered a viable solution. Thus, the Go/No-Go criteria were used to eliminate non-compliant alternatives from further consideration. For example, an alternative that failed to provide the minimum required number of shielded examination cells and non-shielded instrument spaces was not considered a viable solution and, as a result, was screened out of the analysis.

The goals were weighted to reflect their importance to or impact on the overall APIEC performance. The criteria were weighted to reflect their importance relative to their corresponding goal. Each alternative was assigned a score for each of the criteria. These scores were multiplied by the combination of the goal and criteria weights and then summed for each alternative. The goals and criteria with their respective weights are depicted in Figure ES-2.

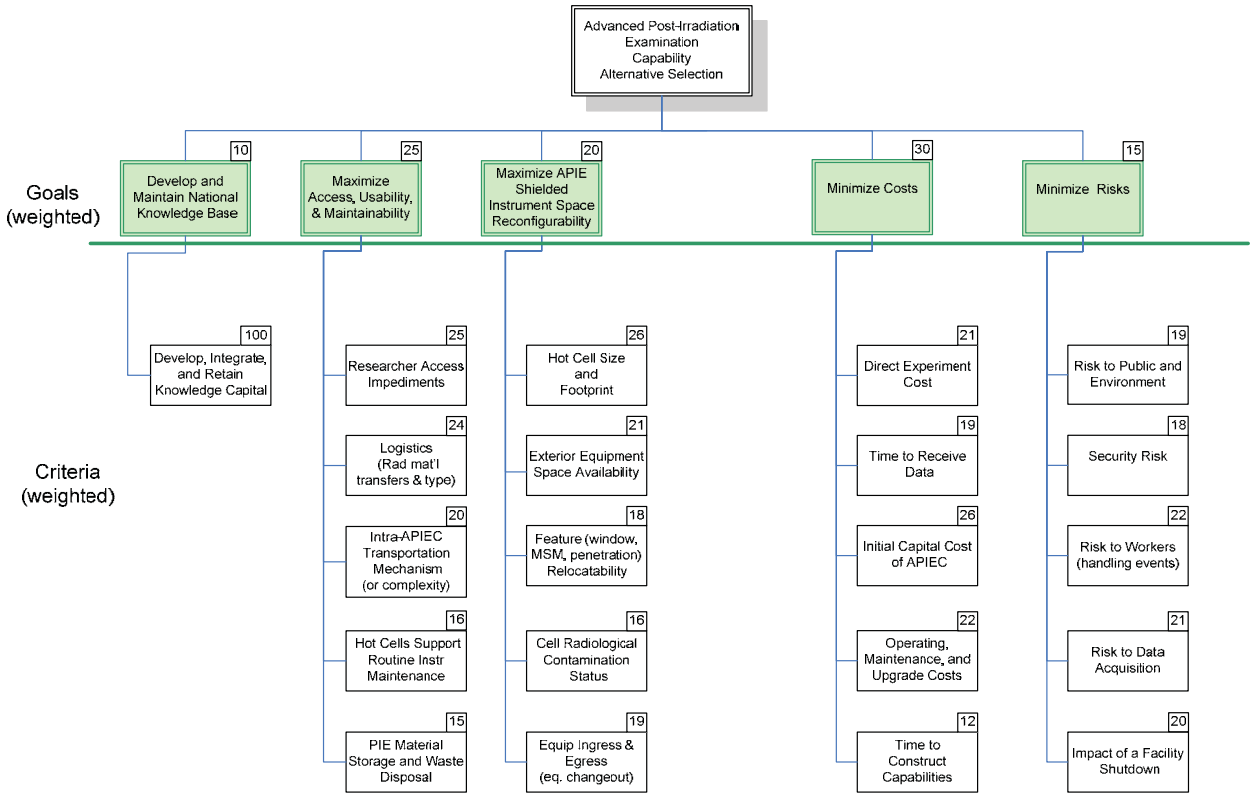


Figure ES-2. Goals and Criteria for APIEC Alternatives Analysis, as weighted by the SRC

Scoring Results

The Go/No-Go analysis evaluated the six alternatives against the APIEC requirements shown in Figure ES-1. Alternatives 1, 5, and 6 were eliminated because they did not meet one or more of the threshold requirements. The remaining alternatives were carried through the scoring process; the combined scores for these alternatives are shown in Figure ES-3. As shown, Alternatives 4a, 4b, and 4c (Construct New Facility) scored substantially higher than Alternative 2 (Existing – Distributed) and Alternatives 3a, 3b, and 3c, (Existing – Consolidated). Alternative 4a (i.e., Construct New Facility at MFC at INL) scored the highest of any alternative.

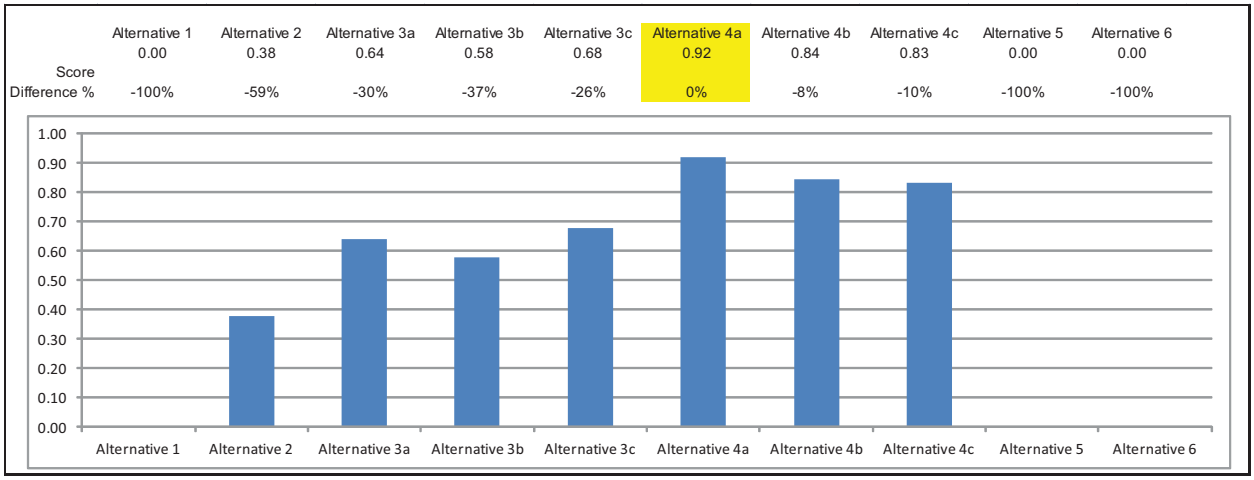


Figure ES-3. Combined Scores for All Alternatives

Sensitivity analyses were performed to evaluate how errors or uncertainties in the assignment of goal/criterion weights or alternative scores might affect the outcome, specifically, the overall alternative ranking and the highest scoring alternative. The sensitivity analyses indicated that the ranking results were very robust, meaning that Alternative 4a remained the highest scoring alternative over a wide range of variation in criteria weights and scores. Furthermore, it should be noted that all members of the SRC scored Alternative 4a highest of all alternatives.

A risk analysis was also performed on Alternatives 4a, 4b, and 4c to further understand the effects of selecting a particular sub-alternative for recommendation as the preferred alternative. This risk analysis addresses the risk areas defined in DOE G 413.3-13, *Acquisition Strategy Guide for Capital Asset Projects*. The results of the risk analysis concluded that Alternative 4a had the least risk, for the following reasons:

1. Smaller legal and regulatory risk (as a result of INL's agreement with the state of Idaho regarding acceptance of used nuclear fuel)
2. Smaller risk from immature scope definition impacting cost due to the ability to leverage IMCL to provide demonstration capability and additional PIE capability at the least cost
3. Smaller interface and integration risk (based on the co-location of the irradiation, non-destructive examination, and post-irradiation examination facilities).

Conclusions and Recommendations

Based on this analysis, the recommended preferred alternative is Alternative 4a, construction of a new facility at MFC at the INL.

CONTENTS

ABSTRACT vi

EXECUTIVE SUMMARY ix

DEFINITIONS xxiv

1. INTRODUCTION 1
   1.1 Background 1
   1.2 Alternative Analysis Process 1

2. STAGE 1 – DECISION FRAMEWORK 3
   2.1 Problem Definition 3
   2.2 APIEC Context and Scope 3
      2.2.1 Science-Based Approach to Fuels and Materials Development 3
      2.2.2 Shielded Cell Space Needs 5
      2.2.3 Basis for Alternatives Comparison 6
   2.3 Analysis Goals and Requirements 7
      2.3.1 Goal 1: Develop and Maintain National Knowledge Base 8
      2.3.2 Goal 2: Maximize Access, Usability, and Maintainability 9
      2.3.3 Goal 3: Maximize APIEC Shielded Instrument Space Reconfigurability 10
      2.3.4 Goal 4: Minimize Costs 10
      2.3.5 Goal 5: Minimize Risks 10
   2.4 APIEC Scope, General Assumptions, and Process Flow 10
      2.4.1 APIEC Scope 10
      2.4.2 APIEC General Assumptions 11
      2.4.3 APIEC Process Flow 13
   2.5 Alternative Definitions 17
      2.5.1 Alternative 1: No Action 17
      2.5.2 Alternative 2: Modify Existing DOE Facilities – Distributed 33
      2.5.3 Alternative 3: Modify Existing DOE Facilities – Consolidated 40
      2.5.4 Alternative 4: Construct New Facility 44
      2.5.5 Alternative 5: Commercial Partnerships 51
      2.5.6 Alternative 6: International Partnerships 58
   2.6 Criteria and Weights 66
      2.6.1 Criteria for Goal 1 (Develop and Maintain National Knowledge Base) 68
      2.6.2 Criteria for Goal 2 (Maximize Access, Usability, and Maintainability) 68
      2.6.3 Criteria for Goal 3 (Maximize APIEC Shielded Instrument Space Reconfigurability) 70
      2.6.4 Criteria for Goal 4 (Minimize Costs) 71
      2.6.5 Criteria for Goal 5 (Minimize Risks) 72

3. STAGE 2 – QUALITATIVE EXPLORATION 74
   3.1 Go/No-Go Analysis 74
      3.1.1 Alternative 1: No Action 74
      3.1.2 Alternative 2: Modify Existing DOE Facilities – Distributed 75
      3.1.3 Alternative 3: Modify Existing DOE Facilities – Consolidated 76
      3.1.4 Alternative 4: Construct New Facility 76
      3.1.5 Alternative 5: Commercial Partnerships 77
      3.1.6 Alternative 6: International Partnerships 78

3.2 Alternative Scoring – Initial 78
3.2.1 Goal 1 (Develop and Maintain National Knowledge Base) 80
3.2.2 Criteria for Goal 2 (Maximize Access, Usability, and Maintainability) 80
3.2.3 Criteria for Goal 3 (Maximize APIEC Shielded Instrument Space Reconfigurability) 86
3.2.4 Criteria for Goal 4 (Minimize Costs) 90
3.2.5 Criteria for Goal 5 (Minimize Risks) 96
3.3 Results Evaluation – Initial 100
4. STAGE 3 – QUANTITATIVE ANALYSIS 104
4.1 Alternative Scoring – Refinement 104
4.2 Results Evaluation – Refinement 104
5. STAGE 4 – RISK AND UNCERTAINTY SENSITIVITY ANALYSIS 106
5.1 Uncertainty Sensitivity Analysis 106
5.1.1 Goal Weighting Sensitivity Analysis 106
5.1.2 Criteria Weighting Sensitivity Analysis 108
5.1.3 Qualitative Scoring Sensitivity Analysis 113
5.1.4 Quantitative Scoring Sensitivity Analysis 114
5.2 Risk Evaluation 115
5.2.1 Scope and Definition Risk 116
5.2.2 Functional Risk 116
5.2.3 Environment, Safety and Health Risk 117
5.2.4 Cost and Schedule Risk 117
5.2.5 Workforce Issues Risk 117
5.2.6 Funding and Budget Risk 118
5.2.7 Technology and Engineering Risk 118
5.2.8 Interfaces and Integration Risk 118
5.2.9 Safeguards and Security Risks 118
5.2.10 Location and Site Conditions Risk 119
5.2.11 Legal and Regulatory Risk 119
5.2.12 Stakeholder Issue Risk 119
5.2.13 Existence of Metrics for Performance Measurement Risk 119
5.2.14 Availability of Government-furnished property/information Risk 119
5.2.15 Expertise and Human Resources Risk 119
6. SUMMARY 120
7. REFERENCES 121
Appendix A Workshop 1 – SRC Review and Comments A-1
Appendix B Workshop 2 – SRC Review and Comments B-1
Appendix C Workshop 3 – SRC Review and Comments C-1
Appendix D DOE Comments and Resolutions D-1
Appendix E Summary Cost Estimates E-1
Appendix F Logistical Analysis F-1

FIGURES

Figure ES-1. Goals and Requirements for APIEC Alternatives Analysis xii
Figure ES-2. Goals and Criteria for APIEC Alternatives Analysis, as weighted by the SRC xiii
Figure ES-3. Combined Scores for All Alternatives xiv
Figure 1. Eight step alternatives analysis process. 2
Figure 2. Alternatives Analysis process (Note: The "r" reflects a refinement to an earlier process step) 2
Figure 3. Identified needs for characterization equipment 5
Figure 4. Cell space requirements determined by workshops, DOE-NE, R&D programs 6
Figure 5. APIEC system boundary in relation to APIEC goals. 7
Figure 6. APIEC Goals and Requirements. 8
Figure 7. HFEF floor plan. 19
Figure 8. IMCL with three shielded development cells. 21
Figure 9. CMR facility at LANL 22
Figure 10. IFEL operating gallery image and hot cell layout. 24
Figure 11. RPL at PNNL 25
Figure 12. PDC and MEC schematics 27
Figure 13. SRNL Shielded Cells Facility floor plan 29
Figure 14. REDC Building 7930 floor plan 35
Figure 15. PIE Line Item Building facility floor plan 46
Figure 16. APEX modular, reconfigurable hot cells 48
Figure 17. B&W LTC hot cell plan view 52
Figure 18. GNF Vallecitos hot cell facility floor plan 53
Figure 19. STAR facility 61
Figure 20. Hierarchy of goals and evaluation criteria, as weighted by the SRC 67
Figure 21. Goals and associated requirements for the APIEC Alternatives Analysis 74
Figure 22. Utility Curve for rating criteria for which a high rating is "Good". 79
Figure 23. Utility Curve for rating criteria for which a high rating is "Bad" 79
Figure 24. Combined Scores for All Alternatives 102
Figure 25. Alternative Ranking by Goal 102
Figure 26. Ranking of Alternatives Based on Criteria (Bar Chart) 103
Figure 27. Effect of Criteria/Weighting Change on Overall Alternative Scores 105
Figure 28. Comparison of Scoring Uncertainty Ranges 113
Figure A-1. Goals and evaluation criteria as revised in Workshop 1 ..... A-26
Figure A-2. Weighted goals and evaluation criteria A-27

Figure A-3. Original Goals and Criteria (prior to workshop) A-28
Figure F-1. Logistics (Type and Complexity) F-4
Figure F-2. Calculation of mileage, offsite legs, risk miles, and freight miles. F-5
Figure F-3. Alternative 3a Risk Miles F-5
Figure F-4. Alternative 3b Risk Miles F-6
Figure F-5. Alternative 3c Risk Miles F-6
Figure F-6. Alternative 4a Risk Miles F-7
Figure F-7. Alternative 4b Risk Miles F-7
Figure F-8. Alternative 4c1 Risk Miles F-7
Figure F-9. Alternative 4c2 Risk Miles F-8
Figure F-10. Alternative 4c3 Risk Miles F-8
Figure F-11. Alternative 4c4 Risk Miles F-8
Figure F-12. Summary of Estimated Annual Transportation Costs F-11
Figure F-13. Estimated Alternative 2 Transportation Costs F-11
Figure F-14. Estimated Alternative 3a Transportation Costs F-12
Figure F-15. Estimated Alternative 3b Transportation Costs F-12
Figure F-16. Estimated Alternative 3c Transportation Costs F-13
Figure F-17. Estimated Alternative 4a Transportation Costs F-13
Figure F-18. Estimated Alternative 4b Transportation Costs F-14
Figure F-19. Estimated Alternative 4c (Avg) Transportation Costs F-14
Figure F-20. Transportation Mileage between Select DOE Laboratories/Facilities F-15
Figure F-21. Summary of Annual Off-Site Mileage by Alternative F-16

TABLES

Table 1. Existing DOE facilities with full NDE and large-scale sizing capabilities 14
Table 2. Receipt, storage, and waste disposition capabilities. 15
Table 3. Alternative 1 mapping of APIEC functions to HC-2 facilities at DOE sites. 30
Table 4. Alternative 2 mapping of APIEC functions of DOE facilities 37
Table 5. Needed facility modifications for implementation of APIEC Alternative 2 38
Table 6. Alternative 3 mapping of APIEC functions to DOE facilities 42
Table 7. Needed facility modifications for implementation of APIEC Alternative 3 43
Table 8. B&W Hot Cell Capability 51
Table 9. GNF Vallecitos hot cell capability 52
Table 10. Westinghouse Building 302 hot cell capability 54

Table 11. Allocation of cell space for commercial hot cells 55
Table 12. Expected commercial facility modifications 56
Table 13. ITU techniques 59
Table 14. STAR and LECA techniques 60
Table 15. Studsvik techniques 61
Table 16. PSI Techniques 62
Table 17. NNL Techniques 63
Table 18. International Alternative allocation table 64
Table 19. Summary of results for logistical analysis 81
Table 20. Summary of results for Intra-APIEC transportation analysis 82
Table 21. Considerations for supporting routine instrument maintenance 84
Table 22. Considerations for PIE material storage and disposition 85
Table 23. Cell size information and resulting sub-criteria scores 88
Table 24. Summary of Direct Experiment Costs – P&T Component 91
Table 25. Summary of Direct Experiment Costs – Staffing Component 92
Table 26. Total Direct Experiment Costs – 40-Year Period; Discounted 92
Table 27. Anticipated Time to Receive APIE Data 94
Table 28. Summary of Initial Capital Cost for APIEC Alternatives 94
Table 29. Summary of Operating, Maintenance, and Facility Refurbishment Costs 95
Table 30. Number of Expected Incidents for Each Alternative 97
Table 31. Environmental Risk Criterion Scores 98
Table 32. SRC Qualitative Raw Scores 101
Table 33. Weighting of Discriminating Criteria 105
Table 34. Goal Weighting Sensitivity Analysis Results 107
Table 35. Criteria Weighting Sensitivity Analysis Results 112
Table A-1. Individual SRC Scores A-29
Table A-2. Adjusted Goals and Weights A-30
Table B-1. Summary for SRC raw scores (with standard deviation) for qualitative criteria B-14
Table B-2. Summary for SRC raw scores (with low/high range) for qualitative criteria B-15
Table F-1. Summary of results for Intra-APIEC transportation analysis F-9

ACRONYMS

ACRR	Annular Core Research Reactor (SNL)
AEM	Auger Electron Microscope
AFM	Atomic Force Microscope
AL	Analytical Laboratory (INL)
APEX	Advanced Post-Irradiation Examination Facility (APIEC Alternative 4 proposed facility reference)
APIEC	Advanced Post-Irradiation Examination Capabilities (Project)
ATR	Advanced Test Reactor
B&W	Babcock and Wilcox
BIO	Basis for Interim Operation
BRRC	Battelle Energy Alliance Research Reactor Cask
CD	Critical Decision
CEA	Commissariat à l'énergie Atomique et aux énergies Alternatives
Ci	Curie
CMR	Chemistry and Metallurgy Research
CNC	computer numerical controlled
CRUD	Chalk River Unidentified Deposit
D&D	decontamination and decommissioning
DE	Destructive Examination
DoD	Department of Defense
DOE	Department of Energy
-LASO	Los Alamos Site Office
-NE	Office of Nuclear Energy
-ORO	Oak Ridge Office
-SR	Savannah River
DOT	Department of Transportation
DSA	Documented Safety Analysis
DSC	Differential Scanning Calorimetry
EIS	Environmental Impact Statement
EMI	Electromagnetic Interference
EML	Electron Microscopy Laboratory (INL)
EPMA	Electron Probe Micro-Analyzer
FASB	Fuels and Applied Sciences Building (INL)
FCF	Fuel Conditioning Facility
FCRD	Fuel Cycle Research and Development

FEG-STEM	Field Emission Gun-Scanning Transmission Electron Microscope
FIB	Focused Ion Beam
FONSI	Finding of No Significant Impact
FTE	full-time equivalent
GASR	Gas Analysis, Sampling, and Recharge
GNF	Global Nuclear Fuels
HC	Hazard Category
HCF	Hot Cell Facility
HCT	Hot Cell Technology
HEPA	High Efficiency Particulate Air
HFEF	Hot Fuels Examination Facility (INL)
HFIR	High Flux Isotope Reactor (ORNL)
HLRF	High-Level Radiochemistry Facility (PNNL)
HRA	hot repair area
HT-XRD	High-Temperature X-ray Diffraction
HVAC	heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
ICP-OES	Inductively Coupled Plasma Optical Emission Spectroscopy
IFEL	Irradiated Fuels Examination Laboratory (ORNL)
IMCL	Irradiated Material Characterization Laboratory (INL)
IMET	Irradiated Materials Examination and Testing (ORNL)
INL	Idaho National Laboratory
ITU	Institute for Transuranium Elements
JRC	Joint Research Center
LAMDA	Low-Activation Materials Design and Analysis
LANL	Los Alamos National Laboratory
LCC	life-cycle cost
LEAP	Local Electron Atom Probe
LECA	Laboratoire d'Examen de Combustibles Actifs
LFD	Laser Flash Diffusivity
LLW	low-level waste
LRUS	Laser Resonant Ultrasonic Spectroscopy
LTC	Lynchburg Technology Center
LTHC	Less than Hazard Category
LWR	Light Water Reactor

MAR	material at risk
MFC	Materials and Fuels Complex
MITR	Massachusetts Institute of Technology Nuclear Research Reactor
MNS	Mission Needs Statement
MOA	Memorandum of Agreement
MR	management reserve
MSE	modular shielded enclosure
MSM	master slave manipulator
MXRD	Micro X-ray Diffraction
NDE	non-destructive examination
NHS	National Homeland Security
NNL	National Nuclear Laboratory (UK)
NNSA	National Nuclear Security Administration
NPH	Natural Phenomena Hazard
NRAD	Neutron Radiography (reactor)
NRC	Nuclear Regulatory Commission
NSUF	National Scientific User Facility
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
P&T	packaging and transportation
PAS	Positron Annihilation Spectroscopy
PGS	Precision Gas Scanner
PIE	Post-irradiation Examination
PNNL	Pacific Northwest National Laboratory
PSI	Paul Scherrer Institute
R&D	research and development
REDC	Radiochemical Engineering Development Center (ORNL)
RFI	Radio Frequency Interference
RH-LLW	remote handled low-level waste
RPL	Radiochemical Processing Laboratory (PNNL)
SAL	Shielded Analytical Laboratory (PNNL)
SCF	Shielded Cell Facility
SEM	Scanning Electron Microscopy
SIMS	Secondary Ion Mass Spectrometry
SME	subject matter expert
SNF	spent nuclear fuel

SPHC	sample preparation and handling capability
SRC	Stakeholder Review Committee
SRNL	Savannah River National Laboratory
STAR	Station de Traitement Assainissement Reconditionnement
STDM	Scanning Thermal Diffusivity Microscope
TEM	Transmission Electron Microscope
TGA	Thermogravimetric Analysis
TMA	Thermomechanical Analysis
TPBAR	Tritium Producing Burnable Absorber Rod
TREAT	Transient Reactor Test (facility)
UNF	used nuclear fuel
WCA	waste characterization area
WIPP	Waste Isolation Pilot Plant

DEFINITIONS

experiment	The assembly that goes into the reactor for irradiation. This may be as simple as a number of coupons in a metal capsule or as complicated as a fuel failure test loop.
rough sizing	Disassembly of the experiment and/or reduction of the experiment to sample pieces 2 ft long or less after NDE, if applicable.
sample	The portion(s) of interest of an experiment. These may be identified during NDE (if any) and isolated by rough sizing (if any) on the experiment.
specimen	The prepared portion of the sample that will be put in the examination or characterization instrument.

Advanced Post-Irradiation Examination Capabilities Alternatives Analysis Report

1. INTRODUCTION

1.1 Background

The demand for clean, sustainable energy is likely to continue to increase in the United States, and nuclear energy will play a major role in fulfilling these demands. The U.S. Department of Energy (DOE) Office of Nuclear Energy (NE) needs advanced post-irradiation examination (PIE) capabilities for the United States to maintain and further a global leadership role in advancing safe and secure nuclear energy technology. Nuclear fuels development has historically been a long, expensive, and largely empirical process, requiring integral effects testing of fuel components followed by PIE activities that entail characterization at primarily the engineering (i.e., macroscopic) scale. Traditional PIE capabilities at DOE laboratories, universities, and in the private sector are widely distributed and lack the resolution necessary to meet the U.S. nuclear energy mission need. While significant advancements have been made, this approach has not maximized the potential to develop new, more robust fuels in a timely fashion. Current PIE capabilities will continue to serve basic needs for fuel examination, material handling, and waste disposal, but they are limited in their ability to function on the micro-, nano-, and atomic scale.

The mission of DOE-NE will be difficult to achieve without establishing a suitable nuclear facility environment that can accommodate micro-, nano-, and atomic-scale research on highly radioactive fuels and materials. In addition, DOE seeks to make these capabilities available to the broader nuclear energy research community in a user facility concept to better enable the United States to effectively harness the intellectual capital of the country in advancing U.S. research and development (R&D) goals and objectives. To fill this need, DOE approved the "Mission Need Statement for Advanced Post-Irradiation Examination Capability" on January 31, 2011.[1]

The Mission Need Statement (MNS) describes the gap between present capabilities and those needed to conduct in-depth micro-/nano-structure characterization of irradiated fuel and materials and to measure their thermal and mechanical properties. The MNS provides high-level preliminary functional and performance requirements and describes environmental, safety, security, health, and quality requirements applicable to alternatives that may meet the mission need. The MNS also identifies six alternatives to be evaluated for closing the capability gap.

The Advanced PIE Capabilities (APIEC) Project is being conducted in accordance with the requirements of DOE O 413.3B.[2] Approval of the MNS completed Critical Decision (CD)-0 activities, and funding has been authorized to conduct the Definition phase activities, including analysis of the alternatives mentioned in the preceding paragraph to identify a preferred system architecture for the capabilities. The plan for completing the alternatives analysis has been documented in PLN-4187, "Plan for Advanced Post-Irradiation Examination Capabilities Alternatives Analysis,"[3] and is based on DOE G 413.3-13, "Acquisition Strategy Guide for Capital Asset Projects."[4]

1.2 Alternative Analysis Process

The general alternatives analysis process described in PLN-4187 was drawn from DOE G 413.3-13 and from previous alternatives analysis work performed by the Idaho National Laboratory (INL) Systems Engineering organization in support of various programs and projects. The eight steps of the alternatives analysis process are as shown in Figure 1.

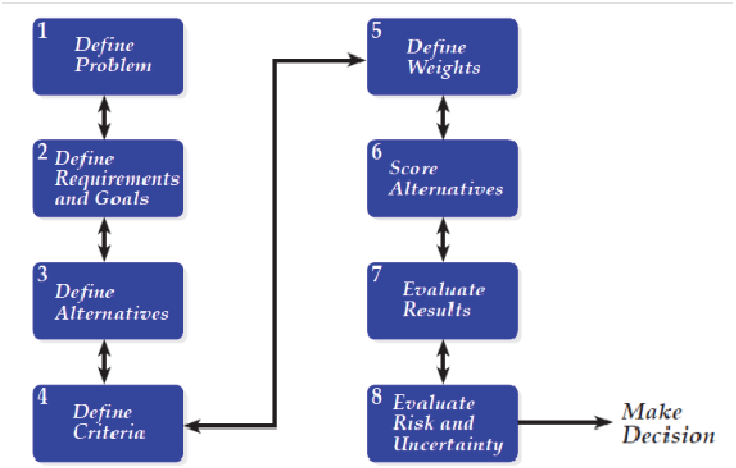


Figure 1. Eight step alternatives analysis process.

The eight steps are executed in four distinct stages to allow for iteration and necessary refinements, as shown in Figure 2. The processes and results from each phase are described in Sections 2 through 5, respectively.

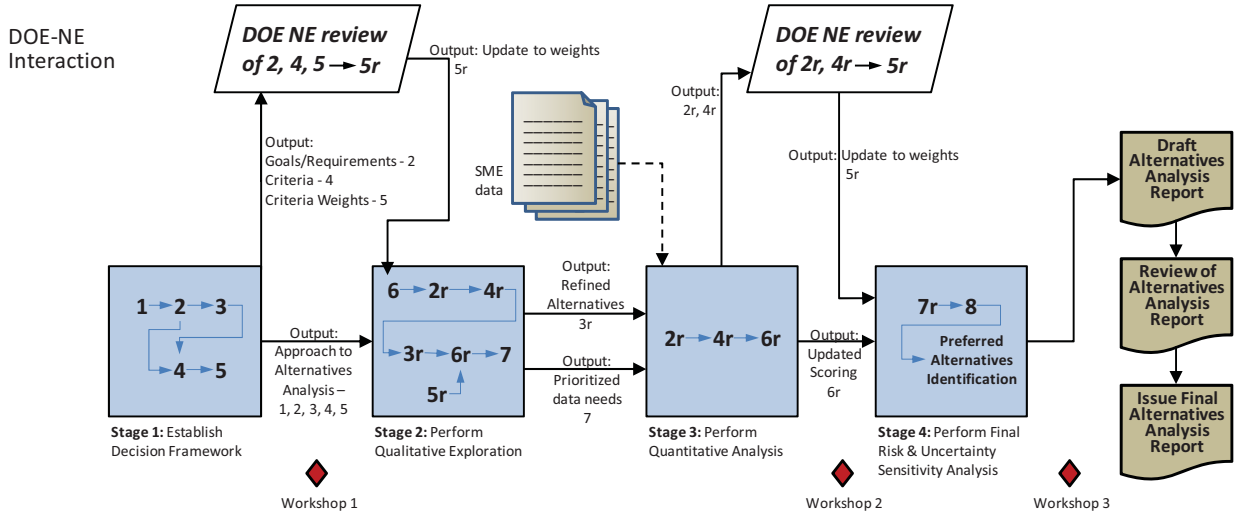


Figure 2. Alternatives Analysis process (Note: The "r" reflects a refinement to an earlier process step)

As described in the Analysis Plan, the results of each analysis stage will be compiled in this "APIEC Alternatives Analysis Report" and reviewed by a Stakeholder Review Committee (SRC) through a series of workshops. Recommended changes and refinements resulting from each workshop will be made to the contents, as needed, along with the addition of new information resulting from ongoing analysis activities. The report will then be redistributed to the SRC as the basis for the next workshop.

2. STAGE 1 – DECISION FRAMEWORK

Stage 1 defines the decision framework that serves as the basis for the alternatives analysis. It is comprised of the problem statement, goals, requirements, criteria and weights, and descriptions for the initial set of alternatives. These key elements form the foundation for qualitative, quantitative, and risk analyses that will be conducted during Stages 2–4 of the process. Additional information regarding the alternatives analysis process can be found in PLN-4187.

2.1 Problem Definition

Current U.S. national laboratory PIE capabilities are located in 30 to 50-year-old hot cell facilities that are not designed for modern-day research tools and instruments. In particular, these research tools and instruments require facility spaces with the flexibility to accommodate their unique set of sensitivities to various environmental conditions, such as, radiation field intensity, dust and contamination, noise and vibration, electromagnetic and radio-frequency interference, and temperature/humidity fluctuations. Thus, existing capabilities, while able to serve the basic functions of PIE, are unable to adequately characterize the behavior of nuclear fuels and materials that have high dose rates at the required resolution (i.e., nano-scale and finer) to accomplish DOE-NE's mission objectives. Adding further complexity is the ongoing need to use these current PIE capabilities to serve basic needs for fresh/conditioned fuel examinations as well as associated material handling and waste disposal.

The desired state will be achieved when a suitable nuclear facility environment has been established for PIE of highly radioactive fuels and materials that includes not only an initial suite of modern tools and instruments, but also the ability to accommodate a future trajectory of cutting-edge tools and instruments covering at least a 40-year period.

2.2 APIEC Context and Scope

Due to the complexities and numerous potential configurations associated with the APIEC, a scoping effort was performed to ensure that a proper number of examination spaces would be provided to meet APIEC needs while at the same time addressing funding and logistical constraints imposed by the U.S. government. This section attempts to bound the size (i.e., number of shielded and unshielded examination spaces) to be considered for each APIEC alternative in an effort to ensure a consistent basis for the analysis and subsequent comparison of results.

2.2.1 Science-Based Approach to Fuels and Materials Development

High technology industries outside the arena of nuclear fuels and materials development have succeeded by using advanced instrumentation and techniques in a "science-based" approach to understanding materials at the micro- and even nano-scales. The knowledge gained from characterization at this scale is used to improve material performance. In the case of nuclear fuel development, where the research cycle times are very long, a function of this characterization is to provide data needed to develop and validate advanced models being developed to predict nuclear fuel performance. This approach will reduce the time required to develop new fuels and was affirmed in reports from national and international workshops:

- The *National Post-irradiation Examination (PIE) Workshop*[5] was held March 29-30, 2011, in Gaithersburg, MD. A conclusion of this workshop was that a complete transition to a science-based approach was achievable with the following progressive set of actions:
  - The first step, after multiple decades of neglect, is to update and refurbish the existing capabilities and replace the older capabilities with newer, more accurate, and more reliable set of instruments.

  - The second step is to introduce advanced instruments and scientific techniques, commonly used in other applications with nonradioactive materials, into PIE applications. The objective is to start characterizing radioactive samples at nano-scale to micro-scale length resolutions. Some of these instruments, when applied to radioactive materials characterization, require special facilities with very strict environmental control.
  - The third step is to design and develop instruments that currently do not exist but are required to measure properties at various length and time scales in order to support a complete fundamental understanding of radioactive materials behavior. Such instruments would be valuable to understand separate effect phenomenology and to support the multi-physics, multi-scale, predictive fuel performance modeling efforts. These capabilities are also likely to require new facilities with very specialized environmental control and integration among multiple techniques.

- The *International Workshop on Characterization and PIE Needs for Fundamental Understanding of Fuels Performance and Safety*[6] was held June 16-17, 2011, in Paris, France. This workshop brought together nine countries (i.e., Finland, France, Germany, Republic of Korea, Russian Federation, Sweden, Switzerland, United Kingdom, and the United States of America) and associated international organizations (i.e., IAEA and ITU [on behalf of European Union Joint Research Centers]) to discuss common needs for nuclear fuels and materials testing, characterization, PIE, and modeling capabilities as well as issues and opportunities for future technical advancements and collaborations. Conclusions of this international workshop included:
  - State-of-the art characterization and PIE capabilities are required to transition into a "science-based" approach in the development of advanced fuels and materials, enabling a fundamental understanding of the behavior under irradiation, and
  - Existing capabilities are not sufficient to meet the needs of a science-based approach.

This aspect of the science-based approach uses multi-physics, multi-scale models working together in an integrated simulation. Data for model development and validation must be collected by a variety of instruments that characterize different micro-structural aspects. The objective of this approach is to develop fundamental material property and irradiation behavior models at the micro and nano-scales that can be used to inform engineering-scale fuel performance simulations. This approach uses mechanistic understanding to reduce the dependence on empirical correlations. Mechanistic understanding embedded in the models allows the simulation to predict performance, rather than to simply interpolate data. This modeling approach seeks to simulate the evolution of fuel micro-structure under irradiation and infer from that micro-structure the resulting engineering-scale material properties and behaviors at any point in time during its irradiation. Since micro-structure evolution modeling makes predictions about many aspects of the micro-structure (i.e., its structural, chemical, thermal, and mechanical state), characterization data from multiple methods can be used to validate the physics models. The understanding extends from studies of micro-structural evolution beginning at low doses to determining failure mechanisms under reactor accident conditions through the examination of failed fuel that has been subjected to power ramps or high rate transients in specialized reactors.

In addition to characterization that directly feeds the mechanistic fuel performance modeling, there are a number of other characterization techniques that emphasize surface analysis considered for inclusion in APIEC. These instruments are used to address the cause of major issues, such as Chalk River Unidentified Deposit (CRUD) formation and irradiation assisted stress corrosion cracking. These techniques and equipment are needed in the APIEC.

Engineering-scale characterization is still needed to verify fuel performance and to validate that the integration of these physics models has been performed correctly. To support continued progress in development, highly irradiated fuels and materials must be characterized at all three scales: engineering-scale, micro-scale, and nano-scale. While most of the instruments needed to perform the engineering-scale characterization are currently available in existing hot cells within the DOE complex, the instruments needed to perform the micro- and nano-scale characterization of materials reside in unshielded work environments, typically in facilities not designed to handle radioactive materials. This limits their application to the characterization of highly radioactive fuel samples. Figure 3 is a list of modern instruments capable of performing the comprehensive characterization of materials at the micro- and nano-scales, the majority requires shielding.

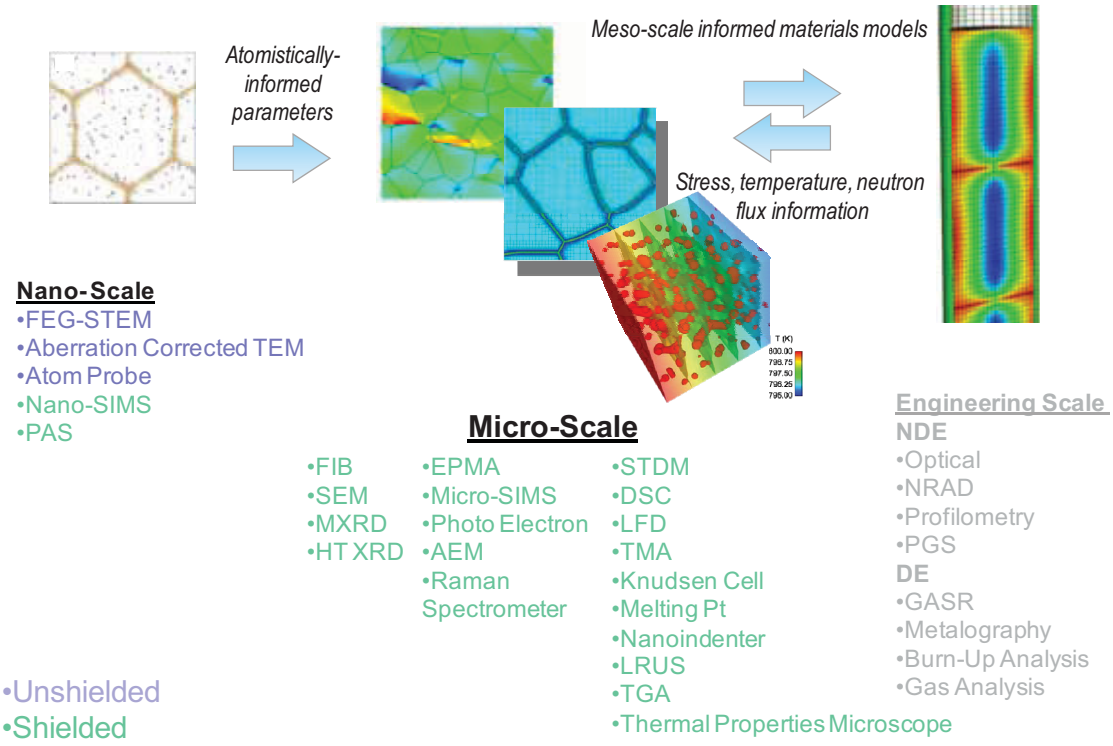


Figure 3. Identified needs for characterization equipment

2.2.2 Shielded Cell Space Needs

Of the 24 items listed in Figure 3, identified by domestic and international experts as instruments capable of performing the comprehensive characterization of nuclear fuels and materials at the micro- and nano-scales, the majority will require shielding. Not all of the items require a “dedicated” shielded enclosure, and some may share shielded space. For example, some of the thermal and mechanical instruments can be located in the same shielded cell. For the APIEC, it is assumed that all of the micro-structural and micro-chemical instruments will need a dedicated shielded enclosure due to either their size or associated interface requirements. To accommodate the full suite of instruments for micro-scale and nano-scale characterization, it is estimated that APIEC will need a total of at least 15 shielded enclosures (as shown in Figure 4). Based on known demands for scanning electron microscope (SEM) analysis and focused ion beam (FIB) preparation of transmission electron microscope (TEM) and atom probe specimens, it would also be reasonable to include two of these instruments, thus raising the projected need and demand for shielded enclosures to 17.

Mating of modern scientific instruments with shielded cell capability and subsequent operation of these sensitive instruments in a high radiation environment has not been routinely achieved. Effective development of these capabilities requires careful engineering, prototyping, and testing of these systems. For this reason, space for these capabilities is required for the APIEC.

Recent experience with production of atom probe tips and TEM specimens from irradiated materials indicates that sample degradation during transport is a common occurrence, and it is highly desirable that the TEM and atom probe instruments be co-located in the same facility with the FIBs, even though they would likely not require shielding.

Figure 4 shows the allocation of shielded enclosures and a notional grouping of instruments within the thermal and mechanical cells.

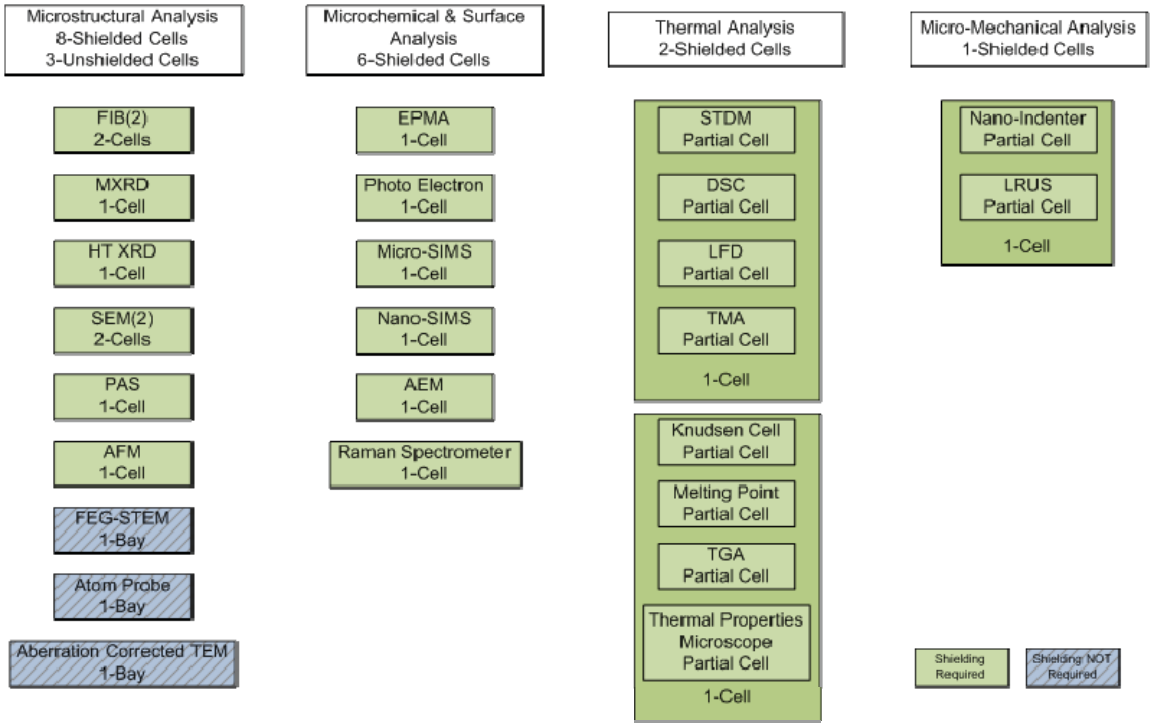


Figure 4. Cell space requirements determined by workshops, DOE-NE, R&D programs

2.2.3 Basis for Alternatives Comparison

During the pre-conceptual design of the PIE Line Item Building, it was determined that a facility capable of accommodating 17 shielded cells would be too expensive and that a smaller, reduced capability facility should be designed and proposed. The resulting design includes seven shielded hot cells (as a base minimum), four unshielded examination bays, a flexible and dedicated sample preparation cell, and floor space for future shielded cell expansion (up to an additional 7 cells).

The seven modular shielded hot cells included are allocated as follows: one dedicated cell for micro-mechanical testing, one dedicated cell for thermal testing, and five dedicated cells for micro-structural and micro-chemical analyses. The modular cells are designed to be reconfigurable to move equipment in and out of the space and provide the flexibility to achieve APIEC objectives.

The estimated cost for the design is $150-200M. The use of the expansion area to house additional shielded cells is pending the availability of future funding. The resulting pre-conceptual design is consistent with the budget constraints that exist within DOE. The pre-conceptual design of the PIE Line

Item Building can therefore be leveraged and used as a basis for the design and comparison of affordable alternatives that are affordable. Once an alternative is selected for implementation, additional efforts will be optimized for size, cost, and functional scope to maximize the DOE investment. Until that time, and for alternative analysis purposes only, the APIEC team will assume that the number of shielded enclosures provided by the APIEC is seven and the number of unshielded spaces is four.

2.3 Analysis Goals and Requirements

This section documents the goals and requirements that will guide the selection of a preferred alternative for providing the APIEC.

- Goals are statements of desired states, responses, or outcomes for the APIEC. Herein, they provide context for the threshold requirements as well as tradable wants and performance objectives. Each goal has been individually weighted based on its relative importance to the overall decision.
- Requirements are conditions that any proposed solution to the problem must meet to be deemed an acceptable solution. They stipulate what the solution must do (i.e., the functions, services that must be performed) and, generally, the threshold performance level associated with those functions or services. The requirements will be used in a "Go/No-Go" analysis to screen out alternatives that are not acceptable solutions.

Figure 5 is a system boundary diagram for the APIEC which illustrates the relationship between the APIEC and the alternative analysis goals.

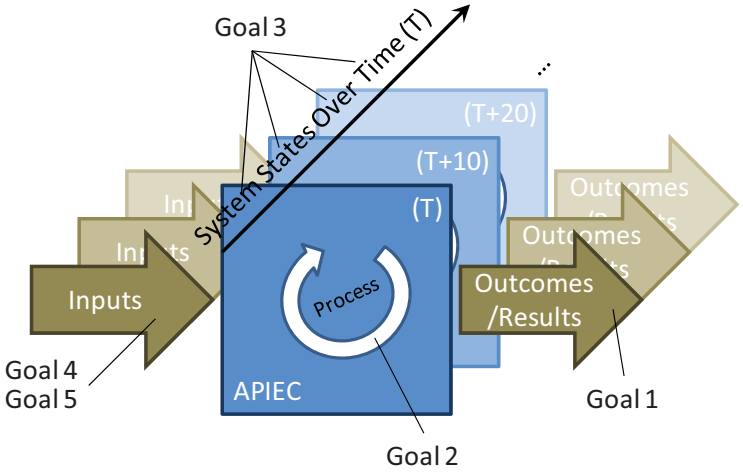


Figure 5. APIEC system boundary in relation to APIEC goals.

It should be noted that each APIEC alternative that includes DOE capital investment has been designed to provide equal technical performance to the extent practical. In other words, modifications (e.g., vibration isolation tables, cell temperature control requirements) have been identified for these alternatives such that they would be capable of housing the initial complement of APIEC examination equipment. Thus, for these alternatives, the ability to support a science-based approach will be a non-discriminator at least as far as the PIE instrumentation is concerned. Then, considering the transitory nature of the APIEC examination equipment over time (i.e., being changed out at the end of their useful lives, approximately every 10 years), the focus of this analysis necessarily moves more and more toward the facilities that house these instruments, the associated fixed hot cell attributes, and the supporting infrastructure. Thus, it is anticipated that the capital costs involved in bringing these facilities and hot cells to a state where they can effectively house the APIEC examination instruments, as well as the

associated operating and maintenance (O&M) costs for the 40 year evaluation period, will serve as key discriminators in identifying a recommended alternative. As such, the criteria listed for this goal in Section 2.6.4 do not include certain technical performance measures associated more directly with PIE results (e.g., PIE resolution quality) that the reader might normally expect for an alternatives analysis of this type.

The goals and their associated requirements are shown in Figure 6 and discussed in detail in the following subsections.

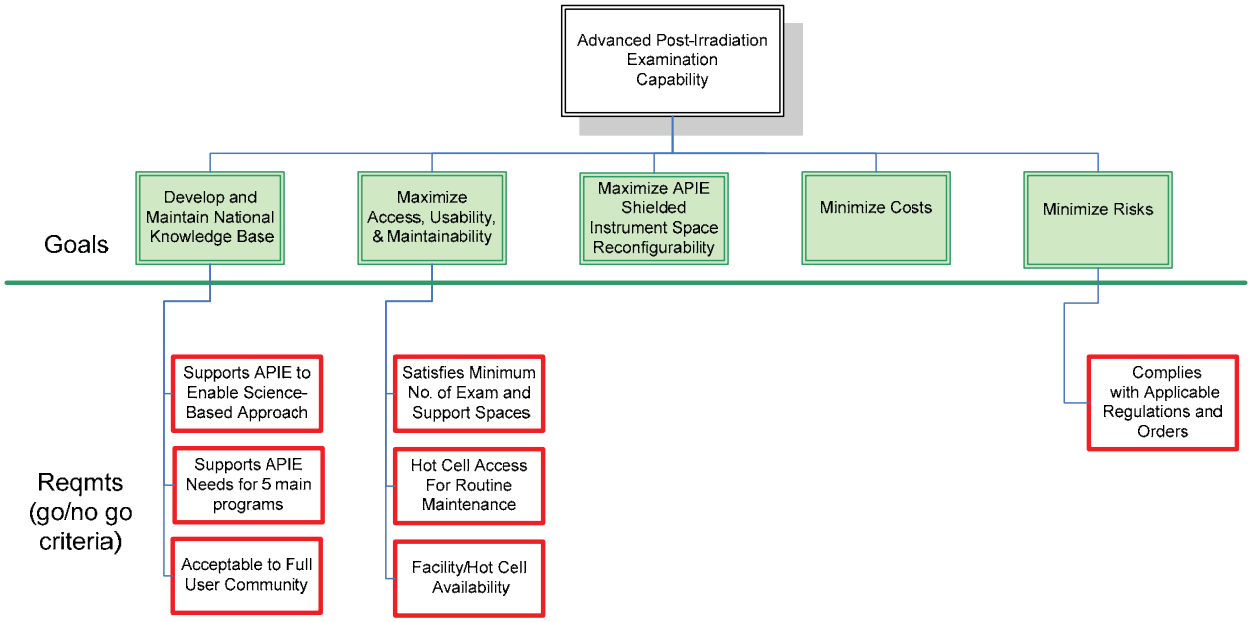


Figure 6. APIEC Goals and Requirements.

The goals and requirements presented in a previous revision were reviewed by the SRC at Workshop 1 and changes to the goals and requirements were recommended by the SRC. The descriptions provided below have been updated to reflect the results of Workshop 1.

2.3.1 Goal 1: Develop and Maintain National Knowledge Base

Goal 1 evaluates the ability of an alternative to support advanced PIE that will improve the U.S. and DOE's capability to advance nuclear energy technology using a science-based approach that meets DOE objectives and will support a variety of programs. The following programs represent likely near-term users of the APIEC whose work encompasses the range of advanced PIE that will be needed:

- Light Water Reactor (LWR) Sustainability
- Fuel Cycle Research and Development (FCRD) Program
- Advanced Reactor Concepts
- Department of Defense (DoD) and National Homeland Security (NHS) Programs
- University Programs.

Goal 1 Requirements

1. Supports advanced PIE to enable science-based approach – This is the fundamental requirement for the APIEC. If an alternative is not able to support the deployment and optimal use of advanced PIE instrumentation for the development of nuclear fuels and

materials, the alternative will be eliminated. This requirement is generally accepted as the ability to examine/characterize high-radiation dose-rate fuels and materials (including those needing inert atmosphere processing) and additionally, relative to micro-/nano-structural examinations, the ability to routinely collect data at the 10^{-9} to 10^{-10} meter resolution scale.

2. Supports advanced PIE needs for the five main programs – The Nuclear Energy, nonproliferation, and university programs noted above represent a broad sample of R&D activities that are being pursued in the development of new nuclear fuels and materials. If the APIEC can support these programs, it is likely that it will be robust enough to support many, if not most, future programs as well.

3. Acceptable to the full user community – This requirement stipulates that the APIEC system architecture, including service provider(s), must be acceptable for use by the entire user community, which is expected to include DOE, U.S. universities, domestic commercial, and international entities engaged in nuclear fuel and materials development; and other U.S. governmental agencies including National Nuclear Security Administration (NNSA), NHS, and DoD. Any alternative that does not address this full range of users will be eliminated from further consideration.

2.3.2 Goal 2: Maximize Access, Usability, and Maintainability

Goal 2 evaluates selected features of the various alternatives that can impact overall APIEC operations, in other words, that might avoid known issues relative to moving through the advanced PIE process.

Goal 2 Requirements

1. Satisfies minimum number of examination and support spaces – A basic assumption for this analysis is that all alternatives must provide advanced PIE instrument space equivalent in number to the space identified in the PIE Line Item Building pre-conceptual design (Reference INL-EXT-10-19923). This space requirement includes six shielded hot cells for micro-structural/mechanical examination, one shielded hot cell for thermal examination (sized to include two or three thermal instruments), and four non-shielded spaces for examination instruments that do not require shielding (e.g., transmission electron microscopes and atom probe microscopes) and for related preparation equipment, such as gloveboxes and hoods.

   It must be noted that the actual number of shielded and non-shielded instrument spaces implemented for the APIEC may deviate from that described above and will likely be determined during conceptual design. The minimum of seven shielded (i.e., six micro-structural/mechanical and one thermal examination cells) and four non-shielded spaces is credible based on the MNS, provides a uniform basis for alternative comparison, and is convenient (i.e., allows existing cost estimates to be leveraged). Also, these instruments are only examples of what might be installed for the APIEC. The APIEC is being implemented to deploy world-leading instruments that might still be in development as of today.

2. Hot cell access for routine maintenance – First, this requirement stipulates that shielded instrument hot cells have an opening through which personnel can enter the cell for routine maintenance of the advanced PIE instruments. The rationale for this is that certain advanced PIE instruments are expected to require hands-on (i.e., non-remote) activities (e.g., calibration, replenishment of coating materials). Second, this requirement stipulates that all instrument hot cell shielding must be configured in such a manner that routine maintenance can occur in one cell without impacting operations in an adjacent cell. Such a configuration supports expectations for state-of-the-art laboratory operations. Ingress to the cell via roof hatches is not considered a viable means of ingress/egress for frequent cell entries.

3. Facility and hot cell availability – This requirement stipulates that the hot cells/workstations identified for use in the APIEC alternatives be dedicated entirely to the advanced PIE mission. It is also expected that these types of advanced PIE instruments cannot be routinely installed and removed to allow other operations to occur in the identified cells.

2.3.3 Goal 3: Maximize APIEC Shielded Instrument Space Reconfigurability

Goal 3 rates the flexibility of the various alternatives to be initially configured and, later, reconfigured for installation of new instruments. The APIEC is expected to operate for 40 years with an "instrument update" period of about 10 years. The updating of instrument capabilities will likely require new alpha/inert atmosphere confinement enclosures as well as modifications to the cells to accommodate different penetration locations, utilities, etc.

Goal 3 Requirements

None identified.

2.3.4 Goal 4: Minimize Costs

Goal 4 evaluates the costs, in money and time, associated with the APIEC. This encompasses the direct costs of obtaining the desired data including packaging and transportation, sample preparation, examination, and reporting, the total project costs (as defined by 413.3B) associated with deploying the capabilities, and the operating and maintenance costs of facilities. This goal also addresses the time component of costs by considering the time to receive data and the time to construct the capabilities.

Goal 4 Requirements

None identified.

2.3.5 Goal 5: Minimize Risks

Goal 5 considers some specific risks associated with the APIEC project, including safety and health risks, security risks, and risks to obtaining the APIE data.

Goal 5 Requirements

1. Complies with all applicable regulations and orders – This requirement stipulates that all the alternatives must comply with the applicable local building codes, federal and state regulations, and DOE Orders.

2.4 APIEC Scope, General Assumptions, and Process Flow

This section provides additional context for understanding the APIEC alternatives and how the capabilities are expected to be evaluated.

2.4.1 APIEC Scope

The APIEC scope includes thermal, micro-/nano-structural, micro-/nano-chemical, and mechanical properties characterization of highly irradiated nuclear fuels and materials including samples of failed fuels and samples from transient testing. In addition to these primary examination/characterization functions (shielded and unshielded), the following support and infrastructure functions are also included in the APIEC scope and must be repeated at each separate DOE, commercial, or international laboratory considered in the APIEC alternatives:

- Shielded cask receiving/unpacking/packing
- Shielded source material storage
- Shielded source material sizing/capsule disassembly

- Shielded sample/specimen preparation
- Final prepared sample/specimen shielded storage and archive
- Shielded waste processing/packaging.

The APIEC scope does not include examination/characterization of pre-irradiation or conditioned specimens.[a] The APIEC scope also excludes other PIE capabilities such as those used for non-destructive examination (NDE), chemical, isotopic, and radiological analyses or any method involving sample dissolution (i.e., wet chemistry).

2.4.2 APIEC General Assumptions

General assumptions, applicable to most APIEC alternatives are as listed below. Additional assumptions, applicable to specific alternatives may be included in the alternative descriptions contained in Section 2.5.

- Seven shielded hot cells and four non-shielded instrument spaces are needed for housing the examination/characterization functions of the APIEC. This is based on the number of spaces identified in the PIE Line Item Building preconceptual design report (INL/EXT-10-19923) and provides a common basis for alternative comparison.
- The amount of space needed for each APIEC function is approximately equal to that planned for the PIE Line Item Building. The approximate areas are summarized below:
  - Cask receiving/unpacking/packing – 80 ft^2
  - Source material storage – 80 ft^2
  - Source material sizing/capsule disassembly and sample/specimen preparation – 400 ft^2
  - Shielded sample/specimen examination – 720 ft^2. (1,160 with support equipment space adjacent to but outside the shielded cell)
  - Non-shielded sample/specimen instrument spaces – 480 ft^2
  - Final prepared sample/specimen storage and archive – 250 ft^2
  - Waste processing/packaging – 100 ft^2.

  Note: *Other facility operations and maintenance support spaces (gloveboxes, lab hoods, hot/cold maintenance shops, radiological control, change areas, offices, restrooms, etc.) are assumed to be present and available in all alternatives. As such, these ancillary areas can be disregarded for this alternatives analysis.*
- The following APIEC functions must be repeated at each location if implementation of the APIEC involves more than one DOE, commercial, or international laboratory site—repeated instances should include the function's full space allocation:
  - Cask receiving/unpacking/packing
  - Source material sizing/capsule disassembly
  - Sample/specimen preparation

[a] Other DOE assets are available for performing these examinations and the APIEC is not intended to replace or supplement them. However, this exclusion is not intended to imply that examination of such specimens could not be performed using the APIEC instruments if the need arose.

  - Waste processing/packaging.

- The following APIEC functions must be repeated at each location if implementation of the APIEC involves more than one DOE, commercial, or international laboratory site—repeated instances may include a portion of the function's full space allocation, however, the total area (summed across laboratory sites) should satisfy the full amount of space needed:
  - Source material storage
  - Shielded sample/specimen examination
  - Non-shielded sample/specimen instrument spaces
  - Final prepared sample/specimen storage and archive.
- Of the shielded spaces available at a specific laboratory, priority must first be given to the functions that provide the minimum necessary infrastructure to perform the advanced PIE work (e.g., cask unpacking/packing, source material storage, sample sizing/preparation, and waste processing/packaging). It is only after all the necessary infrastructure spaces have been allocated to a laboratory, that the first shielded instrument space may be allocated.
- Nuclear materials and fuels received directly at APIEC, via cask, will be 24 inches or less in length. The APIEC is expected to accept samples from all over the world; however, material larger than 24 inches will need to be size-reduced at other facilities (e.g., Hot Fuel Examination Facility [HFEF] at INL or the Irradiated Fuels Examination Laboratory [IFEL] at the Oak Ridge National Laboratory [ORNL]) prior to receipt.
- Facilities currently engaged in PIE work, but not used or modified as part of APIEC implementation, are assumed to still be needed to support lower-radiation PIE research from domestic and international sources as well as other high-radiation PIE and support functions not covered by the APIEC scope (e.g., large scale sizing, non-destructive examination, or radiochemical analysis).
- The facility (or facilities) selected to comprise the APIEC alternatives are limited to Hazard Category 2 nuclear facilities or equivalent (e.g., licensed by the U.S. Nuclear Regulatory Commission [NRC], or a foreign government, to handle and store irradiated nuclear fuels and materials). Furthermore, it is assumed that facilities that are less than the equivalent of Hazard Category (HC)-2 will not upgraded to become HC-2 (or equivalent).

  Exception: *Facilities selected to house the APIEC non-shielded instrument spaces, if not housed within the same facility as the shielded hot cells, may be HC-3, Less than Hazard Category (LTHC)-3 radiological facilities, or equivalent.*
- The following material/thickness shielding guidelines are assumed to represent APIEC minimums (for high-radiation PIE work) when determining either (a) the scope of facilities that may be included in an alternative (for alternatives that do not allow modifications); or (b) the amount of shielding that must be available at hot cells after construction of, or modifications to, facilities included in an alternative (for alternatives allowing modifications only):
  - 6.25 inches of lead (11.35 g/cm3)
  - 11.75 inches of steel (7.86 g/cm3)
  - 35 inches of standard concrete (2.35 g/cm3)

  - Equivalent material/thickness combinations that achieve 0.5 mrem/hr or less for normally occupied areas when shielding a 30 Ci point source at 1 MeV gamma.

Note: *Minimum shielding applies to hot cells used for cask unloading/loading, source material storage, source material sizing/capsule disassembly, sample preparation, specimen examination (excluding non-shielded spaces), final prepared sample storage/archive, and waste processing/packaging. Shielding is based on a representative specimen modeled as a 30 Ci point source with 1 MeV gamma radiation.*

- The facility (or facilities) that comprise the APIEC alternatives, at a minimum, must be capable of receiving, unloading, loading, shipping, and associated handling of the following casks: ALP-7, GE-100, ES-3100, 9975 family, and the 6M drum family.
- All examination instruments used to support the APIEC alternatives are assumed to have an operational life of 10 years. After the 10-year lifespan has concluded, it is assumed that the old examination instruments are removed and new examination instruments are acquired, modified for remote operation, and installed/integrated into the cell. Furthermore, costs for examination instrument acquisition and modification for remote operation are assumed equal for all alternatives and, therefore, will not be a discriminator. Such costs, however, will be developed for the analysis as part of reporting a complete life-cycle cost.

  Notes: *(a) Examination instrument installation costs are expected to differ depending on hot cell attributes specific to the facility, or facilities, comprising the alternatives and must be taken into account when calculating alternative life-cycle costs. (b) For all but the "no action" alternative, replacement instruments are assumed to be state-of-the-art at the time of replacement. In the "no action" alternative, replacement instruments are assumed to be like-for-like with no improvement in PIE performance (e.g., throughput or scale of resolution).*

2.4.3 APIEC Process Flow

The process flow for a typical irradiation experiment starts with initial modeling and experiment design and progresses through a complex path. These experiments can be as simple as an irradiation of material coupons to determine neutron damage or as complex as a fuel length transient test of a liquid metal cooled fast reactor. For the purposes of this alternatives analysis, the process flow will start with completion of irradiation in a DOE, university, commercial, or international reactor.

Experiments supporting DOE-NE missions are typically irradiated at the Advanced Test Reactor (ATR) at INL, the High Flux Isotope Reactor (HFIR) at ORNL, or at a university research reactor (primarily, the Massachusetts Institute of Technology Nuclear Research Reactor [MITR]). Other sources of irradiated experiments to be considered include irradiated fuels and materials from domestic commercial power plants (primarily full-length light water reactor [LWR] rods or fuel bundles) as well as internationally irradiated experiments/samples that are transported to the United States by ocean freighter. ATR and HFIR are the primary irradiation sites for fueled experiments (with and without cladding) and have active sections that can measure up to about 4 ft. in length. Full length LWR fuel rods and fuel bundles (measuring up to 14 ft.) are irradiated only in commercial power plants.

When the irradiation is complete, the experiment is removed from the reactor and after a sufficient "cool down" period it can be shipped directly to the APIEC for examination (in the case of simple materials experiments for example) or, if necessary, to a intermediate facility for disassembly, NDE, and rough sizing, as applicable. The majority of such shipments involves Type B quantities and require heavily shielded and DOT licensed casks, such as the GE-2000, NAC-LWT, or Battelle Energy Alliance Research Reactor Cask (BRRC).[b] Simpler, out-of-commerce shipments are possible if the irradiator and

[b] Special facilities and support equipment are required for loading, unloading, moving, and opening these large and heavy casks.

the destination facility (i.e., APIEC or intermediate NDE/sizing facility) are co-located at a DOE laboratory and covered by a DOE-approved umbrella transportation safety plan.

If intermediate, pre-APIEC processing is required, the experiment must be received into an appropriately equipped hot cell facility. After receipt, NDE will typically involve visual examination, full-length profilometry, bow and length measurements, precision gamma scanning, and eddy current examination. Additional specialty techniques are also available at some sites (e.g., neutron radiography at HFEF and infra-red thermal imaging at IFEL). These non-invasive methods help researchers to, for example, identify defects in cladding, determine oxide layer thicknesses, detect even slight changes in the irradiated item, and identify other areas of scientific interest. Three DOE sites are available for NDE and pre-APIEC processing, as shown in Table 1.

Table 1. Existing DOE facilities with full NDE and large-scale sizing capabilities

Item Type	HFEF (INL)	IFEL (ORNL)	RPL (PNNL)
Fuel Pin/Segment (≤2 ft. long) – for Full NDE Only	✓	✓	✓
Fuel Pin/Segment to Full Length LWR Fuel Rod (>2 ft. long) – Full NDE and Large-Scale Sizing	✓	✓	✓ (up to 8 ft. without segmenting prior to NDE)
Fuel Assembly/Bundle – Full NDE and Large-Scale Sizing	✓	NA	NA

After the NDE is complete, some fueled test articles may be pierced to sample accumulated fission gases for separate analysis. The experiment can then be destructively disassembled, cut/sectioned, or otherwise separated to remove and obtain the previously identified portions of interest. A dry, inert atmosphere is required for these destructive activities if the irradiated materials or fuels involved will react in air or in the presence of moisture. The items to be examined using advanced PIE techniques are assumed to require size reduction to nominally 2-ft lengths or less. These items are then packaged and transported (again as a Type B shipment) to the APIEC facility (or facilities), except that smaller shipping casks such as the ALP-7, 9975 family, GE-100, or ES-3100 can now be used.

Upon receipt of the sample into an APIEC facility's shielded enclosure or hot cell, activities such as wafering/coring, mounting, grinding/polishing, etching, and coating application/deposition will be performed to prepare specimens for examination. Unused sample material or fuel may be placed into storage in case additional specimens are needed. The prepared specimens are then moved via a special transfer device to an appropriately shielded instrument cell for the advanced PIE. The examined specimens may be archived in a shielded storage location for an undetermined period of time.

Wastes from sample preparation and examination activities will need to follow approved disposition paths. Discarded sample material (i.e., non-fuel) and waste incidental to the preparation and examination process (e.g., tools, gloves, and miscellaneous sample waste) can most likely be disposed of by the APIEC facility as low-level waste (LLW) or remote handled LLW (RH-LLW).

Relative to receipt, examination, and storage of irradiated fuel samples and final disposition of fuel wastes, most DOE sites are prevented from receiving such samples without case-by-case review/approval from their DOE site management and their host state unless special agreements have been negotiated and approved that would allow the APIEC facility(ies) to receive them (see Table 2).

Table 2. Receipt, storage, and waste disposition capabilities.

Item	Activity Description	DOE Laboratory Capability?				
		INL	LANL	ORNL	PNNL	SRNL
Irradiated Materials (i.e., non-fuel)	Receipt for PIE	Yes	Yes	Yes	Yes	Yes
	Short-term Storage (during PIE)	Yes	Yes	Yes	Yes	Yes
	Specimen Archive/Library (long-term storage)	Yes	Yes	Yes	Yes	Yes
	Waste Management					
	Secondary Waste Disposition (LLW & RH-LLW)	Yes*	Yes*	Yes*	Yes*	Yes*
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE; LLW & RH-LLW)	Yes*	Yes*	Yes*	Yes*	Yes*
		*On-site or Commercial Disposal Facilities Available				
Irradiated Nuclear Fuel - DOE Owned (defense related & TRU)	Receipt for PIE	Yes	Yes	Yes	Yes	Yes
	Short-term Storage (during PIE)	Yes	Yes	Yes	Yes	Yes
	Specimen Archive/Library (long-term storage)	Yes	Yes	Yes	Yes	Yes
	Waste Management					
	Secondary Waste Disposition (LLW & RH-LLW)	Yes*	Yes*	Yes*	Yes*	Yes*
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE) - Interim Storage	Yes	Yes***	Yes***	Yes***	Yes***
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE) - Final Disposal	WIPP**	WIPP**	WIPP**	WIPP**	WIPP**
		*On-site or Commercial Disposal Facilities Available ** Subject to WIPP WAC for RH-TRU and Authorized Waste Certification *** Requires prior approval by State and/or DOE Field Office				
Irradiated Nuclear Fuel - DOE Owned (all other)	Receipt for PIE	Yes	Yes	Yes	Yes	Yes
	Short-term Storage (during PIE)	Yes	Yes	Yes	Yes	Yes
	Specimen Archive/Library (long-term storage)	Yes	Yes	Yes	Yes	Yes
	Waste Management					
	Secondary Waste Disposition (LLW & RH-LLW)	Yes*	Yes*	Yes*	Yes*	Yes*
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE) - Interim Storage	Yes	Yes***	Yes***	Yes***	Yes***
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE) - Final Disposal	NA	NA	NA	NA	NA
		*On-site or Commercial Disposal Facilities Available ***Requires prior approval by State and/or DOE Field Office NA = Not Available (no permanent repository)				

Item	Activity Description	DOE Laboratory Capability?				
		INL	LANL	ORNL	PNNL	SRNL
Irradiated Nuclear Fuel (SNF/UNF) - Commercially Owned	Receipt for PIE	Yes w/DOE-ID Permission (DOE assumes ownership; annual quantity limited: 400 kg)	Case-by-Case Review (DOE-LASO & State of NM)	Case-by-Case Review (DOE-ORO & State of TN)	Yes	Case-by-Case Review (DOE-SR & State of SC)
	Short-term Storage (during PIE)	Yes	Yes, if accepted	Yes, if accepted	Yes	Yes, if accepted
	Specimen Archive/Library (long-term storage)	Yes (total quantity limited: 10 kg)	Yes, if accepted; Must be returned to owner otherwise	Yes, if accepted; Must be returned to owner otherwise	No. Must be returned to owner	Yes, if accepted; Must be returned to owner otherwise
	Waste Management					
	Secondary Waste Disposition (LLW & RH-LLW)	Yes*	Yes*	Yes*	Yes*	Yes*
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE) - Interim Storage	Yes (until 2035; total quantity limited: 55 MT)	Yes, if accepted; Must be returned to owner otherwise	Yes, if accepted; Must be returned to owner otherwise	No. Must be returned to owner	Yes, if accepted; Must be returned to owner otherwise
	Remnant (i.e., unused) Sample & Discarded Specimens (after PIE) - Final Disposal	NA	NA	NA	NA	NA
		*On-site or Commercial Disposal Facilities Available NA = Not Available (no permanent repository)				

As shown, without such agreements, fuel samples and fuel waste will be returned to its owner (e.g., DOE, a commercial nuclear power plant, or an international nuclear research facility). This is because there is no national repository that is currently licensed to dispose of these materials after the PIE work has been completed.[c] Returns of this kind can be burdensome not only because of transportation costs (they require Type B or A shipments) but also because certain entities, such as U.S. universities, may not be well suited to store these items upon their return. Also, because multiple DOE, commercial, or international laboratories may be involved in implementing the various alternatives, researchers will need to contend with multiple and different processes for storage and disposition of these wastes.

2.5 Alternative Definitions

This section describes each of the six alternatives considered in the alternatives analysis as well as any assumptions made in defining the alternatives. The following list encompasses the alternatives that were identified in the MNS approved by DOE in January 2011. Additional alternatives may be added for consideration during the analysis.

1. No action
2. Modify existing facilities distributed across the DOE complex
3. Modify existing facilities within the DOE complex, but consolidate capabilities at one or two laboratories
4. Construct a modern research facility to support advanced PIE capabilities
5. Establish partnerships or contractual arrangements with commercial laboratories to establish advanced PIE capabilities
6. Leverage international partnerships to use advanced PIE capabilities located around the world.

2.5.1 Alternative 1: No Action

Alternative 1 takes no action (no modifications to existing facilities or construction of new facilities) to implement the APIEC and relies on existing DOE-owned, HC-2, nuclear facilities that already have some space, if not their entirety, dedicated to a PIE mission. To act in the APIEC role, these facilities must already have shielded hot cells with shield walls equivalent to 12 inches of steel, as a minimum. Exceptions to these constraints are made for the non-shielded instrument spaces, which require little or no shielding and can be allocated to HC-3 or LTHC3 radiological facilities. No capital expenditures for modifications to these facilities will be made, although periodic facility "resets" are assumed to occur to extend the useful life of included facilities through the end of the evaluation period. The facilities will be used "as is" with their currently installed PIE instrumentation.

Support of the ATR National Scientific User Facility (NSUF) would continue much as it is today with agreements and funding currently in place. DOE would also continue to provide funding at current levels for operating and maintaining the identified facilities.

2.5.1.1 Assumptions

Assumptions made for this alternative are as follows:

- Existing DOE facilities used to support APIEC alternatives will be "reset" at the end of their expected facility life if the expected facility life is reached within the 40 year APIEC alternatives analysis period. A facility "reset" provides an additional 20 years of facility life. Note: A facility "reset" is assumed to have no effect on PIE performance.

[c] A possible exception is irradiated fuel samples and associated wastes that are determined to be defense-related and TRU. It may be feasible to dispose of these wastes at the Waste Isolation Pilot Plant in New Mexico.

- The facilities comprising the No Action APIEC alternative must be DOE-owned facilities that are available to dedicate to, or otherwise support, the APIEC mission.

2.5.1.2 Facility and Hot Cells Description

The DOE-owned HC-2 facilities with hot cells that currently support PIE activities to some extent, and are potentially available to continue support of APIEC are as follows:

- INL – Materials and Fuels Complex (MFC)-785, Hot Fuels Examination Facility (HFEF)
- INL – MFC 1729, Irradiated Materials Characterization Laboratory (IMCL)[d]
- Los Alamos National Laboratory (LANL) – Chemical and Metallurgical Research (CMR) Facility – Wing 9 Hot Cells
- ORNL – Building 3525, Irradiated Fuels Examination Laboratory (IFEL)
- Pacific Northwest National Laboratory (PNNL) – Building 325, Radiochemical Processing Laboratory (RPL)
- Savannah River National Laboratory (SRNL) – Shielded Cell Facility—High-Level Cell.

These HC-2 facilities, described in detail below in their "as-is" condition, will be graded against the same goals, requirements, and criteria as the other alternatives for providing the APIEC.

Idaho National Laboratory – Hot Fuels Examination Facility [MFC-785]

The HFEF, commissioned in 1975, is a heavily-shielded HC-2 non-reactor, nuclear facility suited by its original design as the front end of the PIE capability. It is a safeguards category III/IV facility and has the ability to receive and handle large quantities (kilograms to hundreds of kilograms) of nuclear fuels and materials in a wide variety of shipping casks, including full-size commercial LWR fuel. The current HFEF mission is to receive irradiated experiments, conduct NDE and optical microscopy, and prepare material and fuel specimens for transfer to characterization laboratories for detailed analyses. Examples of sample preparation for further examination include sectioning fuel rods to produce cross-section specimens on the pellet scale, preparing cladding specimens for mechanical testing and micro-structural analysis, sorting and packaging hundreds to thousands of material test specimens from test reactor irradiation experiments, and machining large pieces of in-core structural materials mined from decommissioned power reactors into test specimens. HFEF also houses limited mechanical testing equipment. A floor plan of the HFEF is shown in Figure 7.

The HFEF houses two adjacent shielded hot cells (the Main and Decontamination cells), a shielded metallography box, and an unshielded hot repair area (HRA) and a waste characterization area (WCA). The building is a three-story structure with a tall high bay on the top floor and a basement support area. The building dimensions are 112 ft. wide by 154 ft. long by 82 ft high, with a lower 19' x 26' extension to the north enclosing a neutron radiography facility. Large equipment items and shipping casks are moved into and out of HFEF through a truck lock on the west end of the building.

The HFEF Main cell is 70' long by 30' wide by 25' high with 4' ft thick high density concrete walls and has an argon gas atmosphere. Moisture and oxygen levels are maintained about 60 ppm using a purification system. There are fifteen workstations in the Main Cell and each is equipped with a lead glass window and two master/slave manipulators. The Main Cell is equipped with six material transfer penetrations. The transfer penetrations include a large equipment vacuum lock, a small equipment lock, a

[d] Assumes that planned relocation of previously purchased PIE instruments to IMCL has occurred for purposes of shielded instrument development activities. These instruments, when installed in IMCL and operational, would provide limited throughput (i.e., non-production) capabilities representing a material step forward in establishing the APIEC.

floor penetration for access to shielded shipping casks, a ceiling penetration equipped with a purged lock for large experiment handling, and two rapid insertion tool locks.

There is a pneumatic transfer station inside the Main cell that connects it to the shielded metallography box. An 8' deep space is located beneath removable flooring over the entire width of the east end of the cell. The space is used for storage of materials and equipment. Also located in this space are the ducts and filters for the Main Cell cooling system. In addition to the sub floor space, two 3' diameter pits extend 30' below the level of the removable floor at two workstations on the east end of the cell. These pits are used for storage and handling of long items such as long experiments and LWR fuel assemblies.

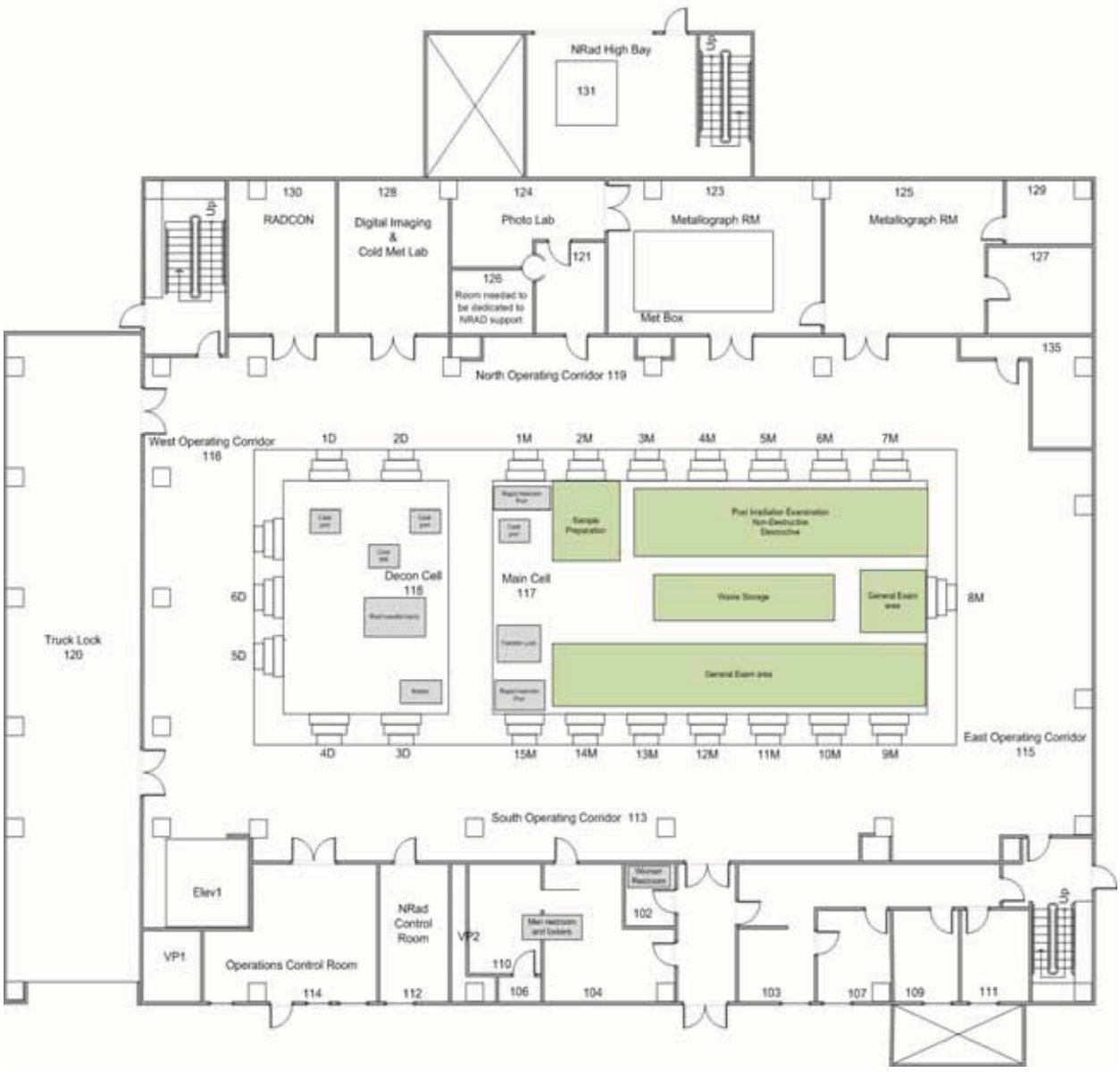


Figure 7. HFEF floor plan.

Idaho National Laboratory – Irradiated Materials Characterization Laboratory [MFC-1729]

IMCL's mission as a "warm shell" facility focuses on demonstrating the instrument modifications to support remote operation, the inert confinement enclosure and associated instrument interfaces, and other

shielded cell concepts. As such and without a change to this mission, IMCL could support limited throughput PIE activities as opposed to the full production mode capabilities associated with APIEC. The IMCL mission strategy requires that equipment and instruments be removable, allowing the space to be reconfigured to support changing Laboratory missions. The full advanced PIE capabilities are not within the current scope of IMCL. For example:

- IMCL will have minimal sample preparation. Samples for analysis will be received at HFEF for any rough sizing. Sample preparation may be provided by the HFEF containment box (limited metallurgical mounts) of the IMCL sample preparation equipment.
- Samples or prepared specimens will be transported to IMCL in a small on-site transport package/container from HFEF
- Shielding design will be based on instrument prototyping needs:
  - Shielding thickness will be based on a single specimen or surrogate as a source (i.e., less than 12” of steel equivalent)
  - Shielding components will support quick changes (assembly/disassembly) to facilitate mockup of alternative configurations to determine what works best for a specific examination instrument
  - Shielded pass-throughs and doors (typical in more permanent applications) will be minimal due to reconfiguration needs
  - Routine use of moveable/temporary shielding is expected for case-by-case conditions
- The shielding will not be considered a secondary contamination confinement. This limits the material at risk (MAR) that will be allowed in the facility
- IMCL will provide storage for only a few samples/specimens at a time – routine storage must be provided elsewhere (i.e., HFEF)
- Temperature control for installed instruments will be limited to that provided by IMCL heating, ventilation, and air conditioning (HVAC) system for the general laboratory area
- Inert gas, if needed, will be supplied to confinement boxes from local gas bottles rather than a general facility Dewar system.

Figure 8. IMCL with three shielded development cells.

Due to the limitations noted above, the IMCL cells and instruments, under its current mission, will not be considered directly (i.e., "as is") in Alternatives 2 (DOE Distributed) and 3 (DOE Consolidated). For those alternatives, it will be assumed that the development cells will be removed and new hot cells and other facility modifications will be made to modify the IMCL mission from a PIE instrument prototyping facility to an APIEC production facility.

Los Alamos National Laboratory - Chemistry and Metallurgy Research Facility, Wing 9 [TA-3-29]

The CMR facility, constructed in 1952, is a three-story, reinforced-concrete structure with seven laboratory wings and one administration wing, all connected to a central (spinal) corridor. Each wing is designed to operate independently, and each has its own electrical power substation and ventilation system. The first floor of each laboratory wing generally contains laboratory space and an equal amount of office space. The basement and second-floor spaces were designed to provide utility services for the first-floor laboratories and offices. Several of the wings of the CMR Facility have discontinued programmatic work, but the main facility, three laboratory wings, and the hot cells continue to serve multiple programs. An aerial photo and cutaway drawing of the CMR building appear in Figure 9.

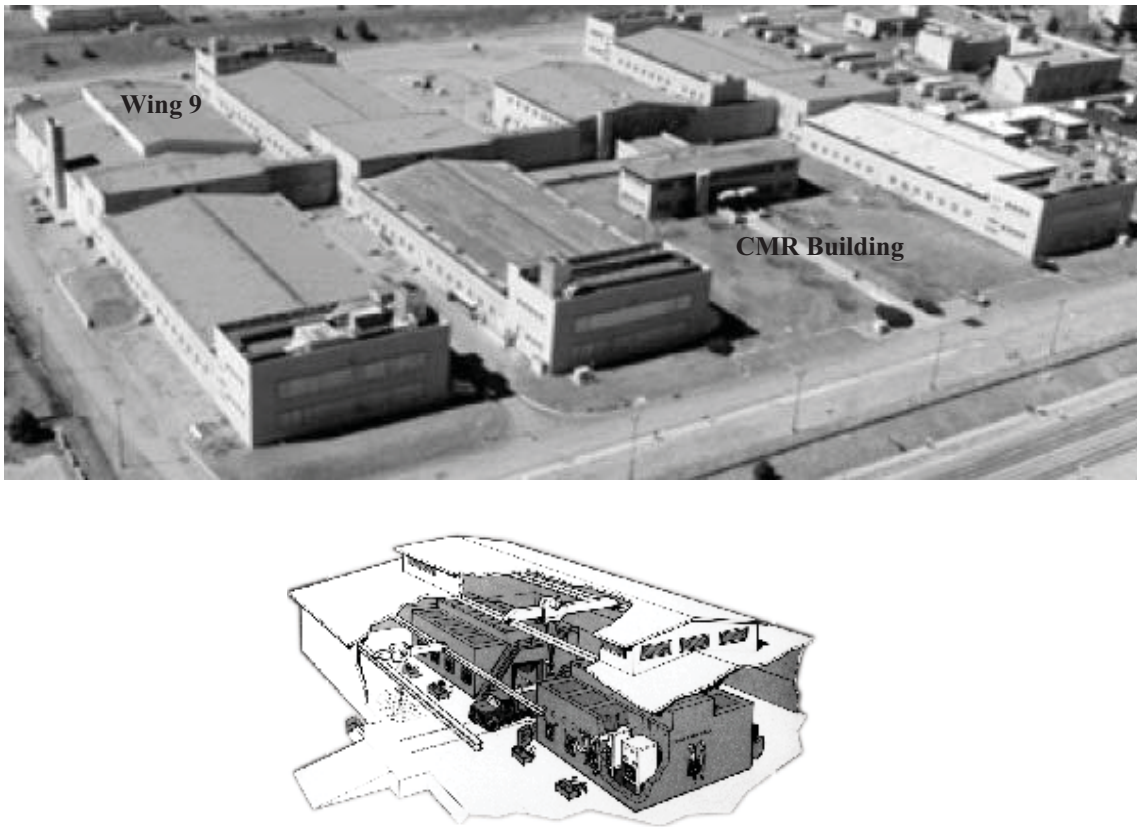


Figure 9. CMR facility at LANL

Wing 9 of the CMR consists of 54,000 ft^2 of industrial-quality space with offices. It was designed and constructed in 1960 and commissioned in 1961 to support programs requiring hot-cell facilities, including the postmortem examination of irradiated fuels for breeder reactors. It has a large bay area that contains hot cells with remote handling capabilities, support laboratories, a high bay area, and railed turntable for receipt and handling of shielded casks and other heavy equipment. A rollup door is located on the south wall of the wing, allowing receipt and shipment of materials, casks, and equipment. Men's and women's change rooms are located at the interior access to the wing. The Authorization Basis for the CMR, as documented in the Basis for Interim Operation (BIO), results in a Security Category III and HC-2 facility. The BIO allows for up to 30 one-meter long fuel stacks to be worked on at one time. All high activity radioactive materials that are alpha, beta, gamma, and/or neutron emitters can be handled.

CMR Wing 9 contains two banks of 8 hot cells, 16 total, that are designed to provide adequate shielding to the worker from a 100,000 Ci source of 1-MeV gamma radiation. Each hot cell is 6 ft. long by 6 ft. wide by 11 ft. high and contains a pair of master-slave manipulators.[e] Many of the cells contain an in-cell hoist and a Kollmorgan periscope. The hot cells within each bank communicate to a common corridor through 6-ft wide shielded doors (hydraulically actuated). Cell access from the shared corridor is by crane or by a cart on rails. Each pair of side-by-side cells can be connected with the lowering of a 6-foot-wide inner-cell door (hydraulically actuated), allowing installation of larger components and equipment. A pass-through system provides limited access through the fixed wall in between the paired

[e] The manufacturer of the master-slave manipulators used in the hot cells is no longer in business, so spare parts may be an issue.

cells. Four hot cells are presently configured for mechanical testing of irradiated materials, remote metallurgical polishing, and for milling/cutting samples from irradiated components.

Contamination control for processes involving dispersible radioactive materials and inert atmosphere operation, if needed, is accomplished via in-cell sealed alpha boxes ($1M to $2M each). Use of such alpha boxes in the past has kept the cells relatively clean of contamination, and man-entries are possible in most cells. Hot cell and alpha box ventilation is maintained through separate single-stage High Efficiency Particulate Air (HEPA) filtration systems. The latter, however, will require reactivation and restart for use.

The shared corridors are 8.33 ft. wide by 32 ft. long by 15 ft. high and are equipped with remotely-operated 3-ton bridge cranes,[f] PAR rectilinear manipulators, one pair of master-slave manipulators, and Kollmorgan periscopes. Each corridor is coupled to a railed transport system leading to a facility door access corridor. Transfer casks can be manipulated in the corridors, or a cask-to-cell adapter and cask-handling dolly system can be utilized for transfer operations.

Additional capabilities in Wing 9 include an array of 364 heavily shielded storage wells and a 25-ton capacity crane. A fully functional shop is available on site for performing manipulator maintenance and repair. An area adjacent to the hot cells has many gloveboxes and hoods available for use in supporting sample preparation and other related activities.

There has been interest in potentially making Wing 9 into a separate facility and keeping it open after the balance of the CMR is decommissioned. An $8M Wing 9 upgrade in FY08 began the extension of the operating life to 2016 or later, but many of the life extension issues were not going to be resolved until after a Documented Safety Analysis (DSA) was completed. A new DSA was completed, approved, and implemented in 2010. A previous study indicated that Wing 9 was in need of a seismic upgrade (to withstand a 7.2 magnitude earthquake as the facility is built over a seismic fault). The study estimated that it would take $20M-$30M to make these upgrades.[g] The facility also needs upgrades to meet fire code, and no fire protection is available in the cells.[8]

Oak Ridge National Laboratory – Irradiated Fuels Examination Laboratory [Building 3525]

The IFEL was constructed in 1963 and there have been no major changes; however, the equipment and building have been modernized through multiyear investments. There are three main air atmosphere hot cells that are each 10 ft deep and 14 ft high equipped with master/slave manipulators. One is 24 ft wide and the other two are 35.5 ft wide. Each has 3 ft of high-density concrete shielding, stainless steel liners, and oil-filled lead glass windows. The NAC-LWT and T-2 casks can be handled using air pallets to introduce irradiated items into the cells, including a single, full-length, commercial LWR fuel rod.

Three smaller stand-alone air atmosphere special-purpose cells, as shown in Figure 10, provide for irradiated microsphere gamma analysis, scanning electron microscopy support, and core conduction cool-down testing. The irradiated microsphere gamma analysis and the scanning electron microscopy support cells are 64 in. wide by 44 in. deep by 44 in. high with 8 in. of steel shielding, and the core conduction cool-down testing cell is 4 ft wide by 6 ft deep by 8 ft high with 4 in. of lead shielding. These cells have dry lead glass windows.

Major activities in the IFEL, Building 3525, include receipt and handling of irradiated materials (fuel or non-fuel, typically as experimental capsules) in shielded casks; transfer of material into and out of the hot cells; capsule disassembly; nondestructive and destructive testing of irradiated materials; repackaging of spent nuclear fuel; packaging and shipment of irradiated materials (on-site and off-site); waste packaging for disposal; maintenance of remote equipment; and decontamination of the facility and equipment. Examination and testing activities include metrology; metallographic sample preparation by

[f] These bridge cranes need replacement.

[g] The cost to upgrade CMR to PC-3 seismic criteria is estimated at $50 million.

sectioning, grinding, and polishing; optical and electron microscopy; gamma spectrometry; and other physical and mechanical properties evaluations as appropriate to the experimental objectives of a particular program.

In-cell equipment includes capabilities for remote examination, cutting and machining, metrology, a gamma scanner and metallographic preparation equipment. The IFEL facility also contains contamination zones where further hands-on specimen fabrication and testing can be performed safely on lower activity materials. TEM sample preparation equipment is available in the contamination zone and is capable of thinning specimens to electron transparency by ion milling.

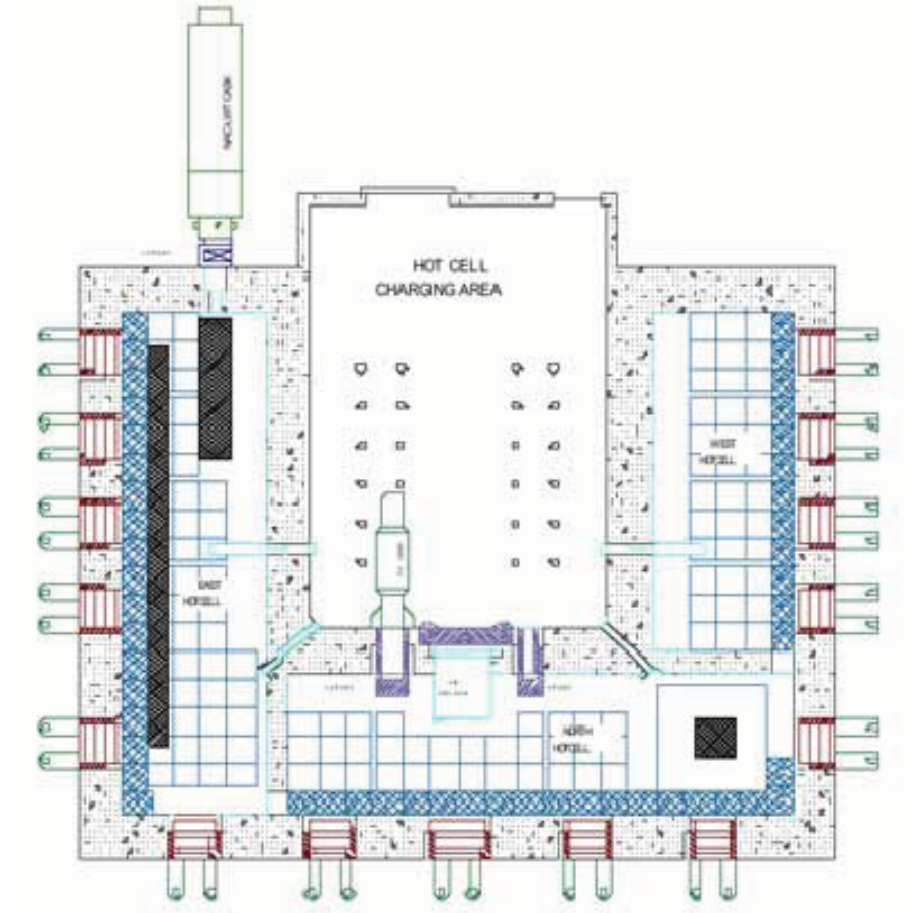


Figure 10. IFEL operating gallery image and hot cell layout.

Pacific Northwest National Laboratory – Radiochemistry Processing Laboratory [Building 325]

The Radiochemistry Processing Laboratory (RPL) was designed and constructed in 1953 to perform general radiochemical research, development, demonstration, and analytical services. It consists of a central section containing general purpose laboratories for low-level radiochemical work; a South (front) wing containing office space, locker rooms, a lunch room, and maintenance shops; and the High-Level Radiochemistry Facility (HLRF)[h] in the East wing and Shielded Analytical Laboratory (SAL) in the West wing, both of which contain shielded enclosures (hot cells) with remote manipulators for high-level radiochemical work. Adjacent to the facility on the east side of the building is an enclosed fenced area designated as the East Storage Yard that is used to store radioactive materials and contaminated equipment. A photo and floor plan of the RPL appear in Figure 11.

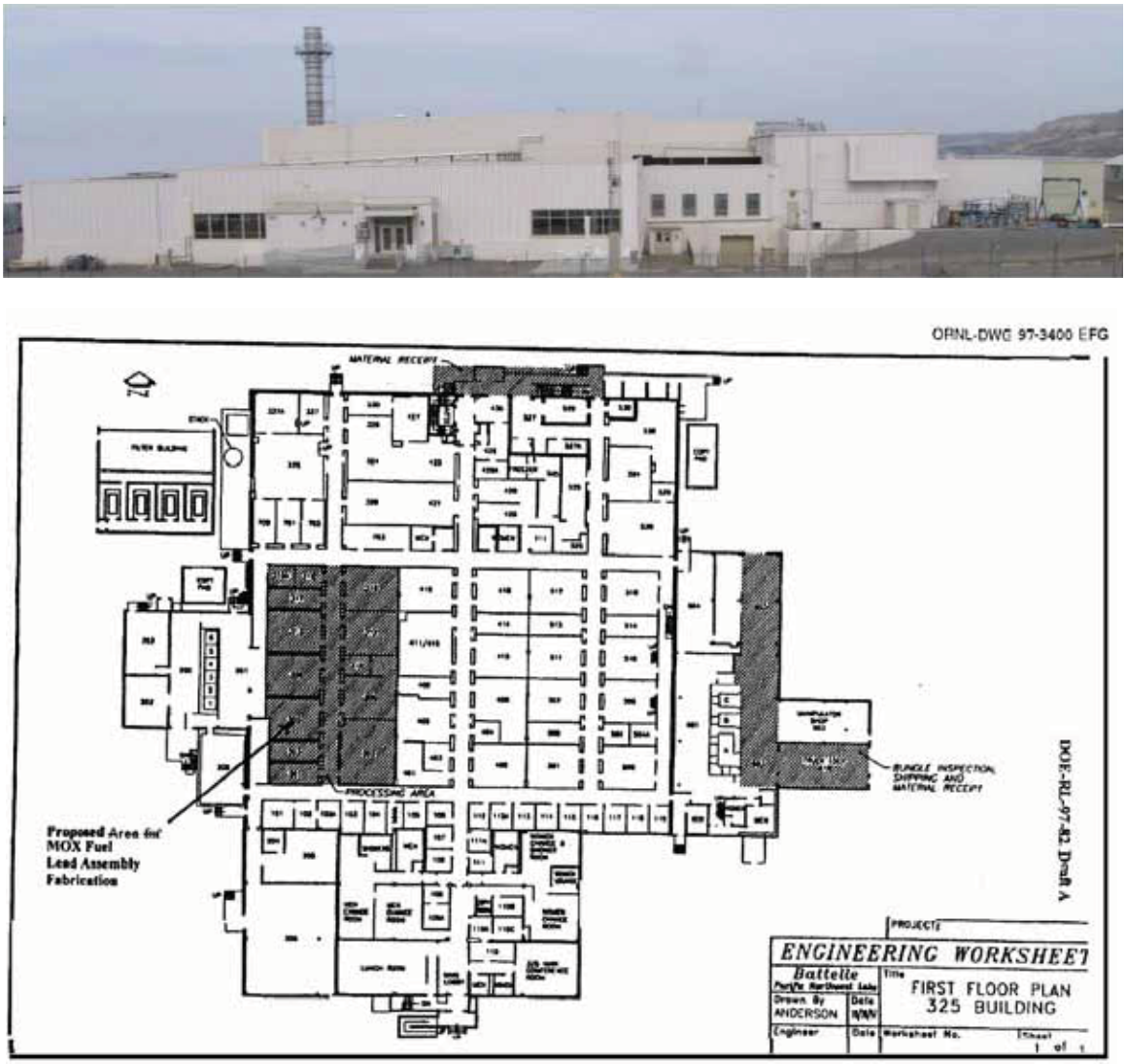


Figure 11. RPL at PNNL

[h] The HLRF is a steel framed structure with partial height reinforced concrete walls located on the east side of the main facility. The HLRF includes the bank of three interconnecting cells (A-Cell, B-Cell, and C-Cell) and supporting facilities designed to provide remote handling, confinement and radiation shielding for work with high-exposure-rate radionuclides.

The RPL is a Safeguards Category III, HC-2 nuclear facility that operates under an approved safety basis (DSA, Technical Safety Requirements, and DOE Safety Evaluation Report). It has two fixed banks of air atmosphere hot cells and several modular hot cells. The first bank of fixed hot cells has three larger side-by-side units (i.e., A-Cell, B-Cell, and C-Cell in the HLRF) designed for performing chemical processes. The second bank of hot cells has six smaller side-by-side units (i.e., Cells 1 through 6 in the SAL) designed more for analytical chemistry functions and small-scale process testing.

With the DOE decision for a 20 year lifetime extension for the RPL (to 2026), a seismic and wind evaluation of the RPL was performed in 2007 against current PC-2 Natural Phenomena Hazard (NPH) criteria specified by DOE-STD-1020-2002.[9,10] Facility modifications were identified and funded as a result of this analysis. These seismic upgrades have been completed, bringing the facility structure into conformance with current DOE NPH PC-2 criteria. The facility upgrades also included roof repairs/replacement and a refresh of C-Cell in the HLRF (including full decontamination and shielding window refurbishment). Four new modular hot cells, adding to three existing modular shielded enclosures,[i] were also installed in the RPL basement as part of these upgrades. A refresh of B-Cell is planned in the near future and will include removal of installed tanks and equipment, removal and repair of its shielding window, and a limited radiological decontamination.

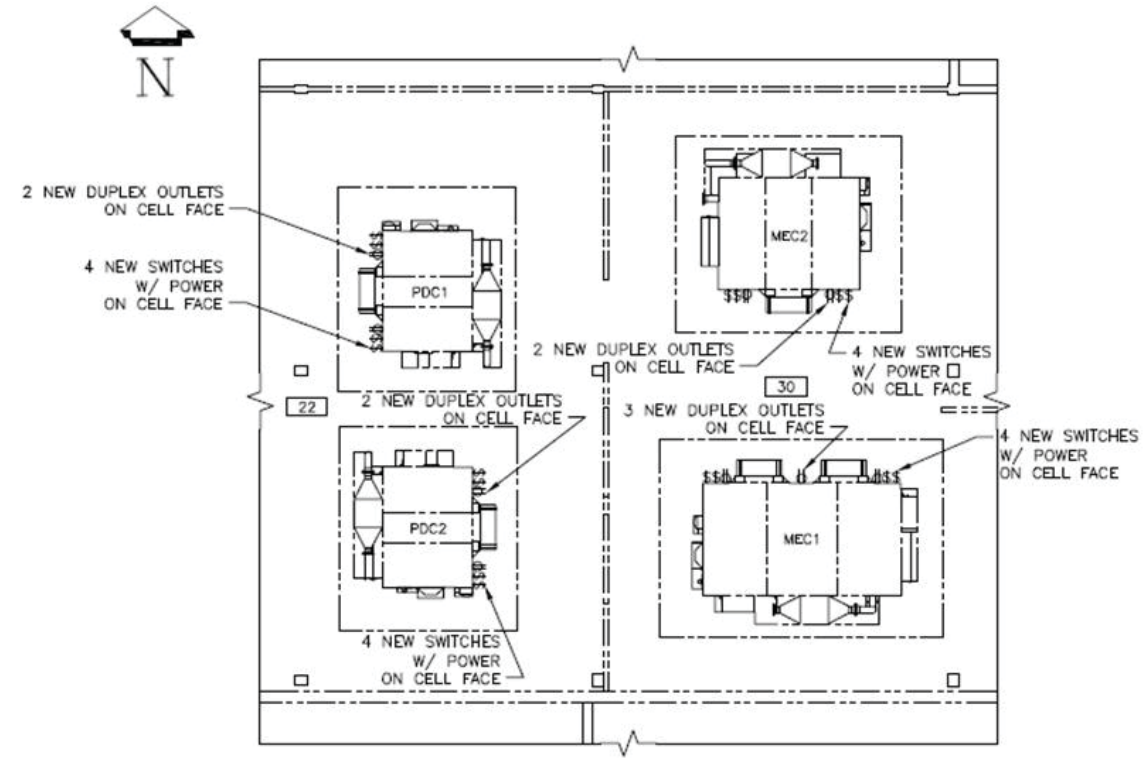
Two of the new modular hot cells (PDC1 and PDC2) are of a standard portable design with internal dimensions of 78 inches (6.5 ft.) wide by 54 inches (4.5 ft.) deep[j] by 100 inches (8.33 ft.) high. The design includes provision for an optional stainless steel liner and one manipulator work station (two mechanical manipulators). The cells allow for operations in an inert (nitrogen) environment and provide a minimum of five replaceable feed-through penetration ports. Shielding consists of 12 inches of steel.

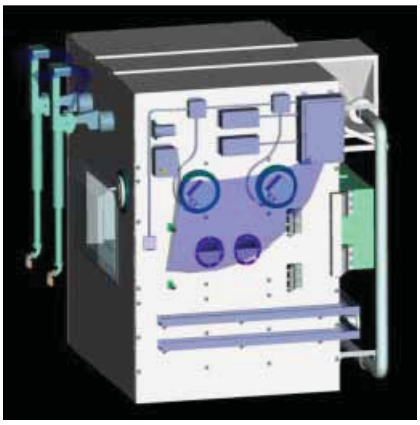
The other two modular hot cells (MEC1 and MEC2) are co-located with PDC1 and PDC2. MEC1 has internal dimensions of 6 ft. wide by 12 ft. long by 8.5 ft. high with 12-inch thick steel plate walls and roof and a 2-inch thick steel plate floor. MEC1 has in-cell shielded storage below the work trays for interim storage of 25 source terms and an in-cell lifting capability of 1000 pounds. Two work stations (4 manipulators, heavy duty) are incorporated into MEC1. MEC2 has internal dimensions of 6 ft. wide by 8 ft. long by 8.5 ft. high with 12-inch thick walls and roof and a 2-inch thick steel plate floor. One work station (2 manipulators) is provided in MEC2. Space for in-cell storage below the work table provides interim storage of source terms in two 150 pound shielded containers.

All four of the new modular hot cells have access doors that allow for man-entries as well as unused penetrations that could support installation of inert atmosphere containment boxes. All four cells are also equipped with manually actuated, dry chemical, pre-engineered, fixed extinguishing systems with fixed nozzles. Schematics for both the PCD and MEC hot cells are shown in Figure 12.

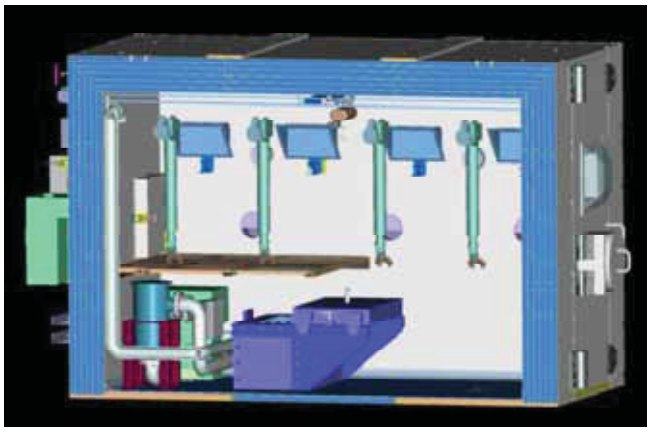
[i] Two of these cells are located in Room 203, behind the SAL, and the other is located in Room 23, in the RPL basement. All three cells measure approximately 5 ft by 5 ft with a shielding window and pair of MSMs. Two of the cells are identical with 9–in. thick steel shield walls, pedestal mounted, with a 2 ft by 3 ft access door. The other cell is full height (10 ft) with a personnel access door, and 6-in thick steel shield walls.

[j] This dimension is below the preferred minimum of 6 feet for use as an advanced PIE instrument enclosure.





PDC1



MEC1

Figure 12. PDC and MEC schematics

The three HRLF hot cells are located on the first floor and are supported by reinforced concrete structures. The cells are constructed of thick, high-density concrete walls and ceiling; high-density lead glass, oil-filled windows to view in-cell work; shielded double-door pass-throughs to interconnect the cells; and iron-shielded doors that provide access to the cells from the rear access gallery (Room 603). The mineral oil within the shielded windows is provided for optical clarity and is not credited with a radiological shielding function.

A-Cell inside dimensions are approximately 15 ft. wide by 7 ft. to 8.5 ft. deep (varies) by 15 ft. high. The B- and C-Cells have inside dimensions of approximately 6 ft. wide by 8.5 ft. deep by 15 ft. high. The cells are shielded with walls of approximately 4-ft. thick, high-density concrete on the front and sides and

approximately 3-ft. thick, high-density concrete on the back. Each cell has an approximately 18-inch thick Meehanite iron door that shields the main entrance and other smaller entry ports on the back. The HLRF hot cells are provided with manual fire suppression capabilities and heat detection in the ventilation exhaust duct.

While no full-length commercial spent fuel rods have been received at the RPL, the RPL has received full-length Tritium Producing Burnable Absorber Rods (TPBARs) in the NAC-LWT cask as part of the Tritium Target Project. The latest receipt and handling was in January 2010, bringing the total to eight shipments. In addition, the RPL has received commercial, DOE, and Navy fuel segments, pieces, and samples shipped in the NAC-LWT, T2, GE2000, and PAS-1 casks. Such operations require and have developed procedures for cask cavity venting, cask decontamination, leak testing, etc. The facility is not currently designed to receive rail casks nor can it currently receive entire fuel assemblies.

The RPL has a 30-ton capacity crane for handling shipping casks, such as the NAC-LWT and GE2000. Currently, there are no funded plans to enhance the capability to receive entire assemblies or to load or unload a dry storage container.

Specimens examined in the RPL may be archived during the duration of the project. Afterward, the specimens (and any unused sample portions) must be disposed of as waste, returned to the owner, or otherwise transferred out.

Savannah River National Laboratory – Shielded Cell Facility High-Level Cells [Building 773-A, Section E]

The Shielded Cells Facility at SRNL is a HC-2 nuclear facility that gives the laboratory the ability to safely work with a wide variety of highly radioactive samples and items in support of various R&D initiatives. The Shielded Cells Facility high-level hot cells consist of two cell blocks (“A” and “B”) containing a total of 16 small, air atmosphere hot cells with a single operator position in each. Each cell module consists of an operating space approximately 6-ft wide by 6-ft deep by 15-ft high with shielding walls. The cell modules within each cell block are interconnected with common partial height walls. Some walls can be removed to combine up to three cells.

The exterior walls of the facility are made of 3-ft thick high-density concrete with a 1/8-inch thick stainless steel liner. Each cell has a 3-ft by 3-ft shielding window consisting of 3-ft thick leaded glass filled with mineral oil for optimal viewing capabilities. The facility is designed to shield a source reading up to 10,000 rem/hour (or 1 MeV gamma radiation from a 10,000 Ci source).

Each cell is equipped with electricity, fire protection, air, gas and water, all operated from outside the cell, as well as two electrically-powered manipulators that are used by operators to perform work inside the cells. The high airflow filtration/exhaust system is triple HEPA filtered and routed through a sand filter system before discharging through a 100-ft high stack.

There are several 11-inch by 11-inch shielded transfer ports throughout the facility for the placement and removal of samples and supplies into the cells. Removable roof panels, roof plugs and transfer ports provide the ability to move equipment and material of many sizes into the cells. The cells are designed to allow easy modifications and the change out of processing equipment. The facility is also able to handle large shielded shipping casks and transfer highly radioactive materials from casks into the cells. Plutonium inventory at the facility is limited to 300 to 400 gm.

The floor plan for the SRNL Shielded Cells Facility is shown in Figure 13.

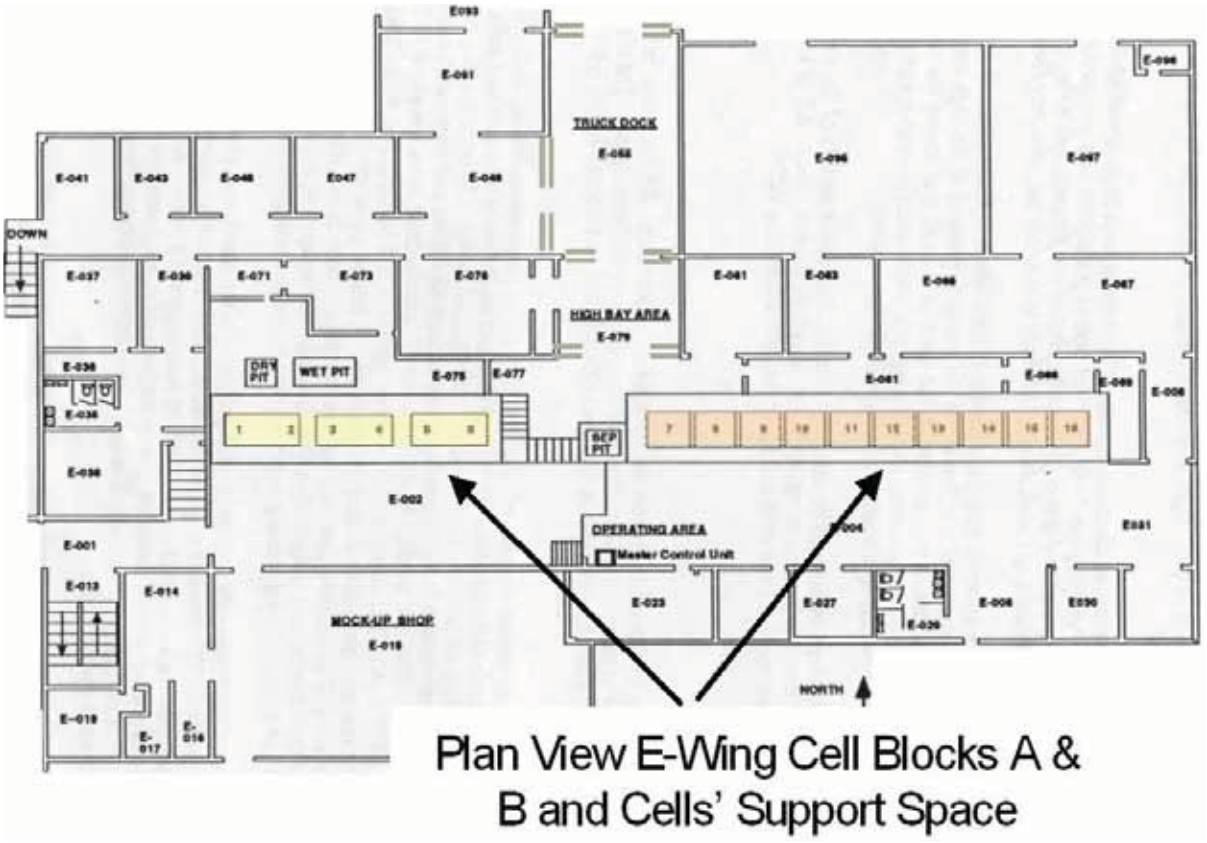


Figure 13. SRNL Shielded Cells Facility floor plan

Cell Block A, which has six cells, was constructed in 1952 with major refurbishments in 1961, 1968, and 1977. Cell Block B has 10 side-by-side hot cells. Cells 7–13 were constructed in 1958 with major refurbishments in 1965, 1975, and 1981. Cells 14–16 were constructed in 1964 with one major refurbishment in 1975.

Cell Block A is equipped with a one-ton crane for transferring material from one cell to another. Cell Block B is equipped with two one-ton cranes. An exterior truck dock has a 10-ton crane for use in loading and unloading radiological trailers and transferring large or heavy material into a high-bay receiving area. This area is adjacent to the cells and has another 10-ton crane, which moves the loads into and out of the cells; this crane is also used for removing the cell ports, roof covers, and roof plugs. The hot cells do not have precision humidity or temperature control (+/- 1°F per hour) within the spaces; they also have no electro-magnetic interference (EMI)/radio frequency interference (RFI) protection, clean room, or special vibration isolation capabilities.

In addition to the operating cells, the facility maintains a set of nonradioactive mock-up cells that provide full-scale replicas of the footprint and operational capability of the radioactive cells, including the manipulators. These cells are used for staging equipment and for developing detailed work procedures for operations to be conducted in the active cells. Research equipment is tested here for compatibility with remote operations before being placed inside the radioactive cells.

Hazard Category 3 Facilities

Several HC-3 or LTHC3 radiological facilities within the DOE Complex are currently being used for PIE. Such facilities may be used, if necessary, to house the non-shielded instrument spaces; however, these spaces are preferred to be co-located with the shielded examination cells (i.e., under the same roof).

Keeping in mind that no capital funding for facility modifications are allowed under this alternative, these HC-3 facilities would not be upgraded to HC-2 or changed to accommodate APIEC work. Current HC-3 facilities that fall into this area are as follows:

- INL – MFC-752, Analytical Laboratory (AL)
- INL – MFC-787, Fuels and Applied Sciences Building (FASB)
- INL – MFC-774, Electron Microscopy Laboratory (EML)
- ORNL – Building 3025E, Irradiated Materials Examination and Testing (IMET).

2.5.1.3 Mapping of APIEC Functions to Included Facilities

There are eight (8) main APIEC functionality areas:

1. Shielded cask receiving/unpacking/packing
2. Shielded source material storage
3. Shielded source material sizing/capsule disassembly
4. Shielded sample/specimen preparation hot cell (SPHC)
5. Shielded sample/specimen examination cells
6. Non-shielded sample/specimen examination spaces
7. Final prepared sample/specimen storage and archive
8. Final prepared sample/specimen storage and archive.

Table 3 maps the APIEC functions against the various DOE sites hosting the facilities discussed previously. For each of the sites, an attempt was made to list which of the existing HC-2 facilities at that site may be best equipped to perform the APIEC functions given no investment or other modifications. A dash in one of the corresponding cells means that the site currently does not have a facility this is fully able to support that particular APIEC function. Where possible, specific hot cells within the HC-2 facilities were identified for the APIEC function that they could likely support.

Table 3. Alternative 1 mapping of APIEC functions to HC-2 facilities at DOE sites.

Functions (Advanced PIE)	Current HC-2 PIE Capabilities at DOE Sites				
	INL	LANL	ORNL	PNNL	SRNL
Shielded cask receiving/ unpacking/packing (*assuming inerted convenience container)	HFEF	CMR Wing 9*	IFEL*	RPL (HLRF A-Cell)*	Shielded Cell Facility (SCF*)
Shielded source material storage (*assuming inerted convenience container)	HFEF	CMR Wing 9 (wells)*	IFEL*	RPL (HLRF B-Cell)*	SCF*
Shielded source material sizing/ capsule disassembly (full capability requires dry, inert cell environment)	HFEF	–	–	–	–

Functions (Advanced PIE)	Current HC-2 PIE Capabilities at DOE Sites				
	INL	LANL	ORNL	PNNL	SRNL
Shielded sample/specimen preparation (SPHC) (full capability requires dry, inert cell environment and shielded focused ion beam milling)	HFEF	–	–	–	–
Shielded sample/ specimen examination cells	IMCL	–	–	–	–
Non-shielded sample/specimen examination spaces (may be mapped to HC-3 or LTHC3 facility)	IMCL	–	IFEL	–	–
Final prepared sample/specimen storage and archive (*assuming inerted convenience container)	HFEF	CMR Wing 9 (wells)*	IFEL*	RPL (Modular Shielded Storage Unit, In-cell shielded storage boxes in MEC1/2)*	SCF*
Waste processing/ packaging (*assuming inerted convenience container)	HFEF	CMR Wing 9*	IFEL*	RPL (HLRF Cells, SAL hot cells, New Modular Hot Cells)*	SCF*

2.5.1.4 Description of Facility Modifications

An underlying tenet to the No Action alternative is that no modifications/changes will be made to any of the existing DOE facilities that currently engage in PIE activities, nor will any new facilities be built to accommodate identified advanced PIE activities. As such, there are no facility modifications to describe for this alternative.

2.5.1.5 APIEC Process Flow Considerations

The typical APIEC process flow for irradiation experiments is described in Section 2.4.3. Under the No Action alternative, experiments and sample items requiring advanced PIE in shielded cells would have to be examined in IMCL, as no other DOE sites have shielded cells that currently perform advanced PIE. The samples would be shipped to HFEF where NDE would be performed, if needed, and the samples reduced in size, prepared for examination in the HFEF sample preparation box, and transferred to a cask designed for unloading in the IMCL hot cells. After examination in IMCL, the specimens would be returned to HFEF for storage. Waste generated during sizing and sample preparation would be packaged for storage or disposal, as applicable, in HFEF.

2.5.1.6 Sample Archival and Waste Disposition Considerations

Short-term storage of samples, at least for the duration of the research, is not expected to be a problem in the No Action alternative for any PIE location. Currently, sites that are authorized and equipped to receive irradiated fuels or material samples should have no problems with short-term storage. Similarly, irradiated material PIE wastes (i.e., non-fuel) including unused portions of the sample,

specimen preparation waste, secondary wastes, and prepared specimens that are no longer needed are not expected to pose a problem for any of the included DOE laboratories relative to their disposal. These wastes will typically be LLW or RH-LLW for which the laboratories have established processes and paths to disposal.

However, longer-term storage (e.g., for sample archival purposes) is a complex issue in this alternative especially for irradiated fuel samples. Most of the sites included in this alternative cannot receive samples of irradiated fuel from outside their host state without case-by-case review/approval or at least a prearranged disposition path. Such arrangements typically involve returning the unused portions of the sample, sample preparation waste, and examined specimens back to the owner/requester to prevent accumulation of significant quantities of such items at the site. Returns of this kind can be burdensome not only because of transportation costs (they require Type B or A shipments) but also because certain entities, such as U.S. universities, may not be well suited to store these items upon their return. Also, because five different DOE laboratories are involved, researchers will need to contend with multiple processes for storage and disposition of these wastes.

2.5.1.7 Partnering Arrangements

Partnering agreements between DOE laboratories specifically for facilitating APIEC work do not yet exist. Although partnering relationships do exist between various labs (e.g., the ATR NSUF and those involved in interfacing programmatic support roles), the labs also at times compete against each other for the same work. Such competition has been known to create duplication of capabilities within the DOE complex as a whole. APIEC partnering would need to overcome past competitive behaviors and create collaborative relationships focused on mutual support for the advancement of the DOE-NE mission. Such arrangements could be created without the expenditure of capital funds, per se, but travel and coordination efforts would require some investment, which may or may not be allowed under this “No Action” alternative.

2.5.1.8 NSUF Considerations

Opening DOE facilities that comprise the APIEC for use by public and commercial entities would further promote collaboration among researchers conducting cutting-edge nuclear R&D. By offering continuing access to world-class PIE facilities and technical assistance at no cost to U.S. university-led research teams, DOE can advance the development of nuclear energy technology. Publication of results is a condition of use under this program if DOE funds are used. In addition to no-cost access, users may choose to fund research experiments through full-cost recovery agreements and thereby gain access to the same world-class PIE facilities and technical assistance while protecting their proprietary information, materials, and intellectual property. The No Action alternative would complicate the use of an APIEC NSUF due to the distributed locations of the capabilities. Travel to more than one location would likely be necessary to complete research goals. Access controls (e.g., badging and site-specific training) could also be different at each of the sites, thus requiring a larger time commitment from users to gain access.

2.5.1.9 Information and Material Security and Protection

Like other APIEC alternatives, this alternative makes use of existing DOE facilities and equipment, albeit without modifications. These facilities, being owned and operated by the government, leverage existing information and physical security infrastructure, including physical access controls (e.g., gates, fences, guards); unclassified/classified information management systems, policies, and procedures; and workforce reliability programs to control and protect government data from inappropriate release. Using these mechanisms, customers’ classified, sensitive, or proprietary materials, information, and intellectual property could be controlled and protected from unauthorized disclosure to other users. Additionally, knowledge capital integration between users will be easier and better facilitated by controls under a government oversight role. Special measures or precautions may need to be implemented for certain advanced PIE work because DOE does allow foreign nationals at some sites.

2.5.1.10 Funding Implications

Since the No Action alternative only uses PIE facilities currently in operation across the DOE complex and since no modifications/changes are allowed to those facilities, it is assumed that there will be no initial acquisition capital costs and no further duplication of PIE functionality/capabilities above that which already exists among existing PIE facilities under this alternative. Similarly, no additional O&M costs are expected above and beyond what is currently necessary to operate and maintain these existing PIE facilities.

2.5.2 Alternative 2: Modify Existing DOE Facilities – Distributed

Alternative 2 represents a distributed architectural approach to implementing the APIEC and includes modifying existing facilities (primarily HC-2 nuclear facilities) located at five DOE laboratories drawn from INL, LANL, ORNL, PNNL, SNL,[k] and SRNL. Advanced PIE instruments will be placed at each of these national laboratories along with other equipment and infrastructure systems that are necessary to provide the flexibility to support the full range of advanced PIE needs (e.g., for fuels and materials) and associated process functions. Further distribution of the APIEC across a greater number of national laboratories was deemed unwarranted due to the limited number of functions to be allocated and because of the limited involvement of other national laboratories in performing PIE activities.

The specific facilities described below, or portions thereof, are reported to be available and can, assuming appropriate modifications, support advanced PIE activities for highly-irradiated nuclear fuels and materials. Modifications to these facilities will include, for example, upgrades to biological shielding, vibration and temperature controls, and other infrastructure systems, as needed, to provide a suitable environment to house state-of-the-art PIE equipment for a 40-year period.

2.5.2.1 Assumptions

Assumptions made for this alternative are as follows:

- Facility modifications do not include converting non-HC-2 facilities to meet HC-2 and associated seismic/performance category requirements.
- Facility modifications do not include wholesale replacement of existing fixed hot cells.
- Each shielded cell (i.e., including examination and process support cells) and non-shielded instrument spaces will be modified, as needed, to provide full flexibility as to the types of advanced PIE instruments to be installed and for the range of fuels and materials to be examined. For example, all shielded examination cells, non-shielded instrument spaces, and sample preparation cells will be equipped for inert atmosphere; all examination cells/spaces will be outfitted for temperature control, vibration isolation, EMI/RFI protection, and acoustic noise control; etc.
- Each of the advanced PIE instruments to be housed within a shielded cell, or non-shielded space, will be unique. Only the process support equipment (e.g., for cask unpacking/packing, sample preparation, sample/specimen storage, and waste packaging) will be duplicated from one national laboratory to another.

[k] Due to late inclusion of SNL's Annular Core Research Reactor (ACRR) Hot Cell Facility (HCF) for consideration within the Distributed alternative and a limited opportunity to collect data on that facility, the HCF is not represented in the Distributed alternative described herein. However, based on the limited information collected on the HCF, it appears that it may be a feasible candidate for inclusion. While the involvement of facilities from 5 separate DOE laboratories is deemed sufficient to assess the performance of a distributed APIEC alternative, the evaluation of an additional alternative with six labs was not deemed necessary. If the Distributed alternative is recommended as the preferred alternative, SNL's HCF will be examined in more detail during conceptual design to determine if it should supplement or replace one of the other facilities.

- Samples requiring the full suite of advanced PIE characterization must be divided and have portions sent to each of the participating DOE sites.
- Other DOE HC-2 facilities with operational hot cells (with the exception of SNL's ACRR HCF) are not available to be dedicated on a full-time basis to the advanced PIE mission. This includes the Fuel Conditioning Facility (FCF) and HFEF (at INL) and Buildings 3525 and 7920 (at ORNL). Further, other hot cells within the facilities listed below that support other missions (even part time) are not available to be dedicated full-time to the advanced PIE mission.
- Each of the DOE national laboratories included in the distributed alternative (i.e., INL, LANL, ORNL, PNNL, and SRNL [or, possibly, SNL as a replacement for one of these]) will be allocated at least one shielded instrument cell, accounting for five of the shielded cells. The remaining two shielded cells will likewise be allocated to two different laboratories. This assumption is intended to ensure that the distributed intent of the alternative is preserved.
- The four non-shielded instrument spaces will be allocated to four different DOE laboratories. This assumption ensures that the distributed intent of the alternative is preserved.

2.5.2.2 Facilities and Hot Cells Description

The DOE-owned facilities and hot cells listed below are considered to support Alternative 2, as described in the following subsections. It should be noted that these facilities may not be dedicated in their entirety to the advanced PIE mission.

- INL MFC-1729 – Irradiated Material Characterization Laboratory (IMCL)
- LANL TA-3-29 – Chemistry and Metallurgy Research (CMR) Facility
- ORNL Building 7930 – Radiochemical Engineering Development Center (REDC)
- PNNL Building 325 – Radiochemical Processing Laboratory (RPL)
- SRNL Building 773-A – Shielded Cell Facility (SCF)

General descriptions for the INL, LANL, PNNL, and SRNL facilities are contained in Section 2.5.1.2. Considerations regarding those facilities as they apply to Alternative 2, as well as a detailed description of the ORNL REDC 7930 facility, appear below.

Idaho National Laboratory – Irradiated Materials Characterization Laboratory [MFC-1729]

As stated in Section 2.5.1.2, the development cells that will be present in IMCL are not set up to function in a production capacity. To implement Alternative 2, the development cells and associated PIE instruments housed therein must be removed to make way for two new 10' by 10' instrument hot cells, a new 10' by 20' hot cell for sample storage and preparation, and other associated facility modifications to convert the IMCL from a PIE instrument prototyping facility to an APIEC production facility. Other specific changes are described below in Section 2.5.2.4.

Los Alamos National Laboratory - Chemistry and Metallurgy Research Facility, Wing 9 [TA-3-29]

As stated in Section 2.5.1.2, the CMR facility (see Figure 9) contains seven laboratory wings and one administration wing, all connected to a central (spinal) corridor. CMR Wing 9 contains two banks of 8 hot cells, 16 total, that are designed to provide adequate shielding to the worker from a 100,000 Ci source of 1-MeV gamma radiation. Four hot cells are presently configured for mechanical testing of irradiated materials, remote metallurgical polishing, and for milling/cutting samples from irradiated components. Twelve of the 16 hot cells are thus available to establish the APIEC. The majority of these hot cells are fully clean, operational, and ready for set-up and use. An area adjacent to the hot cells has many gloveboxes and hoods available for use in supporting sample preparation and other related activities.

There has been interest in potentially making Wing 9 into a separate facility and keeping it open after the balance of the CMR is decommissioned. An $8M Wing 9 upgrade in FY08 began the extension of the operating life to 2016 or later, but many of the life extension issues were not going to be resolved until after a DSA was completed. A new DSA was completed, approved, and implemented in 2010. A previous study indicated that Wing 9 was in need of a seismic upgrade (to withstand a 7.2 magnitude earthquake as the facility is built over a seismic fault). The study estimated that it would take $20M-$30M to make these upgrades.[1] The facility also needs upgrades to meet fire code, and no fire protection is available in the cells.[8]

Oak Ridge National Laboratory – Radiochemical Engineering Development Center (REDC) [Building 7930]

The REDC's Building 7930, constructed in the mid 1960s, is a HC-2 nuclear facility with a Security Category IV rating. Building 7930 houses seven relatively large, air atmosphere hot cells. Cells A, B, C and G are utilized to produce californium-252 sources. Cells D and E have never been used and are available to support the APIEC. Cell D is 20 ft. deep by 41 ft. long by 13 ft. high with concrete shielding and a stainless steel liner. Cell E is 20 ft. deep by 16 ft. wide by 30 ft high with concrete shielding. A stainless steel liner is on the floor and extends one foot up the walls. Cell F, 15 ft. by 37 ft. by 13 ft. with concrete walls, is operated as a spent nuclear material storage vault. Cells A and B are operated as contamination free cells to introduce material to the hot cells. Figure 14 shows the floor plan for REDC Building 7930.

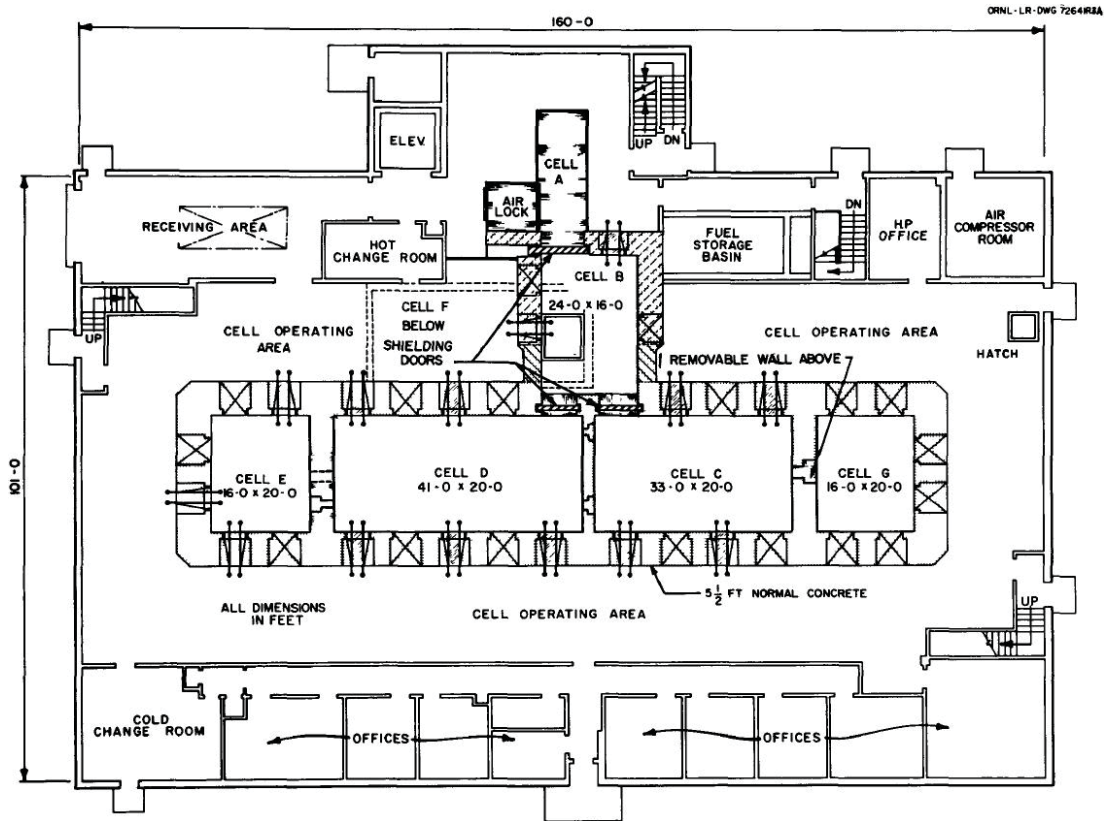


Figure 14. REDC Building 7930 floor plan

To meet the needs of the APIEC, cells D and E will require installation of new shielding windows and MSMs (none are currently installed), as well as personnel access doors (at some of the currently unused

[1] The cost to upgrade CMR to PC-3 seismic criteria is estimated at $50 million.

window locations) to allow man-entries into the cells. Shield walls (e.g., partitions) will also need to be installed to create individual instrument cubicles and spaces for sample preparation and storage. A device for remote transfer of irradiated samples will also be needed between cells B and D.

HFIR and Building 7930 are located within the same ORNL area. ORNL Building 3525, the IFEL, is located nearby and has capability to receive full length fuel rods for full NDE and size reduction. This facility has three large air atmosphere cells.

ORNL hot cell facilities have all the off-gas control systems and liquid waste systems needed for the PIE of used nuclear fuel (UNF). These systems are operational. Building 7930 off-gas passes through multiple HEPA filters for removal of particulate radionuclides prior to discharge through Stack 7911.

Pacific Northwest National Laboratory – Radiochemistry Processing Laboratory [Building 325]

As stated in Section 2.5.1.2, RPL has two fixed banks of air atmosphere hot cells and several modular hot cells.

The four new modular hot cells and two of the three fixed hot cells in the HLRF (i.e., C-Cell and B-Cell [see Figure 11]), are reported to be available to support establishment of the APIEC. These hot cells (with the exception of B-Cell, which will not be fully decontaminated) are clean, operational, and ready for set-up and use. In addition, A-Cell can be used on a shared basis for sample receiving and shipping operations. The six smaller hot cells in the SAL and the three older modular shielded enclosures were determined to not meet the needs established for implementation of the APIEC.

Sample storage during research activities is not a problem; however, archiving would require an exemption to the DSA and special, approved storage containers so the samples would not count against the facility operating limits.

Savannah River National Laboratory – Shielded Cell Facility High-Level Cells [Building 773-A, Section E]

As stated in Section 2.5.1.2, high-level hot cells in the Shielded Cells Facility at SRNL consist of two cell blocks (“A” and “B”) containing a total of 16 small, air atmosphere hot cells with a single operator position in each. Six of these 16 hot cells (7–12; see Figure 13) are reported to be available to help establish the APIEC. These hot cells are currently contaminated but available for decontamination, set-up, and use. Man-entries into the cells are not routine and are limited to very special need cases. No shielded doors are available for personnel access into the cells. The hot cells do not have precision humidity or temperature control (+/- 1°F per hour) within the spaces. They can be dehumidified as needed, but temperature control is the same as it is for the rest of the facility. The hot cells have no EMI/RFI protection, clean room, or special vibration isolation capabilities.

2.5.2.3 Mapping of APIEC Functions to Included Facilities

As shown in Table 4, 13 total shielded examination cells and possibly ten or more non-shielded instrument spaces are available across the DOE complex; however, only seven shielded instrument cells and four non-shielded instrument spaces will actually be allocated and analyzed for this alternative. This is to maintain the underlying basis for alternative comparison. Based on the assumption identified above, each of the laboratories will have at least one shielded instrument cell, which will account for five out of the seven shielded cells. The remaining two shielded instrument cells must then be allocated to INL, LANL, or ORNL because cell availability at PNNL and SRNL has been reached. The specific location for these two cells has been down-selected (preliminary) by the INL team using a subset of the weighted criteria from the overall alternatives analysis, as applicable, and a qualitative 0 to 10 scoring scale. This down-selection resulted in one additional hot cell being allocated to IMCL facility at INL and one to REDC Building 7930 at ORNL. Relative to the non-shielded instrument spaces, the allocation of the four spaces to the five laboratories was similarly decided through a preliminary down-selection process. The result of this down-selection was that one non-shielded instrument space would be allocated to each of the following DOE laboratories: INL, ORNL, PNNL, and SRNL.

Table 4. Alternative 2 mapping of APIEC functions of DOE facilities

Function	APIEC Desired State (in spaces)	APIEC Desired State (in ft^2).[m]	Allocation for Alternative 2 (Distributed)					TOTAL
			INL	LANL	ORNL	PNNL	SRNL	
Shielded cask receiving/ unpacking/packing	1[n]	80	IMCL (direct to SPHC for smaller samples) – 0 ft^2; HFEF (for samples from offsite and/or larger samples) – shared	CMR Wing 9 – Cask receiving capability (existing – rooms 9149, 9163 & 9133)	Bldg. 7930 – Cask receiving capability (existing)	Bldg. 325 – HLRF A-Cell cask receiving capability (shared basis)	Bldg. 773-A, E Wing – SCF cask receiving capability (existing)	5 (equiv)
Shielded source material storage	1[n]	80	IMCL (with SPHC) – 1 partial cell @ 20 ft^2	CMR Wing 9 – Shielded storage wells (existing – room 9165)	Bldg. 7930 (with SPHC) – Cell D partial after mod @ 28 ft^2	Bldg. 325 – Use B-Cell @ 51 ft^2	Bldg. 773-A, E Wing – 1 partial cell (6 ft x 6 ft) @ 18 ft^2	5 (equiv)
Shielded source material sizing/ capsule disassembly	Assume function is included with sample prep	Assume function is included with sample prep	IMCL (with SPHC for smaller samples) – shared; HFEF (for samples from offsite and/or larger samples) – shared	CMR Wing 9 (with SPHC)	Bldg. 7930 (with SPHC) – Cell D partial	Bldg. 325 (initial in A-Cell; final sizing included with SPHC) – PDC1/MEC2	Bldg. 773-A, E Wing (with SPHC)	See SPHC
Shielded sample/specimen preparation (SPHC)	1[n]	400	IMCL – 1 partial cell @ 130 ft^2	CMR Wing 9 – 4 cells @ 36 ft^2 each (2 pairs @ 72 ft^2 each after partitions are removed; 144 ft^2 total)	Bldg. 7930 – Cell D (partial) after mod @ 130 ft^2	Bldg. 325 – Use (PDC1 & MEC2) @ 29 ft^2 & 48 ft2; 77 ft^2 total	Bldg. 773-A, E Wing – 2 cells @ 36 ft^2 each (1 pair @ 72 ft^2 after partition is removed)	5 (equiv)
Shielded sample/ specimen examination cells	7	720 [1,160 with support equipment space]	IMCL – 4 cells @ 95 ft^2 each (380 ft^2 total)	CMR Wing 9 – 6 cells @ 36 ft^2 each (3 pairs @ 72 ft^2 each after partitions are removed; 216 ft^2 total)	Bldg. 7930 – 2 cells @ 150 ft^2 each in Cell E after mod; 2 cells @ 150 ft^2 each in Cell D (partial) after mod (600 ft^2 total)	Bldg. 325 – 1 cell (MEC1) @ 72 ft^2	Bldg. 773-A, E Wing – 2 cells @ 36 ft^2 each (1 pair @ 72 ft^2 after partition is removed)	13 (available)
Non-shielded sample/specimen examination spaces	4	480	IMCL – 2 spaces @ 120 ft^2 each (240 ft^2 total)	CMR Wing 9 – TBD	Bldg 3525: 2 spaces – room numbers/size TBD	Bldg. 325 – up to 2 spaces (12 ft x 15 ft) –Rm 611a	Bldg. 773-A, E Wing – up to 4 spaces (10 ft x 15 ft) on second floor	~ 10
Final prepared sample/specimen storage and archive	1[n]	250	IMCL (with SPHC) – 1 partial cell @ 30 ft^2	CMR Wing 9 – 1 @ 36 ft^2	Bldg. 7930 (with SPHC) – Cell D partial after mod @ 40 ft^2	Bldg. 325 – Use PDC2 cell @ 29 ft^2	Bldg. 773-A, E Wing – 1 partial cell (6 ft x 6 ft) @ 18 ft^2	5
Waste processing/ packaging	1[n]	100	IMCL (with SPHC) – 1 partial cell @ 20 ft^2	CMR Wing 9 – 1 @ 36 ft^2	Bldg. 7930 (with SPHC) – Cell D partial after mod @ 30 ft^2	Bldg. 325 – Use HLRF C-Cell @ 51 ft^2	Bldg. 773-A, E Wing – 1 cell @ 36 ft^2	5

[m] Based on PIE Line Item Building pre-conceptual design report space allocation values (rounded up to the nearest 10 square feet).

[n] Infrastructure function – must be allocated to each site participating in the alternative.

2.5.2.4 Description of Facility Modifications

Table 5 identifies the key modifications necessary to implement the APIEC within existing facilities at INL, LANL, ORNL, PNNL, and SRNL.

Table 5. Needed facility modifications for implementation of APIEC Alternative 2.

Facility/Portion Allocated to APIEC	Required Hot Cell Modifications/Upgrades ["✓" = needed; "-" = not applicable or not needed].															
	Access Door for Man-Entries	Acoustical Noise Isolation/Protection	Alpha Containment (infrastructure)	Decontamination	EMI/RFI Protection	Fire Protection Upgrade	Inert Atmosphere (infrastructure only)	Manipulator Upgrade/Update	Penetrations/Ports	Shielding (added depth/partitions)	Refurbish/ Replace Shielding Windows	Sample Prep Equip.	Seismic Upgrade	Temperature Control	Vibration Isolation	Other (e.g., SAR update)
INL MFC-1729 – Irradiated Material Characterization Laboratory (IMCL)/Entire Facility	-	✓	✓ Ties into existing HEPA exhaust	-	-	-	✓ Needs piped to modular shielded enclosures (MSEs)	✓ New for MSEs	-	✓ New MSEs	✓ New for MSEs	✓	-	-	-	-
LANL TA-3-29 – Chemistry and Metallurgy Research (CMR) Facility/12 out of 16 Hot Cells; other support areas shared	Use existing	✓	✓ Restart only	✓ Minor for some cells	✓	✓	✓	✓	✓	-	-	✓	✓	✓ Indepen-dent, but > 1°F/hr	✓	✓ Replace cranes in hot cell corridors
ORNL Bldg. 7930 – Radiochemical Engineering Development Center (REDC)/Hot Cells D and E; other support areas shared	✓	✓	✓	-	✓	✓	✓	✓ None currently installed	✓ Need all but utilities	✓ Needs new partitions added	✓ None currently installed	✓	-	✓	✓	✓ Needs material transfer device (B to D)
PNNL – Radiochemical Processing Laboratory (RPL)/ B&C-Cells, PDC1&2, MEC1&2; other support areas shared	-	✓	-	✓ B-Cell	✓	-	✓ Needs argon infra-structure	-	-	-	-	✓	-	✓	✓	-
SRNL Bldg. 773-A – Shielded Cell Facility (SCF)/Hot Cells #7 – 11; other support areas shared	✓	✓	✓ Ties into existing HEPA exhaust	✓	✓	-	✓ Needs piped to cells; filtering	-	✓	✓ Partial shield wall between cells 12 & 13	-	✓	-	✓	✓	-

2.5.2.5 APIEC Process Flow Considerations

The APIEC process flow for Alternative 2 is described in Section 2.4.3. However, based on the distribution of instruments to the various DOE laboratories required by this alternative, multiple shipments between the NDE/sizing facility, if used (or the receiving APIEC facility if intermediate processing is not required), and the various other APIEC facilities will be required. In cases where the sample needs characterization by the full suite of APIEC instruments, a total of five shipments will be necessary. These shipments may be Type A or B depending on the size and isotopic compositions of the individual sample partitions.

Distribution of the APIEC instruments by characterization type (e.g., micro-/nano-structure, thermal properties, mechanical properties) or other strategy might help to minimize the total number of shipments required. Such analysis, however, is beyond the scope of this alternatives analysis effort. The worst case scenario is that a portion of the sample will need to be shipped to each of the sites participating in the APIEC.

2.5.2.6 Sample Archival and Waste Disposition

Most DOE sites with facilities that could be used for APIEC activities cannot receive commercial UNF without a clear disposition path and concurrence from their respective DOE Site Office and/or applicable state government. Subsequently, it is a challenge to move (and ultimately dispose of) even small research quantities of UNF within the DOE complex.

This alternative invokes a wide range of processes, different at each DOE laboratory, which researchers and other users would need to navigate. For example, on the one hand, portions of irradiated commercial fuel samples sent to one laboratory would need to be reviewed and approved on a case-by-case basis by DOE and the host state if the sample material was to be retained. If not approved, the samples would have to be returned to the owner. In contrast, portions of the same sample sent to another DOE lab might be accepted for long-term retention under an existing Memorandum of Agreement (MOA). However, in all of these examples, no path exists for a final, permanent disposition for such waste with the one possible exception, noted previously, for defense-related irradiated fuel samples and associated waste.

2.5.2.7 Partnering Arrangements

Close cooperation and teamwork will need to be developed and maintained between the five DOE laboratories involved to ensure the advanced PIE work is accomplished in a timely and efficient manner, data quality requirements are met, and advanced PIE customers are satisfied with the current suite of DOE complex facilities identified for handling advanced PIE activities/research. Ideally, customers would perceive the various identified existing APIEC facilities and technicians as a fully-integrated and functional entity with consistent policies, procedures, and interfaces.

2.5.2.8 NSUF Considerations

NSUF considerations for Alternative 2 are the same as for the No Action alternative, as described in Section 2.5.1.8.

2.5.2.9 Information and Material Security and Protection

Information and material security and protection for Alternative 2 are the same as for the No Action alternative, as described in Section 2.5.1.9.

2.5.2.10 Funding Implications

It is anticipated that all five of the facilities listed above would be included in this APIEC alternative, when fully defined, and undergo the identified modifications using capital funds provided by DOE. The level of funding required for making the necessary modifications is expected to necessitate funding as a

congressional line item. In facilities that are not wholly dedicated to the APIEC mission (e.g., co-located with other non-NE programs), a cost sharing arrangement (e.g., based on the pro-rated facility area used) would be worked out to fund the APIEC's share of O&M and facility reset costs.

2.5.3 Alternative 3: Modify Existing DOE Facilities – Consolidated

Alternative 3, like Alternative 2, implements the APIEC by modifying a selected set of existing primarily HC-2 nuclear facilities within the DOE complex. However, an additional requirement for this alternative is that the capabilities must be consolidated at one or two DOE laboratories. Advanced PIE instruments will be placed at each of the included national laboratories along with other equipment and infrastructure systems that are necessary to support the associated process functions.

The specific facilities identified and described below, or portions thereof, are reported to be available and can, assuming appropriate modification, support advanced PIE activities for highly-irradiated nuclear fuels and materials. Modifications to these facilities will include, for example, upgrades to biological shielding, vibration and temperature controls, and other infrastructure systems, as needed, to provide a suitable environment to house state-of-the-art PIE equipment for a 40-year period.

2.5.3.1 Assumptions

Assumptions made for this alternative are as follows:

- Facility modifications do not include converting non-HC-2 facilities to meet HC-2 and associated seismic/performance category requirements.
- Facility modifications do not include wholesale replacement of existing fixed hot cells.
- Each of the advanced PIE instruments to be housed within a shielded cell, or non-shielded space, will be unique. Only the process support functions and associated equipment (e.g., for cask unpacking/packing, sample preparation, sample/specimen storage, and waste packaging) will be duplicated from one national laboratory to another.
- DOE HC-2 facilities with operational hot cells other than those listed below were considered but were either not available to be dedicated on a full-time basis to the advanced PIE mission or did not contain a sufficient amount of hot cells to enable implementation of the alternative. These include, for example, FCF and HFEF at INL and IFEL (Building 3525) and REDC (Building 7920) at ORNL; all of which support functions and/or programs beyond the scope of APIEC. Furthermore, other hot cells within the facilities listed below were determined to support other missions at least part-time and, thus, were also not available to be dedicated full-time to the advanced PIE mission.

2.5.3.2 Facilities and Hot Cells Description

After a review of candidate facilities, it was determined by the alternatives analysis team that no single DOE laboratory has a sufficient number of available hot cells of the type that can be effectively modified to meet APIEC needs. Three DOE-owned facilities and their available hot cells (listed below) could be paired, in any combination, to provide the requisite number of shielded instrument cells. These combinations will be considered as sub-alternatives in the APIEC alternatives analysis and, collectively, represent Alternative 3 as described in the APIEC MNS. The set of feasible facilities are described in the following subsections. It should be noted that these facilities may not be dedicated in their entirety to the advanced PIE mission.

- INL MFC-1729 – Irradiated Material Characterization Laboratory (IMCL)
- LANL TA-3-29 – Chemistry and Metallurgy Research (CMR) Facility
- ORNL Building 7930 – Radiochemical Engineering Development Center (REDC).

The three sub-alternatives are as follows:

- Alternative 3a – IMCL at INL paired with the CMR Facility at LANL
- Alternative 3b – CMR Facility at LANL paired with REDC at ORNL
- Alternative 3c – REDC at ORNL paired with IMCL at INL.

Detailed descriptions of these three facilities appear in Sections 2.5.1.2 and 2.5.2.2 of this report.

2.5.3.3 Mapping of APIEC Functions to Included Facilities

A preliminary mapping for APIEC functions to DOE facilities considered under Alternative 3 appears in Table 6.

Table 6. Alternative 3 mapping of APIEC functions to DOE facilities

Function	APIEC Desired State (in spaces)	APIEC Desired State (in ft²)[o]	Allocations for Alternative 3 (Consolidated)		
			3a. INL + LANL	3b. LANL + ORNL	3c. ORNL + INL
Shielded cask receiving/ unpacking/packing	1[p]	80	IMCL (direct to SPHC for smaller samples) – 0 ft² & HFEF (for samples from offsite and/or larger samples) – shared basis; + CMR Wing 9 - Cask receiving capability (existing)	CMR Wing 9 – Cask receiving capability (existing); + Bldg. 7930 – Cask receiving capability (existing)	Bldg. 7930 – Cask receiving capability (existing); + IMCL (direct to SPHC for smaller samples) – 0 ft² & HFEF (for samples from offsite and/or larger samples) – shared basis
Shielded source material storage	1[p]	80	IMCL (with SPHC) – 1 partial cell @ 20 ft²; + CMR Wing 9 – Shielded storage wells (existing)	CMR Wing 9 – Shielded storage wells (existing); + Bldg. 7930 (Cell F or w/ SPHC) – Cell D partial after mod @ 28 ft²	Bldg. 7930 (Cell F or w/ SPHC) – Cell D partial after mod @ 28 ft²; + IMCL (with SPHC) – 1 partial cell @ 20 ft²
Shielded source material sizing/ capsule disassembly	Assume function is included with sample prep	Assume function is included with sample prep	IMCL (with SPHC for smaller samples) – shared; HFEF (for samples from offsite and/or larger samples) – shared basis; + CMR Wing 9 (with SPHC)	CMR Wing 9 (with SPHC); + Bldg. 7930 (with SPHC) – Cell D partial	Bldg. 7930 (with SPHC) – Cell D partial; + IMCL (with SPHC for smaller samples) – shared; HFEF (for samples from offsite and/or larger samples) – shared basis
Shielded sample/specimen preparation (SPHC)	1[p]	400	IMCL – 1 partial cell @ 130 ft²; + CMR Wing 9 – 4 cells @ 36 ft² each (2 pairs @ 72 ft² each after partitions are removed; 144 ft² total)	CMR Wing 9 – 4 cells @ 36 ft² each (2 pairs @ 72 ft² each after partitions are removed; 144 ft² total); + Bldg. 7930 – Cell D (partial) after mod @ 130 ft²	Bldg. 7930 – Cell D (partial) after mod @ 130 ft²; + IMCL – 1 partial cell @ 130 ft²
Shielded sample/ specimen examination cells	7	720 [1,160 with support equipment space]	IMCL – 4 cells @ 95 ft² each (= 380 ft²); + CMR Wing 9 – 6 cells @ 36 ft² each (3 pairs @ 72 ft² each after partitions are removed; = 216 ft²); 7 cells, 596 ft² total	CMR Wing 9 – 6 cells @ 36 ft² each (3 pairs @ 72 ft² each after partitions are removed; = 216 ft²); + Bldg. 7930 – 2 cells @ 150 ft² each in Cell E after mod; 2 cells @ 150 ft² each in Cell D (partial) after mod (= 600 ft²); 7 cells, 816 ft² total	Bldg. 7930 – 2 cells @ 150 ft² each in Cell E after mod; 2 cells @ 150 ft² each in Cell D (partial) after mod (= 600 ft²); + IMCL – 4 cells @ 95 ft² each (= 380 ft²); 8 cells, 980 ft² total
Non-shielded sample/specimen examination spaces	4	480	IMCL – 2 spaces @ 120 ft² each (= 240 ft²); + 2 spaces @ CMR Wing 9 – TBD	2 spaces @ CMR Wing 9 – TBD; + 2 spaces @ Bldg 3525 – TBD	2 spaces @ Bldg 3525 – TBD; + IMCL – 2 spaces @ 120 ft² each
Final prepared sample/specimen storage and archive	1[p]	250	IMCL (with SPHC) – 1 partial cell @ 30 ft²; + CMR Wing 9 – 1 @ 36 ft²; 66 ft² total	CMR Wing 9 – 1 @ 36 ft²; + Bldg. 7930 (Cell F or w/SPHC) – Cell D partial after mod @ 40 ft²; 76 ft² total	Bldg. 7930 (Cell F or w/SPHC) – Cell D partial after mod @ 40 ft²; + IMCL (with SPHC) – 1 partial cell @ 30 ft²; 70 ft² total
Waste processing/ packaging	1[p]	100	IMCL (with SPHC) – 1 partial cell @ 20 ft²; + CMR Wing 9 – 1 @ 36 ft²; 56 ft² total	CMR Wing 9 – 1 @ 36 ft²; + Bldg. 7930 (with SPHC) – Cell D partial after mod @ 30 ft²; 66 ft² total	Bldg. 7930 (with SPHC) – Cell D partial after mod @ 30 ft²; + IMCL (with SPHC) – 1 partial cell @ 20 ft²; 50 ft² total

[o] Based on PIE Line Item Building pre-conceptual design report space allocation values (rounded up to the nearest 10 square feet).

[p] Infrastructure function – must be allocated to each site participating in the alternative.

2.5.3.4 Description of Facility Modifications

Table 7 identifies the key modifications necessary to implement the APIEC within existing facilities at INL, LANL, and ORNL.

Table 7. Needed facility modifications for implementation of APIEC Alternative 3

Facility/Portion Allocated to APIEC	Required Hot Cell Modifications/Upgrades ["✓" = needed; "-" = not applicable or not needed]															
	Access Door for Man-Entries	Acoustical Noise Isolation/ Protection	Alpha Containment (infrastructure)	Decontamination	EMI/RFI Protection	Fire Protection Upgrade	Inert Atmosphere (infrastructure only)	Manipulator Upgrade/Update	Penetrations/Ports	Shielding (added depth/partitions)	Refurbish/ Replace Shielding Windows	Sample Prep Equip.	Seismic Upgrade	Temperature Control	Vibration Isolation	Other (e.g., SAR update)
INL MFC-1729 – Irradiated Material Characterization Laboratory (IMCL)/Entire Facility	-	✓	✓ Ties into existing HEPA exhaust	-	-	-	✓ Needs piped to Modular Steel Enclosures (MSEs)	✓ New for MSEs	-	✓ New MSEs	✓ New for MSEs	✓	-	-	-	-
LANL TA-3-29 – Chemistry and Metallurgy Research (CMR) Facility/12 out of 16 Hot Cells; other support areas shared	Use existing	✓	✓ Restart only	✓ Minor for some cells	✓	✓	✓	✓	✓	-	-	✓	✓	✓ Indepen-dent, but > 1°F/hr	✓	✓ Replace cranes in hot cell corridors
ORNL Bldg. 7930 – Radiochemical Engineering Development Center (REDC)/Hot Cells D and E; other support areas shared	✓	✓	✓	-	✓	✓	✓	✓ None currently installed	✓ Need all but utilities	✓ Needs new partitions added	✓ None currently installed	✓	-	✓	✓	✓ Needs material transfer device (B to D)

2.5.3.5 APIEC Process Flow Considerations

The APIEC process flow considerations for Alternative 3 are similar to those discussed for Alternative 2, as described in Section 2.5.2.5. However, based on the fewer involved DOE laboratories required by this alternative, fewer shipments will be required between the NDE/sizing facility, if used (or the receiving APIEC facility if intermediate processing is not required), and the facilities making up the APIEC. In cases where the sample needs characterization by the full suite of APIEC instruments, a minimum of two shipments will be necessary. These shipments may be Type A or B depending on the size and isotopic compositions of the individual sample partitions.

Distribution of the APIEC instruments by characterization type (e.g., micro-/nano-structure, thermal properties, mechanical properties) or other strategy might help to minimize the total number of shipments required. Such analysis, however, is beyond the scope of this alternatives analysis effort. The worst case scenario is that in every case a portion of the sample will need to be shipped to each of the sites participating in the APIEC.

2.5.3.6 Sample Archival and Waste Disposition

In general, sample archival and waste disposition considerations for Alternative 3 are similar to those for the No Action alternative described in Section 2.5.1.6 and for Alternative 2 described in Section 2.5.2.6. However, because of the fewer number of laboratory sites involved, this alternative will have a narrower range of processes that will be invoked compared to the No Action or Distributed alternatives. The irradiated fuel sample archival and fuel waste storage situations will vary somewhat depending on which two DOE laboratories are paired up in the sub-alternatives considered.

2.5.3.7 Partnering Arrangements

Partnering arrangements for Alternative 3 are the same as for Alternative 2, as described in Section 2.5.2.7, except that close cooperation and teamwork will only need to be negotiated and developed between two laboratories instead of five.

2.5.3.8 NSUF Considerations

NSUF considerations for Alternative 3 are the same as for the No Action alternative, as described in Section 2.5.1.8.

2.5.3.9 Information and Material Security and Protection

Information and material security and protection for Alternative 3 are the same as for the No Action alternative, as described in Section 2.5.1.9.

2.5.3.10 Funding Implications

Funding implications for Alternative 3 are similar to those for Alternative 2, as described in Section 2.5.2.10. The major difference between these two alternatives is that the investment of capital funds for the needed modifications will be limited to two DOE sites in the Alternative 3 sub-alternatives. Less duplication of necessary infrastructure functions is expected in this alternative as compared to Alternative 2. Variation between the Alternative 3 sub-alternatives is also expected for capital costs as well as O&M costs due to differences in the beginning states of the modified facility pairs and differences in the facilities employed, respectively.

2.5.4 Alternative 4: Construct New Facility

Alternative 4 implements the APIEC by constructing a new HC-2 building—the Advanced Post-Irradiation Examination (APEX) Facility—to house the high-radiation advanced PIE activities. This facility provides, under one roof, a suite of hot cells for sample receipt, storage, preparation, and examination as well as unshielded instrument spaces and support hoods/glove boxes that will enable world-class micro-structural characterization, thermal property measurement, and mechanical testing into

the future. The facility will include features such as advanced temperature control, HEPA-filtered suspect exhaust ventilation, EMI/RFI protection, vibration and noise control, and capabilities for providing dry, inert (i.e., argon) environments where necessary. Additionally, facility space will be provided for PIE instrument development, hot/cold equipment maintenance, and personnel support (e.g., radiological control, offices, locker/restrooms).

Three sub-alternatives will be evaluated for this alternative to ascertain the effect of APEX facility siting. The three sub-alternatives are:

- Alternative 4a – New facility (i.e., APEX) sited at MFC at the INL (i.e., co-located with HFEF, NRAD, IMCL, AL, EML, and FASB pre- and post-irradiation examination capabilities and the ATR and Transient Reactor Test (TREAT) irradiation facilities)
- Alternative 4b – New facility (i.e., APEX) sited at ORNL (i.e., co-located with IFEL, IMET, and Low-Activation Materials Design and Analysis (LAMDA) PIE pre- and post-irradiation examination capabilities and the HFIR irradiation facility)
- Alternative 4c – New facility (i.e., APEX) sited at a DOE laboratory with only pre- and post-irradiation capabilities and no irradiation facility (i.e., LANL, PNNL, or SRNL).

2.5.4.1 Assumptions

Assumptions made for this alternative are as follows:

- This alternative will construct a single new facility (at a single DOE laboratory site) capable of housing the required APIEC functions and associated support areas and equipment. This alternative does not evaluate multiple new smaller facilities located at one or more DOE laboratories.
- For cost estimation purposes, the APEX facility will be similar in construction to the PIE Line Item Building preconceptual design with appropriate adjustments for items such as scope differences and escalation. The APEX facility—if recommended, approved, and constructed—would not necessarily use this design. The floor plan for the PIE Line Item Building preconceptual model is shown in Figure 15.
- Each of the advanced PIE instruments to be housed within a shielded cell or non-shielded instrument space will be unique, and vibration isolation pads are required for all instrument cells.
- Floor space and the portion of the pneumatic rabbit transfer system included in the *PIE Line Item Building Preconceptual Design Report* for future expansions is not included in the cost estimate for this alternative to maintain comparability with other APIEC implementation alternatives.
- For this alternative, other DOE facilities with availability to perform APIEC functions (with or without modifications) that have been identified in this analysis as part of any other alternative are not considered in this alternative. These facilities are assumed to be dedicated to other program functions or to have been decontaminated and decommissioned (D&D) and demolished such that O&M costs associated with those facilities can no longer be ascribed to PIE work. This assumption also supports compliance with the One-for-One Replacement legislation (excess space/offset requirement) as mandated in House Report 109-86 for all new construction.

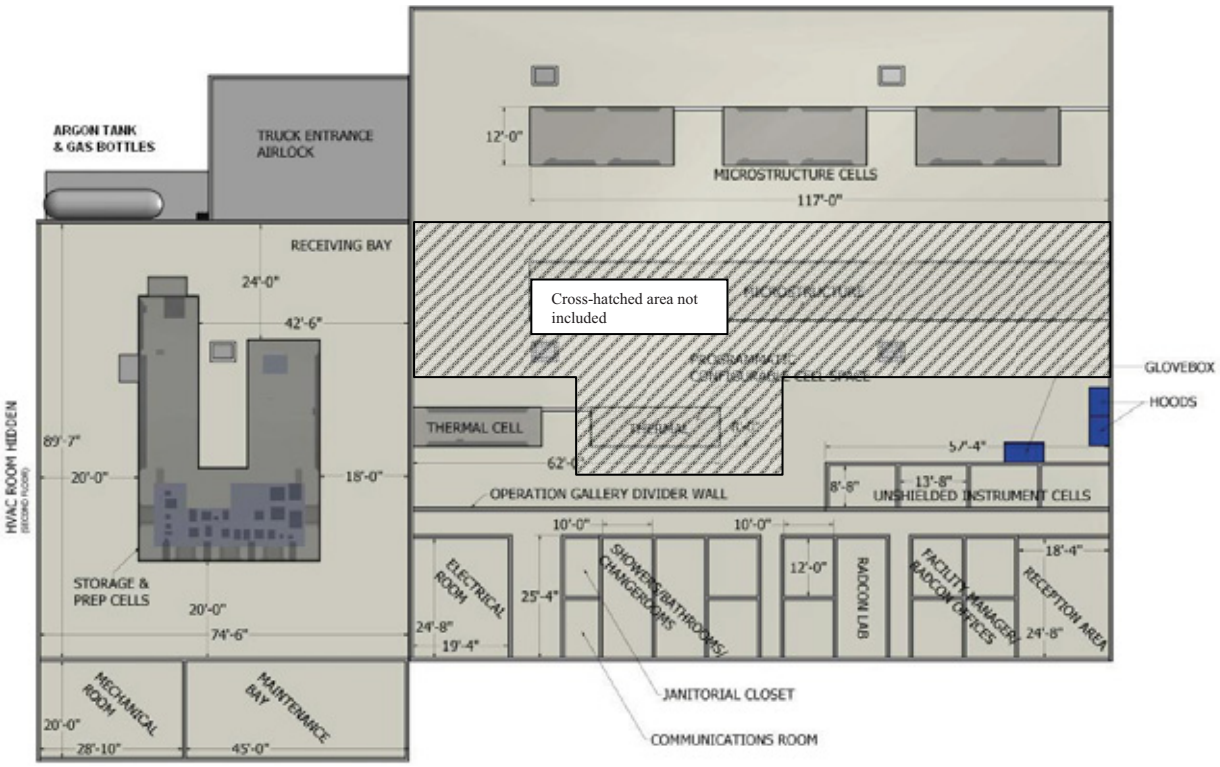


Figure 15. PIE Line Item Building facility floor plan

2.5.4.2 Facility and Hot Cells Description

The APEX facility, as envisioned, will be a HC-2 non-reactor nuclear facility that provides world-leading capabilities to examine irradiated fuel and materials. Additionally, the APEX will include capability for advanced PIE instrument development (one shielded development cell) and for preparing a wide variety of received material for storage and analysis, including sodium-bonded fuels. Sample preparation capabilities will be available for all examination techniques and for all materials and fuels to be received at the facility. The APEX facility will also include shielded cells for sample (source) material storage as well as for prepared specimen archive. The APEX facility will receive, prepare, examine, and store these materials.

APEX facility areas providing APIEC functionality include the following:

1. Six (6) reconfigurable shielded enclosures (i.e., hot cells) of approximately 10-ft by 10-ft by 13-ft internal dimension will be provided to support micro-structural examination work. In addition, the facility will provide one (1) large reconfigurable examination cell (approximately 6-ft by 20-ft by 13-ft internal dimension) to support APIEC thermal examination work. Not including necessary shielding for these examination hot cells, this equates to approximately 720 ft^2 of shielded sample/specimen examination hot cell space for APIEC examination activities. A full-thickness shield wall is shared between the two hot cells comprising the paired hot cell blocks. This shield wall ensures that operations and equipment maintenance within each cell can be conducted in an independent manner.
2. Approximately 440 ft^2 of total space will be provided in and around the examination hot cells for hot cell support equipment. Each of the examination hot cells will be arranged in pairs with a common equipment area between cell pairs to accommodate instrument support equipment outside of the cells. This workspace will allow maintenance of the equipment without obstructing the operating workspace.

3. Four (4) non-shielded instrument bays will be provided for additional examinations. These bays provide approximately 475 ft^2 of space for non-shielded sample/specimen examination activities. The internal dimensions for these spaces are approximately 8.75-ft deep by 13.75-ft wide by 13-ft high for these non-shielded examination activities. Space adjacent to the non-shielded instrument bays is provided for supporting hoods and/or gloveboxes.
4. The shielded cask receiving/unpacking/packing hot cell inside dimensions are 8-ft by 10-ft (80 ft^2). Manned entry into the cell is possible when radioactive material is not present since this cell is anticipated to remain a low-contamination area.
5. The shielded source material hot cell will provide approximately 88 ft^2 of space, not including necessary shielding for storage of source material.
6. An area of approximately 400 ft^2 will be provided within the shielded sample/specimen preparation hot cell to prepare samples and specimens for various APIEC examinations. The 400 ft^2 includes capability to perform source material sizing and/or any capsule disassembly activities.
7. In addition to initial source material storage, the APEX facility will also provide approximately 247 ft^2 of hot cell space for storage and archival of final prepared samples/specimens.
8. APEX will provide 100 ft^2 of hot cell space for any waste processing/packaging activities resulting from APIEC sample preparation and examination activities.
9. In addition to the approximately 440 ft^2 of space that will be provided for support equipment in and around the hot cell examination cells (detailed above), additional space will be allocated for the following types of facility functions: facility receiving bay, cask transfer corridor, operating galleries, operational support areas, mechanical and electrical rooms, communications rooms, facility janitorial rooms, facility HVAC room, and a maintenance bay.

As shown in Figure 16, the envisioned shielding enclosures have removable front and back walls for instrument changeout and a shielded access door for routine entries for instrument maintenance. Sample preparation and instrument cell shielding (equivalent) for the new facility will be based on the ability to safely handle individual samples up to a 30 Ci point source at 1.0 MeV gamma radiation.

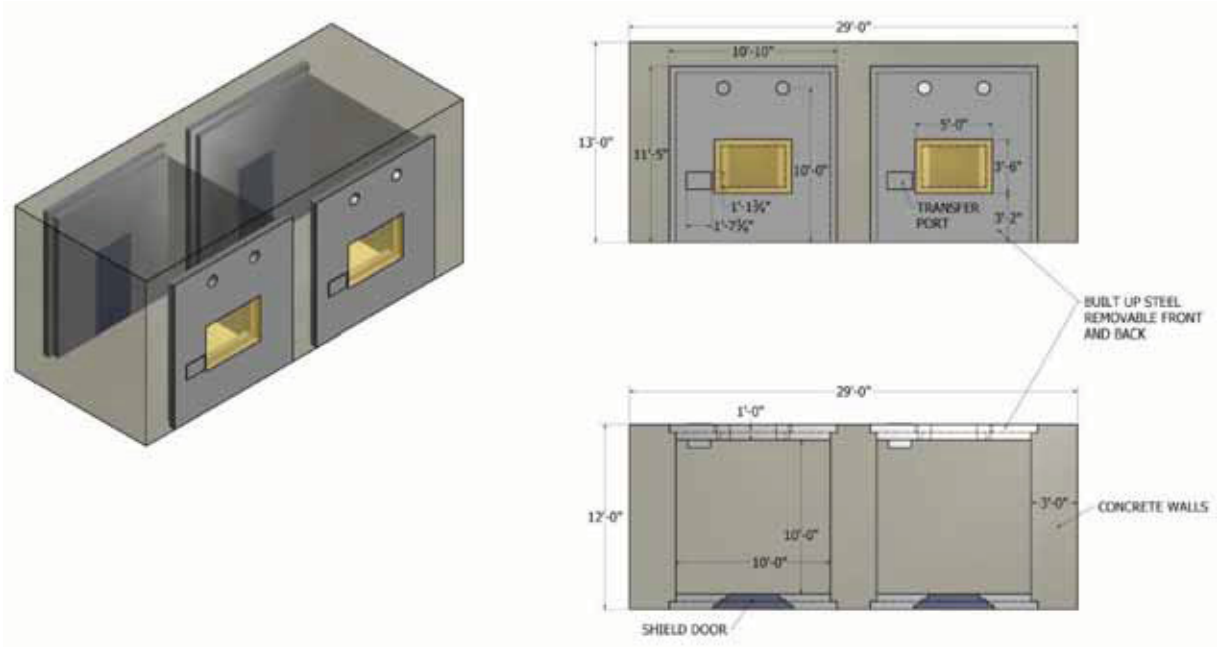


Figure 16. APEX modular, reconfigurable hot cells

Each of the APEX shielded examination hot cells is planned to have at least one lead glass shield window, steel shield doors, and a pair of master-slave manipulators (MSMs). In addition, the examination cells will have a standard interface for core utilities and a means of transferring materials into and out of the cells. All APEX facility areas where PIE instrumentation will be installed will have a means of vibration isolation to support flexibility, reconfigurability, and equipment replacement.

In the APEX facility examination instrument areas, the portions of the instruments containing the nuclear material samples will be contained within sealed enclosures, providing primary confinement of any loose contamination. These enclosures will also have inert atmosphere capability to provide the appropriate examination environment and necessary flexibility to examine all fuel types and materials. Each of the APEX hot cells is also envisioned to include in-floor sample/material storage within the shielding enclosure to allow local storage of samples to facilitate instrument maintenance and to improve characterization process flow.

The APEX facility will have the capability to ship and receive casks containing items up to 24 inches in length from other onsite and offsite facilities. Because no pool or canal is envisioned, the APEX facility transfers to/from casks are expected to be dry transfers. Sample transfers (from sample preparation to the examination instrumentation cells and back) will likely occur by a variety of methods depending on the point of origin. These transfer methods are expected to include the use of casks (or small on-site transport package/containers), a pneumatic rabbit transfer (intra-facility transfer system at a minimum), and simple hot cell-to-hot cell pass-throughs.

The sample storage, preparation, and HVAC support equipment areas of the APEX facility are expected to meet PC-3/SDC-3 standards and will be seismically isolated via a separate foundation from the remainder (i.e., examination portion) of the facility, which is planned to be PC-2 compliant. Isolation will ensure that interaction from the PC-2 portion of the facility during a seismic event does not impact the PC-3 portion of the facility. Thus, each portion of the facility will be designed and constructed as an individual structure that must resist the appropriate site-specific seismic and other NPH forces. A vibrationally isolated HVAC structure will be constructed over the PC-3 storage annex of the facility. Exterior support equipment space will be provided outside each of the APEX examination cells for

vibration producing equipment and components that need to be vibrationally isolated from the instruments within the cells.

2.5.4.3 Mapping of APIEC Functions

The APEX facility will be designed and built to house all desired APIEC equipment and perform all APIEC functions; therefore, the APEX facility will provide all necessary functionality needed to perform the APIEC research scope. Since all APIEC functions will be included in the single APEX facility, it is not necessary to individually map the APIEC functions for this alternative.

2.5.4.4 Description of Facility Modifications

Since the APEX facility will be designed and built to house all desired APIEC equipment and perform all APIEC functions, no modifications to other existing facilities are required. As such, APIEC implementation risk due to integration issues would be limited in this alternative to those for designing and building a single facility at a given site. By comparison, Alternatives 2 and 3 would involve multiple project teams working at geographically dispersed locations to modify and integrate the overall APIEC.

2.5.4.5 APIEC Process Flow Considerations

The general APIEC process flow is described in Section 2.4.3. In this alternative (regardless of the site selected to host APEX), shipments of experiments can be accomplished with a single transfer, either directly from the irradiator or from the NDE/large-scale sizing facility. Intra-APIEC moves are also simplified as compared to the other alternatives because all elements of the APIEC are housed within a single facility.

2.5.4.6 Sample Archival and Waste Disposition

As with other alternatives, most DOE sites cannot receive commercial UNF without a clear disposition path and concurrence from their respective DOE Site Office and/or applicable state government. Agreement complexity and/or approval regarding APIEC fuel, sample, and material receipt, storage, archival, and generated waste disposition is expected to vary and will depend on where the APEX facility is sited within the DOE complex. Such agreements will need to address the various APIEC fuels and materials to be examined, whether they can be received on site, what kind of limitations are placed on how much material/fuel can be kept on site in any given period, how the material/fuel will be managed and/or stored, any conditions associated with specimen archival, and how any wastes generated as a result of PIE activities/research will be dispositioned.

For example, if APEX were sited at INL, the 2011 Memorandum of Agreement (MOA) to the Idaho 1995 Settlement Agreement and Order allows for receipt of “research quantities” of commercial spent nuclear fuel (SNF) per paragraph 3(a), which reads:

> *3. Limits and Material Management: (a) INL may receive for the purpose of research and examinations conducted at the INL research quantities of Commercial Power SNF. For purposes of this Agreement “research quantities” shall mean only those quantities of Commercial Power SNF necessary for the specific research project for which the shipment to INL is made.*

Further, limitations and management of these materials/fuels, as well as requirements for storage and dispositions of generated wastes, are also spelled out in the 1995 Idaho Settlement Agreement and Order and the 2011 MOA. This MOA allows up to 400 kg of UNF to be received at the INL per year and a library of spent fuel types to be established (up to 10 kgs).

The disposition of PIE waste following APIEC research activities under this alternative is primarily controlled by DOE O 435.1 Chg. 1, which applies equally at any of the identified DOE laboratory siting locations for the APEX. Additional constraints or provisions may also apply from settlement agreements

or MOAs between the APEX facility's site and state and federal officials relative to PIE waste disposition for wastes generated as a result of research activities.

For example, if APEX were to be sited at the INL, the 2011 MOA to the original Idaho 1995 Settlement Agreement and Order allows for research activity waste to be consolidated with other Idaho wastes and managed per paragraph 4 of the Idaho Settlement Agreement, which reads:

> *4. Management of wastes generated during examination: Wastes generated during the research activity will be managed dependent upon the nature of research conducted in the form of destructive or NDE. Material that is classified as transuranic or low-level waste (LLW) may be consolidated with other laboratory wastes and managed appropriately.*

2.5.4.7 Partnering Arrangements

Close cooperation and teamwork will need to be developed and maintained between any DOE laboratories/sites involved in necessary support activities (e.g., irradiations, NDE, rough-sizing) before receipt of samples/material at the APEX facility to ensure the advanced PIE work is accomplished in a timely and efficient manner, data quality requirements are met, and advanced PIE customers are satisfied.

For the APEX facility, all required APIEC functions and instruments will reside in a single facility versus multiple facilities at multiple sites. Customers using the APEX facility would interface with a single set of scientists, engineers, and technicians and a consistent set of policies and procedures. With all equipment and instruments operating in the same facility, there is anticipated to be a much quicker turnaround of results from PIE research as integration and transfer of materials/data will be greatly facilitated.

2.5.4.8 NSUF Considerations

From an NSUF perspective, a single APIEC facility results in reduced implementation costs and more timely conduct of examinations due to fewer material shipments and simplifies access by the user community (e.g., reduced facility access training and controls) while deriving the same benefits obtained from the other APIEC alternatives. Improved user convenience should result with co-location of the APEX with one of the ATR NSUF partner reactors (e.g., ATR, or HFIR) or partner PIE facilities by providing improved access to other individuals involved in the experiment process (e.g., design engineers, reactor safety analysts, and post-irradiation instrument technicians).

2.5.4.9 Information and Material Security and Protection

Information and material security and protection for Alternative 4 are anticipated to be the same as for the other DOE alternatives (i.e., Alternatives 1, 2, and 3) and are described in Section 2.5.1.9.

2.5.4.10 Funding Implications

This alternative uses DOE line-item capital acquisition funding for design, construction, and initial complement of equipment. As with all new construction, an associated one-for-one facility footprint reduction will be necessary (to be identified). The new facility alternative leaves unchanged the various DOE facilities currently supporting lower-radiation PIE research as well as any high-radiation PIE (and supporting functions) not covered by the APIEC scope (e.g., large scale sizing, NDE, and radiochemical analysis). DOE funding of these other facilities is assumed to continue under this alternative or possibly could be reduced by the migration of some of the existing DOE PIE workload to the new APEX facility.

In the area of irradiated examinations, the new APEX facility is expected to provide the advanced PIE functionality not present with current PIE capabilities but that are needed to employ a science-based approach to the development of new nuclear fuels and materials. As a result, it is not anticipated that the APEX facility will duplicate any examination functionality that currently exists across the DOE complex. This means there will also not be any portion of the initial acquisition capital cost amount for the APEX

facility that will involve duplication of advanced PIE functionality for examinations or for associated infrastructure functions.

Although some of the sample preparation functions implemented for the APEX facility could appear to duplicate various sample preparation activities that currently exists across the DOE complex; the sample preparation equipment envisioned for the APEX facility directly supports advanced PIE capabilities housed within the APEX facility. As such, it is assumed that any costs associated with these duplicate functions will be offset (or negated) by having the capability to prepare the advanced PIE samples within the same facility versus needing to transport them to another facility (either at the APEX site or to another DOE site).

2.5.5 Alternative 5: Commercial Partnerships

Alternative 5 involves developing partnerships or contractual arrangements with commercial nuclear companies to establish advanced PIE capabilities by utilizing existing hot cell facilities at commercial sites. One or more domestic commercial facilities will be identified that have the hot cell spaces, infrastructure, and availability to support the development of nuclear fuels and materials.

2.5.5.1 Assumptions

Assumptions made for this alternative are as follows:

- Commercial hot cells made available to the APIEC are dedicated for that purpose (i.e., 100% of the time).
- Contractual arrangements can be made with the commercial suppliers that maintain the necessary control and protection of the physical items and data.
- If the alternative must involve more than 1 facility, a portion of every sample will go to each facility.

2.5.5.2 Facility Descriptions

The candidate facilities that that have been identified for the Commercial Alternative are the Babcock and Wilcox (B&W) Lynchburg Technology Center (LTC) cells, located in Virginia; the Global Nuclear Fuels (GNF) Vallecitos Nuclear Center in Vallecitos, CA; and the George Westinghouse Research and Technology Park in Churchill, PA.

B&W Lynchburg Technology Center

The B&W LTC has a NRC-licensed hot cell facility that consists of four hot cells. The cells were constructed in the early 1960s and have the dimensions and shielding shown in Table 8. The combined total of the cell areas is about 270 ft^2, and the shielding capabilities meet the APIEC requirements. The cells are lined with painted carbon steel.

Table 8. B&W Hot Cell Capability

Cell #	Size(W×L×H)	Shielding material	Shielding Capability	Function
Cell 1	8'×16'×15'	42" of high density concrete	300,000 curies of Co-60	Fuel Assembly handling
Cell 2	4.5'×15.5'×9'	13' Lead shot filled calls	6,000 curies of Co-60	Metallographic Examinations
Cell 3	4'×9'×9'	10" Lead shot filled calls	600 curies of Co-60	Used in the past for fuel decladding and fuel density measurements
Cell 4	6'×6'×9'	10" Lead shot filled calls	600 curies of Co-60	Mechanical testing and cladding

The cells are air cells contaminated to the extent that personnel access requires bubble suits. At one time the facility had NDE equipment such as profilometry and eddy current measurements, but those capabilities do not exist at present.

The Cell 1 can handle a full-length LWR fuel assembly, although disassembly of the fuel assembly would be difficult. Access to Cell 1 can be made through the 25-ft deep pool via a 2-ft square hatch, a roof hatch, or a large door. Access to Cells 2, 3, and 4 is through pass-throughs between cells. Layout of the B&W hot cells is shown in Figure 17.

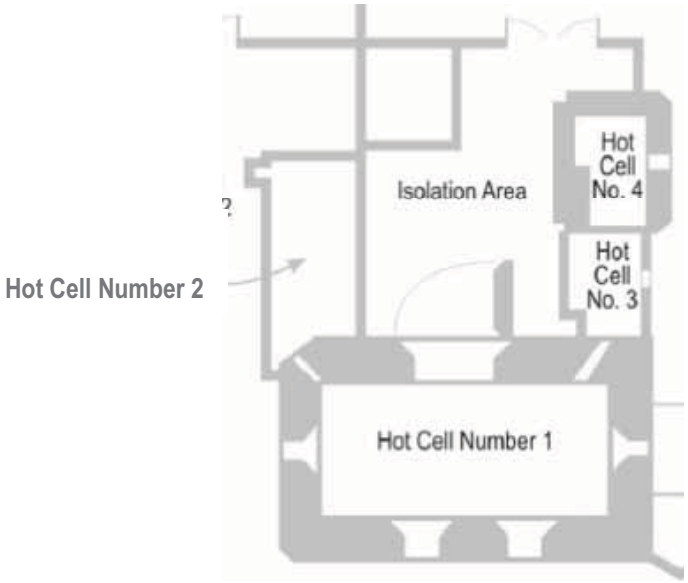


Figure 17. B&W LTC hot cell plan view

The facility seismic structural analysis has not been updated since the initial license application. Further, the impacts of the NRC's update to the seismic source zones in the central and eastern United States have not been evaluated.

Global Nuclear Fuels

Global Nuclear Fuels, in Vallecitos, CA, has a hot cell facility with four large hot cells and four smaller hot cells. The hot cells were constructed in the late 1950's and have the dimensions and shielding shown in Table 9. The floor plan for the GNF hot cell facility is shown in Figure 18.

Table 9. GNF Vallecitos hot cell capability

Cell #	Size (W×L×H)	Shielding material	Function
Cell 1	6'×16'×7'	3' high density concrete	Supported by 6'×6'×10' interlocks. One of these cells is currently being used for PIE on spent fuel including Metallographic/Ceramic and SEM examinations.
Cell 2	6'×16'×7'	3' high density concrete	
Cell 3	6'×16'×7'	3' high density concrete	
Cell 4	6'×16'×7'	3' high density concrete	
Cell 9	5'×5'×7'	18" high density concrete	Two of these cells, along with one larger cell, are currently being used for PIE on spent fuel including Metallographic/Ceramic and SEM examinations.
Cell 10	5'×5'×7'	18" high density concrete	
Cell 11 (A & B)	5'×5'×7'	18" high density concrete	The shielding on these cells is not sufficient to meet the requirements of the APIEC.

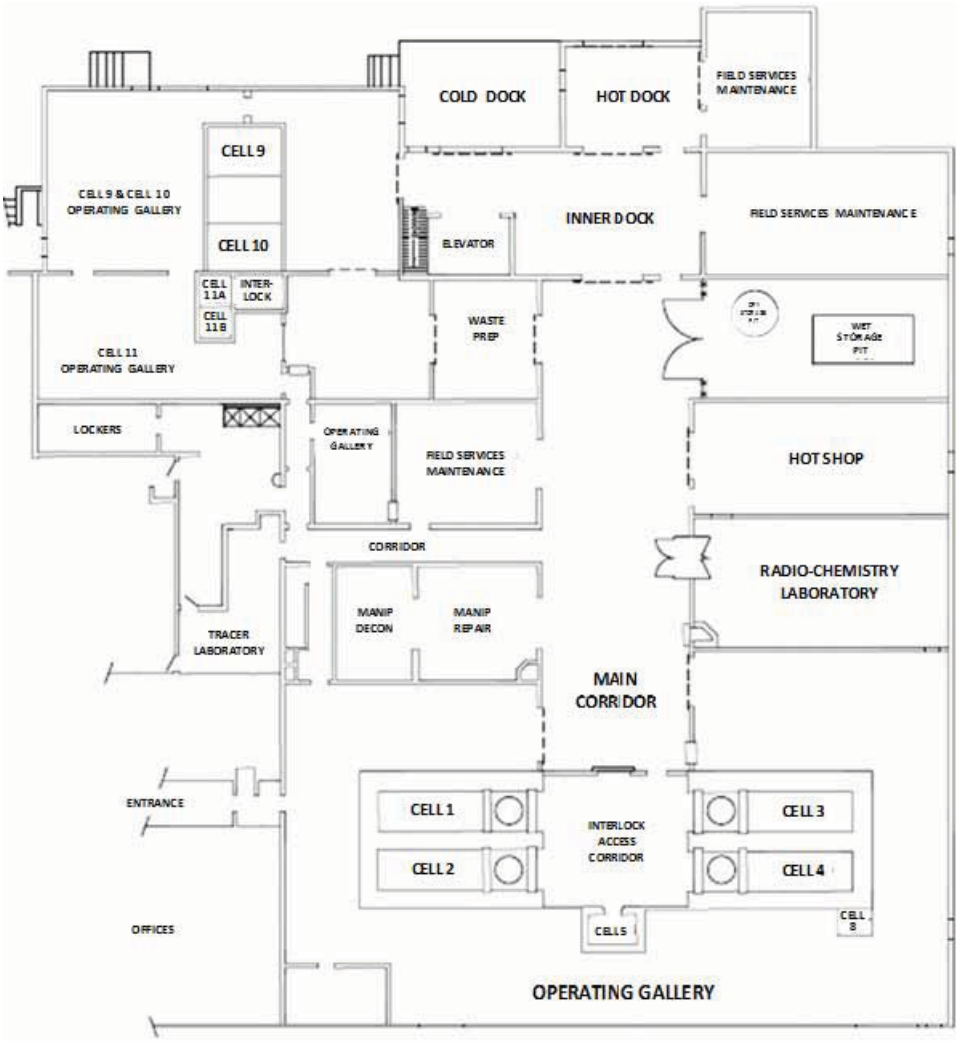


Figure 18. GNF Vallecitos hot cell facility floor plan

The four larger cells have sufficient shielding to support the APIEC, but the other four cells do not. The total area of hot cells at the GNF facility with sufficient shielding for the APIEC is 384 ft^2. The ceiling height of the hot cells is 7 ft which might constrain the types of instruments that could be installed therein. There is an additional 75 ft^2 of cell space that is not shielded to meet APIEC requirements but could be used for non-shielded examination space. One of the large cells and two of the smaller cells are currently being used to support other work so availability is an issue.

The cells are air cells with concrete walls and floors. Each of the cells has a metal cover that can be removed to allow access to a 10-ft deep pit, which facilitates unloading of casks. Each large cell has three work stations consisting of a shield window and a set of manipulators (two on the side, one on the end).

The facility can handle full-length fuel rods and has full-length NDE capability, including gamma spectroscopy, eddy current, profilometry, and digital imaging. The facility also contains sizing equipment and destructive examination capability, including SEM, Inductively Coupled Plasma Mass Spectroscopy (ICP-MS), and ICP Optical Emission Spectroscopy (OES).

Westinghouse Hot Cells

The Westinghouse Building 302 facility is located at the George Westinghouse Research and Technology Park, located in Churchill, PA, and has a 30,000 Ci hot cell licensed by the NRC. The hot cell is dedicated to irradiated materials testing and evaluation and does not engage in research on nuclear fuels.

In total, Westinghouse has four hot cells with nine remote handling stations, which are continuously utilized to support commercial industry PIE efforts and a wide variety of irradiated materials R&D activities. Additionally, Westinghouse has in-cell computer numerical controlled (CNC) machining, metallographic specimen preparation, and mechanical property testing capabilities, as well as dedicated autoclaves for irradiated materials testing. The cells are essential to support the worldwide commercial nuclear fleet and have been in continuous operation since their opening. As such, the cells cannot be dedicated solely for the use of any single customer, but can be made available to support DOE on an as-needed basis. Table 10 shows dimensions and primary functions of the four Westinghouse hot cells.

Table 10. Westinghouse Building 302 hot cell capability

Cell #	Size(W×L×H)	Shielding Material	Function
Cell 1	24'×5'×12'	Sufficient shielding for 30Ci at 1MeV material unknown	Mechanical, Limited microstructural, Chemical analysis with some flexibility in the cells
Cell 2	17.5'×6'×10'		
Cell 3	6'×6'×11.5'		
Cell 4	6'×6'×11.5'		

2.5.5.3 Mapping of APIEC Functions to Included Facilities

This section maps the required functions of the APIEC project to the space available in the various commercial facilities. At this time, these allocations have been assigned by the INL team and may require removal of existing equipment in the cells. If the Commercial Alternative seems viable after the go/no go analysis and qualitative scoring, more detailed discussions will be needed with the commercial suppliers.

Results of this initial functional allocation are shown in Table 11. Based on these results, the commercial capability alone is not sufficient to meet the needs of the APIEC. Additional space would be required from the DOE or international alternatives.

Table 11. Allocation of cell space for commercial hot cells

Allocation for Alternative 5 (Commercial)					
Function	**APIEC Desired State (in spaces)**	**APIEC Desired State (in ft^2)[q]**	**B&W**	**GNF**	**Westinghouse**
Shielded cask receiving/ unpacking/packing	1[r]	80	Use part of Cell 1	Use Interlock access area	Yes
Shielded source material storage	1[r]	80	Use Cell 4 (36 ft^2)	Use part of third available cell for source material storage (40 ft^2 of 96 ft^2)	No Fuels
Shielded source material sizing/ capsule disassembly	Assume function is included with sample prep	Assume function is included with sample prep	With sample prep	With sample prep	With sample prep
Shielded sample/specimen preparation (SPHC)	1[r]	400	A limited prep area could be provided in cell 1 (128 ft^2 total)	Use second available cell for sample prep (96 ft^2)	Housed in some of the 4 cells
Shielded sample/ specimen examination cells	7	720 [1,160 with support equipment space]	Cell 2 could provide space for one instrument (70 ft^2)	Use first available cell for one instrument (96 ft^2)	Use first available cell for one instrument
Non-shielded sample/specimen examination spaces	4	480	Unshielded areas available	Unshielded areas available	Unshielded areas available
Final prepared sample/specimen storage and archive	1[r]	250	Limited temporary storage could be provided in cell 4	Use part of third cell for sample/specimen storage (56 ft^2 of 96 ft^2)	Very limited storage and NO fuel storage
Waste processing/ packaging	1[r]	100	Limited space could be provided in Cell 1	Limited space may be available in second cell	Limited space could be provided

2.5.5.4 Anticipated Facility Modifications

None of the identified commercial facilities can support the APIEC mission without modifications. Table 12 identifies the modifications that are expected to be needed.

[q] Based on PIE Line Item Building pre-conceptual design report space allocation values (rounded up to the nearest 10 square feet).

[r] Infrastructure function – must be allocated to each site participating in the alternative.

Table 12. Expected commercial facility modifications

Facility/APIEC Portion	Required Hot Cell Modifications/Upgrades ["✓" = needed; "-" = not applicable or not needed].															
	Access Door for Personnel or Equip	Acoustical Noise Isolation/Protection	Alpha Containment (infrastructure)	Decontamination	EMI/RFI Protection	Fire Protection Upgrade	Inert Atmosphere (infrastructure only)	Manipulator Upgrade/Update	Penetrations/Ports	Shielding (added depth/partitions)	Refurbish/ Replace Shielding Windows	Sample Prep Equip.	Seismic Upgrade	Temperature Control	Vibration Isolation	Other?
B&W Lynchburg Technology Center	Use existing	NA	-	✓	NA	-	✓	✓	✓	-	NA	✓	NA	✓	✓	-
GNF Hot Cells	Use existing	NA	-	✓	-	-	✓	✓	✓	-	NA	✓	✓	✓	✓	-
Westinghouse Hot Cells	Use existing	NA	✓	✓	NA	-	-	✓	✓	-	NA	✓	NA	✓	✓	-

NA – Not Available

2.5.5.5 APIEC Process Flow Considerations

The general APIEC sample process flow is described in Section 2.4.3. A direct sample shipment approach from the irradiator to the APIEC would work well if all of the advanced PIE capability needed for that experiment is located at one commercial facility. However, if advanced PIE capabilities from more than one commercial facility are needed, which is the more likely case, the simplest contractual approach would be to send the experiment to a DOE facility that can perform the necessary NDE and rough sizing and then send samples to various commercial facilities in the appropriate packaging. This approach simplifies contractual arrangements and optimizes the sample logistics.

Upon receipt of the sample, the commercial facility will perform the sample preparation (activities such as sizing, mounting, polishing, and coating) and the actual examination. The examined specimens will be retained at the commercial facility in specimen storage for some period of time.

Waste from the sample preparation and examination activities will follow an approved disposition path. It is very likely that fuel and fuel waste will be returned to the owner of the fuel (e.g., DOE, a commercial reactor owner, or an international facility). Unneeded material (i.e., non-fuel) and waste incidental to the preparation and examination process (e.g., tools, gloves, miscellaneous sample waste) can most likely be disposed of by the advanced PIE facility as LLW or RH-LLW.

2.5.5.6 Sample Archival and Waste Disposition

Material and fuel samples and specimens should be archived for some period of time; in fact, some of the commercial suppliers have archived materials of their own dating back many years. Providing an archival service for the research items would probably be accomplished more productively and less expensively at a DOE site, though storage will likely be required at multiple sites, resulting in a distributed library. Over the long term, the transportation costs to return the samples to the originator would be paid for by reduced storage costs. Return of the specimens might also be problematic, especially in the case of delicate specimens.

The preferred waste management approach is to have the facility where the examinations are performed provide final disposition. At a minimum, appropriate waste streams will need to be established according to waste attributes and the facility's standard disposition practices. Most excess sample material (as opposed to fuel) and wastes generated when preparing the specimen and performing the examinations can be disposed of as LLW at available commercial facilities, and it is likely that such an approach would be the most cost-effective solution. Disposal of fuel, however, is another issue. It is expected that fuel and fuel-related wastes would be returned to the originator. This can have significant impact on the cost of project.

2.5.5.7 Partnering Arrangements

Some contractual arrangements will be needed between the DOE and the commercial facilities to provide the APIEC. The nature of these agreements could vary from DOE direct funding for modifications to the commercial entities (unlikely) to the commercial entities developing the capabilities at risk (also unlikely). If this alternative shows promising advantages over the other alternatives, some kind of cost sharing or lease agreement may be possible. However, pursuing such discussions with the commercial suppliers at this time would not be productive.

2.5.5.8 NSUF Considerations

The Commercial Alternative poses some problems to becoming part of the ATR NSUF from the "supply side." Efforts to develop collaborations between research entities and industry are underway, but at present there are no commercial facilities providing services. Developing a funding mechanism for a private facility would be challenging.

2.5.5.9 Information and Material Security and Protection

The Commercial Alternative will comply with all known applicable security / protection requirements, as well as with DOE Order 471.6, Information Security. It is expected that such measures would be implemented via contract and/or applicable non-disclosure agreements such that all information can be protected. Even so, commercial and university users may still have concerns regarding access to their proprietary information and intellectual property. It is known that each facility may have its own methods and procedures that must be adapted and adhered to. As such, data from one location needs to be handled differently than similar data collected from a different location.

2.5.6 Alternative 6: International Partnerships

Alternative 6 involves the use of existing PIE capabilities in hot cell facilities located throughout the world. The International Atomic Energy Agency (IAEA) maintains a database that, along with presentations given at an International PIE Workshop held in Paris, France, in June 2011,[6] were used to identify the facilities and associated information presented in this description.

2.5.6.1 Assumptions

Assumptions made for this alternative are as follows:

1. DOE will not invest any taxpayer money in developing an alternative that is not owned and managed within the United States.
2. The alternative will be generated by the least number of international facilities that will meet the required hot cell space.
3. There will only be one international shipment for each APIEC experiment.
4. The alternative will be evaluated based on the current state without any modifications, using information found in the IAEA database and presented at the International PIE Workshop, as well as other open source data.

2.5.6.2 Facility Downselect

The IAEA database identifies 42 PIE facilities in 22 countries and is located at the following website http://infcis.iaea.org/PIE/PIEMain.asp. With the exception of U.S. capabilities, the facilities listed in the database can be separated into two regions: (1) Asian (Korea, Japan etc.) and (2) European (Germany, France, etc), and this distinction was used as the first criterion for reducing the number of facilities to be considered. Options for the International alternative that employed both Asian and European facilities were deemed impractical due to the logistics of shipments to two continents. Additionally, a treaty exists between the United States and the European Atomic Energy Community that governs the transfer of nuclear fuels and materials. This treaty allows the process of transporting irradiated materials to/from Europe to be simplified. Currently, no such treaty exists between the United States and Asian countries. Therefore, INL subject matter experts (SMEs) and the alternatives analysis team selected the European facilities for consideration in this alternative. This selection is made for the purposes of comparison for this alternative and does not mean that Asian facilities cannot be considered if this alternative is pursued further.

The European subset still involves a large number of facilities, which was further reduced by limiting consideration to the countries and facilities that participated in the International PIE Workshop.[6] Twenty-five individuals representing eight international facilities and three national laboratories attended that workshop. The presentations at the International Workshop provided a good understanding of the capabilities of facilities that are currently involved in PIE and, for the purposes of this alternative, identify a feasible subset that could support the APIEC mission.

2.5.6.3 Facility and Hot Cell Descriptions

The international facilities that were selected to comprise this alternative are as follows:

1. The Joint Research Centre (JRC)-Institute for Transuranium Elements (ITU) in Germany
2. Two facilities that are part of the Commissariat à l'énergie Atomique et aux énergies Alternatives (CEA) facilities in Cadarache, France
    a. Laboratoire d'Examen de Combustibles Actifs (LECA)
    b. Station de Traitement Assainissement Reconditionnement (STAR)
3. The Studsvik site in Sweden.
4. Paul Scherrer Institute - Hot Laboratory in Switzerland
5. National Nuclear Laboratory – Windscale in United Kingdom.

Again, it is important to note that these facilities were selected to represent a feasible alternative. A different set of facilities could be selected but it is expected that the results of the evaluation using a different set would be essentially the same. However, if the International alternative is rated highly in the initial qualitative evaluation, additional facilities can be evaluated in more detail as part of conceptual design.

JRC Institute for Transuranium Elements

ITU is a nuclear research facility consisting of six scientific and two supporting units, including their Hot Cell Technology (HCT) unit located in Karlsruhe, Germany. JRC-ITU's prime objectives are to serve as a reference center for basic actinide research, to contribute to an effective safety and safeguards system for the nuclear fuel cycle, and to study technological and medical applications of radionuclides/actinides. ITU has 24 shielded hot cells with up to 1×10^6 Ci shielding along with two decontamination cells. Most of the cells are equipped with an alpha tight stainless steel containment box that is removable to support change in equipment and processes. This removable containment box also helps to minimize the down time of the shielded enclosure because one can be configured while another is operational. ITU has at least one cell that currently has an Electron Probe Micro-Analyzer (EPMA); this cell currently meets the thermal, EMI, and shielding requirements set forth by the manufacturer for optimal operation. This cell appears to be the only cell with this capability. The concrete cells in ITU's hot cells are used for rough sample sizing and sample preparation for existing capabilities. A list of available ITU techniques is found in Table 13.

Table 13. ITU techniques

Technique	Destructive /Non-Destructive
Visual Examination	Non-Destructive
Eddy Current Testing	Non-Destructive
Oxide Thickness	Non-Destructive
Rod Puncture	Non-Destructive
Visual Examination	Non-Destructive
Rod Length measurement	Non-Destructive
Gamma Scanning	Non-Destructive
Length and Diameter	Non-Destructive
Density	Destructive
EPMA	Destructive
Open Porosity	Destructive

Technique	Destructive /Non-Destructive
Retained gas measurement	Destructive
Optical Microscopy	Destructive
SEM	Destructive
Burnup	Destructive
Micro Gamma Scanning	Destructive
X-ray Diffraction	Destructive
Clad Creep Testing	Destructive

CEA Facilities LECA and STAR

CEA is a French government-funded organization focused on four research areas, one of them being nuclear energy. The energy research CEA focuses on nuclear waste, nuclear systems for the future, and new energy technologies. LECA and STAR facilities, located in Cadarache, France, are the nuclear facilities owned and maintained by CEA. The STAR facility is primarily an NDE facility, while LECA has both non-destructive and destructive capabilities. Table 14 shows the techniques offered by the two facilities.

Table 14. STAR and LECA techniques

Technique	Site	Destructive /Non-Destructive
Length and Diameter	STAR	Non-Destructive
Oxide Thickness	STAR	Non-Destructive
Gamma Scanning	STAR	Non-Destructive
Visual Examination	STAR	Non-Destructive
Eddy Current Testing	STAR	Non-Destructive
X-Radiography	STAR	Non-Destructive
Rod Puncture	STAR	Non-Destructive
Length and Diameter	LECA	Non-Destructive
Eddy Current Testing	LECA	Non-Destructive
Oxide Thickness	LECA	Non-Destructive
Gamma Scanning	LECA	Non-Destructive
Visual Examination	LECA	Non-Destructive
Optical Microscopy	LECA	Destructive
SEM	LECA	Destructive
Image Analysis	LECA	Destructive
EPMA	LECA	Destructive
Heat treatments with on-line gas analysis	LECA	Destructive
X-ray Diffraction	LECA	Destructive
Density	LECA	Destructive
Micro-coring	LECA	Destructive
Burnup	LECA	Destructive
Secondary Ion Mass Spectrometry (SIMS)	LECA	Destructive
Retained gas measurement	LECA	Destructive

Technique	Site	Destructive /Non-Destructive
Numerical Macroscope	LECA	Destructive
Oxidation Furnace	LECA	Destructive

LECA has 10 concrete cells with 100K Ci shielding capability and 7 lead cells with about 1000 Ci shielding capability; these air cells can accept a fuel rod up to 2.5m in length. It is assumed that LECA can generate the samples that correspond with the techniques they claim to provide. LECA also has the ability to receive a horizontal cask. The TN-106 cask is currently licensed in France but requires DOT review and significant documentation for use in the United States.

Figure 19 shows the STAR facility, which has three concrete cells with over 280K Ci shielding. STAR has cells that are both air and inert, the largest being 3m wide by 9m long by 5m high. STAR can also accept a fuel rod 4.5m long, if needed, with a horizontal cask.

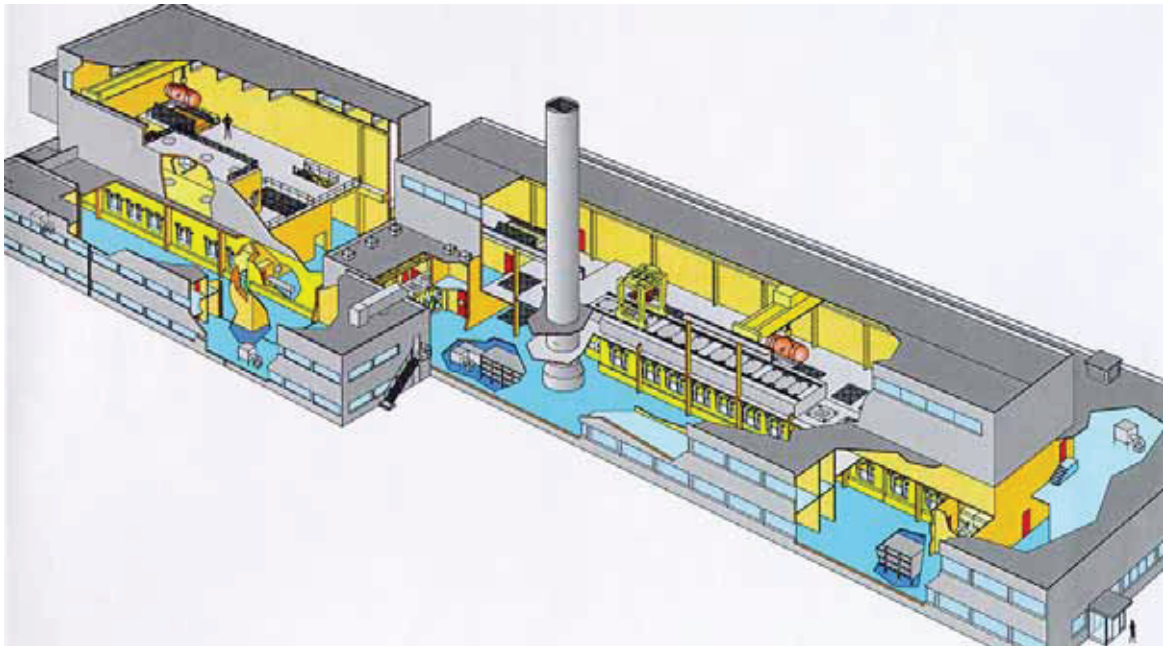


Figure 19. STAR facility

Studsvik Nuclear

The Studsvik facility, located in Nykoping, Sweden, is focused on the international nuclear power industry and offers advanced services in waste treatment, decommissioning, engineering and services, and operating efficiency. Studsvik has 7 concrete cells with about 13.5K Ci shielding and 10 lead cells. Studsvik can receive a fuel rod up to 4.5m in length using a horizontal cask. Table 15 shows the different techniques that Studsvik can currently perform. Studsvik has the ability to receive used LWR fuel rods and then dispose of them within Sweden, thereby cutting down on the cost to ship the material back to the original owner.

Table 15. Studsvik techniques

Technique	Destructive /Non-Destructive
Optical Microscopy	Destructive
SEM	Destructive

Technique	Destructive /Non-Destructive
Image Analysis	Destructive
EPMA	Destructive
X-ray Diffraction	Destructive
Density	Destructive
Burnup	Destructive
O to M Ratio	Destructive
Hydrogen Analysis	Destructive
Clad Creep Testing	Destructive
Clad Fatigue Testing	Destructive
Other Mechanical Testing	Destructive
Length and Diameter	Non-Destructive
Gamma Scanning	Non-Destructive
Eddy Current Testing	Non-Destructive
Oxide Thickness	Non-Destructive
Neutron Radiography	Non-Destructive
Clad-fuel Gap	Non-Destructive
Non-destructive Gas Release	Non-Destructive
Rod Puncture	Non-Destructive
Tube Burst Testing	Destructive
Leak Testing	Destructive

Paul Scherrer Institute – Hot Laboratory

The Paul Scherrer Institute (PSI) – Hot Laboratory is located in Switzerland and is focused on three areas: Matter and Materials, Energy and Environment, and Human Health. PSI currently has five concrete cells, three steel cells, and three lead cells all appear to have sufficient shielding for the APIEC. All the PSI hot cells are air cells with the largest being 2.5 meters wide, 5 meters long, and 4 meters high. Table 16 shows the different techniques that PSI can currently perform.

Table 16. PSI Techniques

Technique	Destructive/Non-Destructive
Visual Examination	Non-Destructive
Length and Diameter	Non-Destructive
Gamma Scanning	Non-Destructive
Eddy Current Testing	Non-Destructive
Oxide Thickness	Non-Destructive
Neutron Radiography	Non-Destructive
Rod Puncture	Non-Destructive
Optical Microscopy	Destructive
SEM	Destructive
Image Analysis	Destructive
Density	Destructive

Hydrogen Analysis	Destructive
TEM	Destructive
SIMS	Destructive
EPMA	Destructive

National Nuclear Laboratory – Windscale

The National Nuclear Laboratory (NNL) is located in the United Kingdom. The hot cells at NNL are located at their Windscale facility, which has 13 concrete cells with about five workstations each as well as one steel cell and one lead cell. All of the hot cells at NNL are air atmosphere cells with the largest being 3 meters wide, 9.5 meters long, and 4 meters high. Table 17 shows the different PIE techniques that NNL can currently perform.

Table 17. NNL Techniques

Technique	Destructive /Non-Destructive
Length and Diameter	Non-Destructive
Gamma Scanning	Non-Destructive
Eddy Current Testing	Non-Destructive
Oxide Thickness	Non-Destructive
Clad-fuel Gap	Non-Destructive
Rod Puncture	Non-Destructive
Visual Examination	Non-Destructive
Auger Spectroscopy	Destructive
Tube Burst Testing	Destructive
Charpy Testing	Destructive
Optical Microscopy	Destructive
X-ray Diffraction	Destructive
Tensile Testing	Destructive
EPMA	Destructive
Density	Destructive
Open Porosity	Destructive
SEM	Destructive
Image Analysis	Destructive
Thermal Diffusivity	Destructive
Specific Heat	Destructive
Hydrogen Analysis	Destructive
Thermal Conductivity	Destructive
Clad Creep Testing	Destructive
Clad Fatigue Testing	Destructive
FEGSTEM	Destructive

2.5.6.4 Mapping of APIEC Functions to Included Facilities

Table 18 identifies and allocates the space available at the six international facilities that could best provide the needed advanced PIE capability.

Table 18. International Alternative allocation table

International Capabilities Assessment (Alternative 6)								
Function	**APIEC Desired State (in spaces)**	**APIEC Desired State (in ft²)[s]**	**ITU (Germany)**	**STAR Cadarache (France)**	**LECA Cadarache (France)**	**Studsvik (Sweden)**	**PSI (Switzerland)**	**NNL (United Kingdom)**
Shielded cask receiving/ unpacking/ packing	1[t]	80	Cask weight max 40t Max cask length 4.5m Horizontal Actual Casks compatibility to United States Casks is unknown	Cask weight max 60t Max cask length 4.5m Horizontal Actual Casks compatibility to United States Casks is TN-106 it requires some DOT review.	Cask weight max 32t Max cask length 2.5m Horizontal Actual Casks compatibility to United States Casks is TN-106 it requires some DOT review.	Cask weight max 30t Max cask length 4.5m Horizontal Actual Casks compatibility to United States Casks is unknown	Cask weight max 30t Max cask length 4.3m Horizontal Actual Casks compatibility to United States Casks is unknown	Cask weight max 55t Max cask length 5m Horizontal Actual Casks compatibility to United States Casks is unknown
Environment of cell (i.e., air, inert)	Inert	N/A	Air/nitrogen	Air/Nitrogen/Argon	Air	Air	Air	Air
Shielded source material storage	1[t]	80	Interim Storage only	Interim storage	Interim dry storage	Interim in cell storage available	Interim Storage and encapsulation for reinsertion and other encapsulation	Has connection to long term storage
Shielded source material sizing/ capsule disassembly	Assume function is included with sample prep	Assume function is included with sample prep	Sizing on-site	Sizing on-site	Sizing on-site	Sizing on-site	Sizing on-site	Sizing on-site
Shielded sample/specimen preparation (SPHC)	1[t]	400	Assumed to be present for the capabilities they currently have	Assumed to be present for the capabilities they currently have	Assumed to be present for the capabilities they currently have	Assumed to be present for the capabilities they currently have	Assumed to be present for the capabilities they currently have	Assumed to be present for the capabilities they currently have

[s] Based on PIE Line Item Building pre-conceptual design report space allocation values (rounded up to the nearest 10 square feet).

[t] Infrastructure function – must be allocated to each site participating in the alternative.

International Capabilities Assessment (Alternative 6)								
Function	**APIEC Desired State (in spaces)**	**APIEC Desired State (in ft^2)[s]**	**ITU (Germany)**	**STAR Cadarache (France)**	**LECA Cadarache (France)**	**Studsvik (Sweden)**	**PSI (Switzerland)**	**NNL (United Kingdom)**
Shielded sample/ specimen examination cells	7	720 [1,160 with support equipment space]	15 Concrete (1MCi) 3 Steel(100Ci) 5 Lead (10KCi)	3 Concrete (280KCi)	10 Concrete (100KCi) 7 Lead(1081Ci)	7 Concrete (13.5K Ci) 10 Lead (unknown Ci)	5 Concrete (100KCi)) 3Steel and 3 Lead (unknown Ci)	13 Concrete 1 Steele 1 Lead All have 3783Ci shielding
Non-shielded sample/specimen examination spaces	4	480	Unknown: Assumed to have enough	Unknown: Assumed to have enough	Unknown: Assumed to have enough	Unknown: Assumed to have enough	Unknown: Assumed to have enough	Unknown: Assumed to have enough
Final prepared sample/specimen storage and archive	1[t]	250	Interim Storage only	Interim storage in dedicated facilities	Interim dry storage	Interim in cell storage available	Interim Storage and encapsulation for reinsertion and other encapsulation	Interim in cell storage available
Waste processing/ packaging	1[t]	100	Unknown: Assumed to a determined disposal path that may include sending back to provider	Unknown: Assumed to a determined disposal path that may include sending back to provider	Unknown: Assumed to a determined disposal path that may include sending back to provider	Foreign fuel can be waste disposed in Sweden	Unknown: Assumed to a determined disposal path that may include sending back to provider	Unknown: Assumed to a determined disposal path that may include sending back to provider

2.5.6.5 APIEC Process Flow Considerations

Generally, process flow considerations for Alternative 6 are the same as for Alternative 5, as described in Section 2.5.5.5, except that international hot cells would not be dedicated full-time to the APIEC mission. Rather, irradiated samples (materials and fuels) would be submitted into the normal processing queue of the international facilities to await and eventually receive advanced PIE.

2.5.6.6 Shipping and Handling

The International Alternative will use existing casks that are acceptable for international shipments. Most countries have specific casks that have been licensed for their country. Such international shipments would require a DOT security plan and appropriate documentation to use them domestically. Each shipment will then need to be reviewed and accepted by DOT. Shipments made internationally usually cost between $750K and $1M each (see TEV-1634)[11].

2.5.6.7 Waste Management

Waste management could be different for each PIE facility included in this alternative. The most preferred waste management plan is to have the facility that performs the examinations also store the waste. At a minimum, a waste stream will be established according to the facility's standard operating conditions. Waste management at ITU and the CEA facilities is unknown, but Studsvik can accept foreign LWR fuels, and the waste is disposed of in Sweden, thus eliminating an extra shipment. It is expected that disposal of R&D fuel samples and specimen at Studsvik would require case by case negotiation and approval if they were different than standard LWR fuel types.

2.5.6.8 NSUF Considerations

The International Alternative poses some problems to becoming part of the ATR NSUF because of the distance and cost of international shipments. One of the primary users of the ATR-NSUF is academia, which is typically on a very small research budget. The ability for users to use the international capability will not change based on the outcome of this alternatives analysis because international companies currently welcome all users.

2.5.6.9 Information and Material Security and Protection

The International Alternative may preclude some potential users from taking full advantage of APIEC capabilities due to issues such as export controls. For example, the U.S. military (primarily the Navy) cannot allow non-U.S. citizens to perform analyses on their nuclear fuels and materials. Furthermore, there may be some concerns regarding access to intellectual property and/or proprietary information that may be an issue for some researchers from the commercial, DOE, and university sectors.

2.6 Criteria and Weights

The criteria are qualitatively and/or quantitatively defined metrics developed to help evaluators decide between competing alternatives that may meet APIEC needs. Criteria are derived from and align with the goals and requirements identified in Section 2.3 and constitute the lowest level of the analysis. The hierarchy of the goals and their associated criteria is shown in Figure 20.

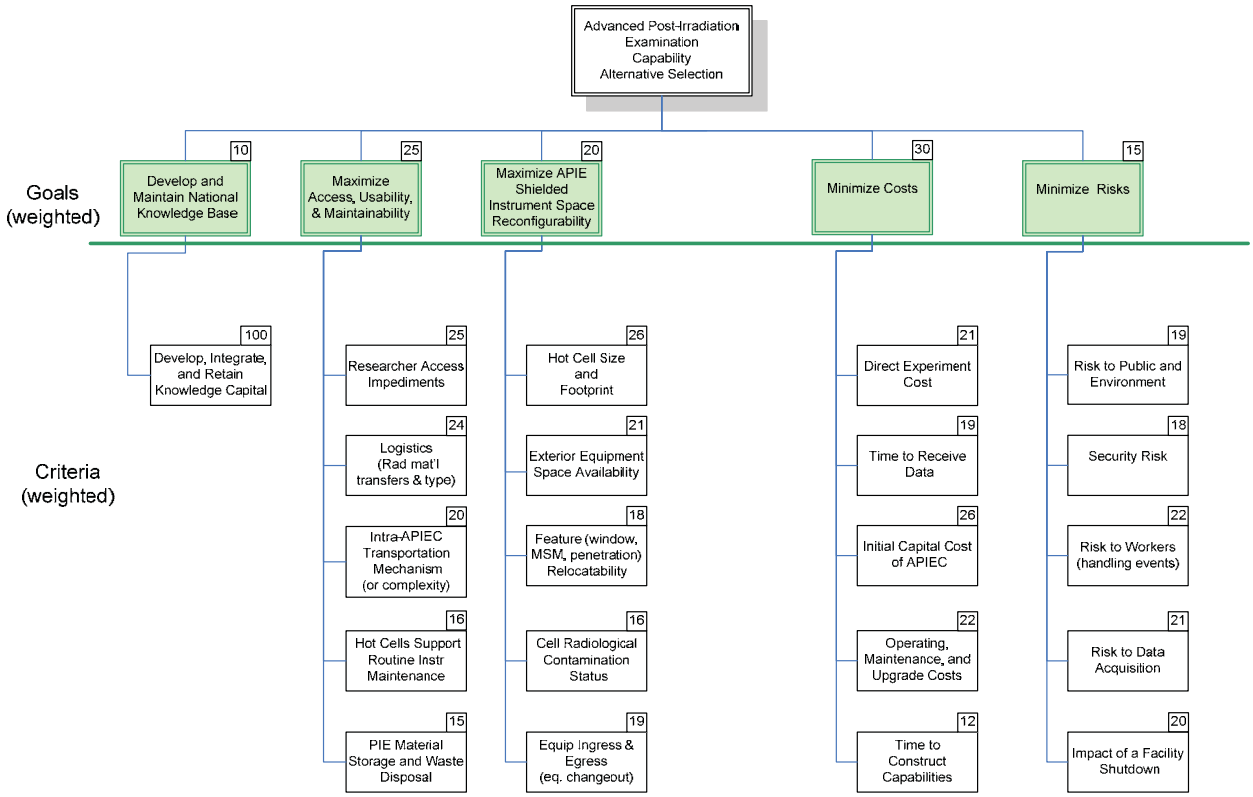


Figure 20. Hierarchy of goals and evaluation criteria, as weighted by the SRC

The goals are assigned weights (expressed as percentages) based on their importance to the APIEC, the sum of which total to 100%. Each criterion is also assigned a weight (expressed as a percent) that represents its importance to the goal to which it applies. Again, the sum of the weights for all the criteria associated with a goal will total 100%. The criteria weights are multiplied by their respective goal weight to determine the computed weight of each criterion to the APIEC. The weights for each goal and criterion are discussed below.

As noted previously, each APIEC alternative that includes DOE capital investment has been designed to provide equal technical performance to the extent practical. In other words, modifications (e.g., vibration isolation tables, cell temperature control requirements) have been identified such that it would be capable of housing the initial complement of APIEC examination equipment. Thus, for these alternatives, the ability of the PIE instrumentation to support a science based approach will be a non-discriminator.

Initial estimates of the goal and criteria weights were made by the APIEC team and were reported in revision 0 of this report. The goals and criteria were reviewed by the SRC at Workshop 1 and changes to the goals, criteria, and their respective weights were made based on the recommendations of the SRC. The revised goal weights were obtained by calculating the average of the weights provided by the SRC members and rounding them to the nearest 5. The revised criteria weights were calculated by computing the average of the goal weight times the criteria weight for each criterion and adjusting the criterion weight to the nearest whole integer to approximate the average computed weight. Additional details can be found in Appendix A.

The goal and criteria descriptions and weights provided below have been updated to reflect the results of Workshop 1.

2.6.1 Criteria for Goal 1 (Develop and Maintain National Knowledge Base)

Goal 1 was assigned a weight of 10%. There is only one criterion associated with this goal:

1. Develop, Integrate, and Retain Knowledge Capital– This criterion addresses the ability to
    a. Develop and retain U.S. experience in deploying the advanced PIE instrumentation in high radiation, remote environments
    b. Develop the technical expertise within the United States to prepare specimens for examination
    c. Develop the technical expertise within the United States to operate and maintain these advanced instruments remotely in high radiation environments
    d. Obtain and retain the data from the advanced examinations and integrate that information with other programs
    e. Facilitate communications across all phases of the experiment program, from design of the experiment to its irradiation and subsequent examination, for the purpose of identifying and incorporating process improvement.

    Alternatives that allow more of the APIEC functions to be performed domestically by U.S. researchers and technicians or that promote better communication across the PIE life-cycle will score higher.

    Criterion Weight – This criterion will receive **100**% of the Goal 1 allocated weight. When multiplied by the respective goal weight of 10%, this criterion accounts for **10**% of the overall analysis weight.

2.6.2 Criteria for Goal 2 (Maximize Access, Usability, and Maintainability)

Goal 2 was assigned a weight of 25%. The weights for the criteria associated with Goal 2 are discussed below.

1. Researcher access impediments – This criterion evaluates the impact of the alternative on the effort needed from a researcher to establish agreements with the parties providing the APIE capabilities and gain access to the facility(ies). Things to be considered include the complexity of agreements to perform work, the access controls associated with each facility (e.g., clearances), and the amount of training needed to access each facility. It is expected that the use of multiple facilities implies additional barriers to researcher access..

    Criterion Weight – This criterion will receive **25**% of the Goal 2 allocated weight. When multiplied by the respective goal weight of 25%, this criterion accounts for **6.25**% of the overall analysis weight.

2. Logistics (type and complexity of initial radioactive material transfers) – This criterion evaluates the logistics associated with transporting irradiated fuel or material from the originating site to the APIEC in a form that is acceptable for receipt. This scope covers shipment from the irradiation facility; receipt at an NDE/sizing facility; and subsequent transfer from the NDE/sizing facility to the APIEC facility. Alternatives that necessitate fewer sample transfers or perform irradiations, or advanced PIE at the same site would rate higher (e.g., because the shipments can be made over site-controlled roads as opposed to public highways, and the distances are shorter, and risk to the public is minimized (e.g., the probability of traffic-related deaths would be reduced).

Criterion Weight – This criterion will receive **24**% of the Goal 2 allocated weight. When multiplied by the respective goal weight of 25%, this criterion accounts for **6**% of the overall analysis weight.

3. Intra-APIEC transportation mechanism (or complexity) – This criterion evaluates the transportation needs between buildings or facilities associated with sample examination after they have been received at the APIEC. This criterion differs from the previous criterion in that it addresses transfers that occur after the sample has been prepared for examination in the APIEC sample preparation area. Some alternatives collocate sample preparation in the same building as the examination cells, while other alternatives require transportation of the prepared sample from one building to another (it is assumed that specimen preparation and subsequent examinations are carried out on the same site). Options that have sample preparation and all the examination cells in the same building would score higher than those that require shipments to other buildings, even if they are still within the facility boundary, because (for example) the probability of specimen damage or worker exposure is reduced.

   Criterion Weight – This criterion will receive **20**% of the Goal 2 allocated weight. When multiplied by the respective goal weight of 25%, this criterion accounts for **5**% of the overall analysis weight.

4. Hot cells support routine instrument maintenance – This criterion is similar to the requirement that the cell has a door for personnel access but will be used to evaluate the alternatives on the ease with which the maintenance activities can be performed. Cells that have a door that is readily accessible and easy to open are rated higher than cells that require a crane or fork truck to remove a ceiling or wall plug for access. Cells that can implement additional pass-throughs, pneumatic transport (rabbit) stations, and other enhancements rate higher than cells that only have a door. Finally, this criterion also considers the amount of cell space available in which to perform the maintenance. Cells that have space that allows the worker to easily move around the equipment would rate higher than smaller cells that would make maintenance activities more difficult.

   Criterion Weight – This criterion will receive **16**% of the Goal 2 allocated weight. When multiplied by the respective goal weight of 25%, this criterion accounts for **4**% of the overall analysis weight.

5. PIE material storage and waste disposition – This criterion evaluates the involved facilities' ability to store specimens after examination as well as temporary storage and disposition of the unused sample portions and resultant waste after destructive examination. This includes consideration of fuels and materials that may be accepted for examination as well as the source of the sample (e.g., government, commercial, international). Sites that have the ability for blanket acceptance of a wide range of fuels and materials and the ability for long-term on-site storage of these materials are rated higher than sites that require individual government approvals and requirements for short-term waste disposition.

   Criterion Weight – This criterion will receive **15**% of the Goal 2 allocated weight. When multiplied by the respective goal weight of 25%, this criterion accounts for **3.75**% of the overall analysis weight.

2.6.3 Criteria for Goal 3 (Maximize APIEC Shielded Instrument Space Reconfigurability)

Goal 3 was assigned a weight of 20%. The weights for the criteria associated with Goal 3 are discussed below.

1. Hot cell size and footprint – This criterion evaluates the size (area and height) and shape (aspect ratio) of the hot cells with respect to installation of an instrument (and future instruments) in the cell. The size of a hot cell is a measure of how likely examination instruments are to fit in the hot cell. An area of 100 sq ft is considered optimal. Cell height should be at least 10 ft.

   The hot cell shape is another measure of how well the space can be used to house any particular examination instrument. For example, a very deep but narrow cell could have the same cell area as a square cell but would likely be less than optimal for installation of an instrument.

   Criterion Weight – This criterion will receive **26**% of the Goal 3 allocated weight. When multiplied by the respective goal weight of 20%, this criterion accounts for **5.2**% of the overall analysis weight.

2. Exterior equipment space availability – This criterion evaluates the ability to locate the instrument support system and radiation-sensitive components outside of the shielding wall but adjacent to the instrument. Generally, most advanced examination instruments have items that should not be installed in a high-radiation environment or should be separated from the measuring portion for maintenance reasons. Often, there are also constraints on the distance that this equipment can be located from the instrument. Ideally, this external equipment should be located within the parameters of the instrument requirements but in protected areas away from instrument operators and routine traffic patterns outside the cell.

   Criterion Weight – This criterion will receive **21**% of the Goal 3 allocated weight. When multiplied by the respective goal weight of 20%, this criterion accounts for **4.2**% of the overall analysis weight.

3. Feature relocatability – This criterion evaluates the ability to relocate features of the cell, such as windows, manipulators, and pass-throughs, to accommodate installation of a new instrument that may require certain actions (e.g., placing the specimen in the machine). It should also evaluate the ability to modify the shape, or footprint, of the cell (e.g., add length, width, or height).

   Each instrument will have unique requirements for access and operation. Ideally, a cell would easily accommodate pass-throughs or telemanipulators in different locations. Less frequently, changing the dimensions of a cell may be advantageous in deploying a new instrument.

   Criterion Weight – This criterion will receive **18**% of the Goal 3 allocated weight. When multiplied by the respective goal weight of 20%, this criterion accounts for **3.6**% of the overall analysis weight.

4. Cell radiological contamination status – This criterion evaluates the levels of radioactive contamination in the cell, which will affect the maintenance activities or reconfiguration of the cell from both cost and personnel exposure perspectives. For this analysis, it is assumed that all existing cells that are proposed will be used to house APIEC instruments and will be decontaminated to levels that are as low as reasonably achievable. However, surfaces (concrete in particular) often cannot be decontaminated to “clean” conditions and tend to “leak” contamination over time. This source of radioactive contamination can affect both routine maintenance activities and reconfiguration efforts. Cells that have minimal or no

contamination would rate higher than contaminated steel-lined cells, which would rate higher than cells with concrete surfaces.

Criterion Weight – This criterion will receive **16**% of the Goal 3 allocated weight. When multiplied by the respective goal weight of 20%, this criterion accounts for **3.2**% of the overall analysis weight.

5. Equipment ingress and egress (equipment change-out) – This criterion evaluates the ease with which personnel and equipment can access a hot cell to replace an instrument and its associated confinement enclosure. The APIEC concept employs a containment enclosure within a shielded enclosure. This concept maintains the cleanliness of the cell and facilitates reconfiguration because the "new" confinement enclosure can be fabricated and assembled outside the cell and easily replaced when the "old" confinement enclosure is removed. Cells that have a way to allow access to large components (e.g., removable walls) would rate higher than cells with traditional personnel access doors only.

   Criterion Weight – This criterion will receive **19**% of the Goal 3 allocated weight. When multiplied by the respective goal weight of 20%, this criterion accounts for **3.8**% of the overall analysis weight.

2.6.4 Criteria for Goal 4 (Minimize Costs)

Goal 4 was assigned a weight of 30%. The weights for the criteria associated with Goal 4 are discussed below.

1. Direct experiment cost – This criterion evaluates the direct life-cycle cost of obtaining the desired data including packaging and transportation, sample preparation, examination, and reporting. This cost is a function of the level of staffing required to perform these functions assuming a fully utilized capability. The direct experiment cost is also dependent on the cost of transporting the samples from the irradiator to NDE/sizing and then to the facility(ies) performing the APIE. This cost does not include facility-related operations and maintenance costs that are considered in a separate criterion.

   Criterion Weight – This criterion will receive **21**% of the Goal 4 allocated weight. When multiplied by the respective goal weight of 30%, this criterion accounts for **6.3**% of the overall analysis weight.

2. Time to receive data – This criterion considers the time it will take to obtain the data from the advanced PIE alternative. It spans the duration from initial receipt from the irradiator to completion of the examination data report. The number of handling events and transport time are expected to be a key discriminators for this criterion. After delivery to a site, the time to prepare and examine the sample and to develop the report is expected to be similar for all alternatives and thus would not be a discriminator in this analysis.

   Criterion Weight – This criterion will receive **19**% of the Goal 4 allocated weight. When multiplied by the respective goal weight of 30%, this criterion accounts for **5.7**% of the overall analysis weight.

3. Initial capital cost of providing the APIEC – The capital cost includes the engineering, procurement, and construction of modifications and upgrades to existing facilities or a new facility to a level that meets the requirements for the APIEC. The modifications to existing facilities may include the following:

   - Cell decontamination
   - Modifications to meet vibration, electromagnetic interference, and temperature requirements of the advanced instrumentation

- Initial refurbishment of cell components, such as manipulators and shield windows
- Installation of inert gas supply systems to the cells (but not the inert gas recirculation and cleanup that would be associated with the confinement enclosure)
- Cell modifications for accessibility for installation.

Alternatives with lower initial capital costs will rate higher.

Criterion Weight – This criterion will receive **26**% of the Goal 4 allocated weight. When multiplied by the respective goal weight of 30%, this criterion accounts for **7.8**% of the overall analysis weight.

4. Operating, maintenance, and refurbishment costs – This criterion considers the ongoing costs associated with operating and maintaining the APIEC facility(ies). These costs would include any costs associated with facility labor, facility utilities, facility maintenance, and periodic refurbishments to the facility structure (e.g., new roof) that will be required over the 40 year evaluation period. Alternatives which require duplication of functions are anticipated to require higher facility operating and maintenance costs. This criteria also considers decontamination and decommissioning costs assumed to occur at the end of the 40 year evaluation period. Alternatives with lower overall costs will rate higher.

   Criterion Weight – This criterion will receive **22**% of the Goal 4 allocated weight. When multiplied by the respective goal weight of 30%, this criterion accounts for **6.6**% of the overall analysis weight.

5. Time to Construct capabilities – This criterion evaluates the time it will take to implement the APIEC. New facilities typically require less time in design, field verification, and construction as compared to retrofitting existing facilities.

   Criterion Weight – This criterion will receive **12**% of the Goal 4 allocated weight. When multiplied by the respective goal weight of 30%, this criterion accounts for **3.6**% of the overall analysis weight.

2.6.5 Criteria for Goal 5 (Minimize Risks)

Goal 5 was assigned a weight of 15%. The weights for the criteria associated with Goal 5 are discussed below.

1. Risk to Public and Environment – This criterion evaluates the risk to the public and the environment resulting from APIEC operations. Because all alternatives are required to meet DOE or equivalent standards, risks to the public and the environment from operations within those facilities are essentially equivalent. Thus, the primary discriminator is expected to be related to the transportation of experiments over public roads. Alternatives that result in fewer miles travelled on public roads will rate higher.

   Criterion Weight – This criterion will receive **19**% of the Goal 5 allocated weight. When multiplied by the respective goal weight of 15%, this criterion accounts for **2.85**% of the overall analysis weight.

2. Security Risk – This criterion evaluates the security risk associated with unauthorized access to material or data. This unauthorized access may occur either on-site or off-site. On-site risks are related to adequacy of site procedures and engineered barriers. Also, dissimilar procedures at multiple facilities may result in mistakes that compromise the security of material or data. Off-site security risks are expected to be primarily related to the amount of time material is in transit, outside of associated site boundaries, thus presenting opportunities for loss of control of the material. Thus, alternatives that involve more sites, less stringent

physical security measures, or that require samples to spend more time in transit will rate higher for risk.

Criterion Weight – This criterion will receive **18**% of the Goal 6 allocated weight. When multiplied by the respective goal weight of 15%, this criterion accounts for **2.7**% of the overall analysis weight.

3. Risk to Workers – This criterion evaluates the risk to facility workers. All of the alternatives are assumed to be compliant with DOE and federal regulations, or equivalent standards. Thus, risks due to PIE activities such as sample preparation and instrument operation are considered to be the same for all alternatives and thus are not discriminators.

   For this criterion, the risk to workers will primarily depend on the number of handling operations. Each transport-related loading or unloading operation is a point where worker dose is incurred and where accidents could occur that might result in harm to a worker.

   Criterion Weight – This criterion will receive **22**% of the Goal 5 allocated weight. When multiplied by the respective goal weight of 15%, this criterion accounts for **3.3**% of the overall analysis weight.

4. Risk to Data Acquisition – This criterion evaluates the potential for data to be unavailable due to damage to or loss of the experiment or prepared specimen. It is assumed that the component of this risk that stems from sample preparation activities is equivalent for all alternatives and is not a discriminator. The potential for data unavailability is increased due to the number of handling events, mode and distance of transport, delicacy of the item being transported, and time that the material or fuel is under transport. Alternatives that reduce such handling and transport will pose a lower risk.

   Criterion Weight – This criterion will receive **21**% of the Goal 5 allocated weight. When multiplied by the respective goal weight of 15%, this criterion accounts for **3.15**% of the overall analysis weight.

5. Impact of Facility Shutdown – This criterion evaluates the impact of a facility shutdown, if one occurs, on the APIEC mission and the need to obtain the PIE data. The probability of a shutdown occurrence is assumed to be essentially equal for all of the alternatives and will not be a discriminator.

   Criterion Weight – This criterion will receive **20**% of the Goal 5 allocated weight. When multiplied by the respective goal weight of 15%, this criterion accounts for **3**% of the overall analysis weight.

3. STAGE 2 – QUALITATIVE EXPLORATION

The primary objective of Stage 2 was to help the alternatives analysis team qualitatively understand what makes up a good alternative using the decision framework established in Stage 1. The primary outputs from this stage are the refined alternatives and the prioritized data needs.

3.1 Go/No-Go Analysis

The requirements are conditions or states that each alternative must meet in order to be considered a real or feasible solution. The requirements used in this APIEC alternatives analysis are summarized in Figure 21. A Go/No-Go analysis was performed to evaluate the various alternatives against the requirements and to eliminate alternatives that do not meet the requirements from further consideration.

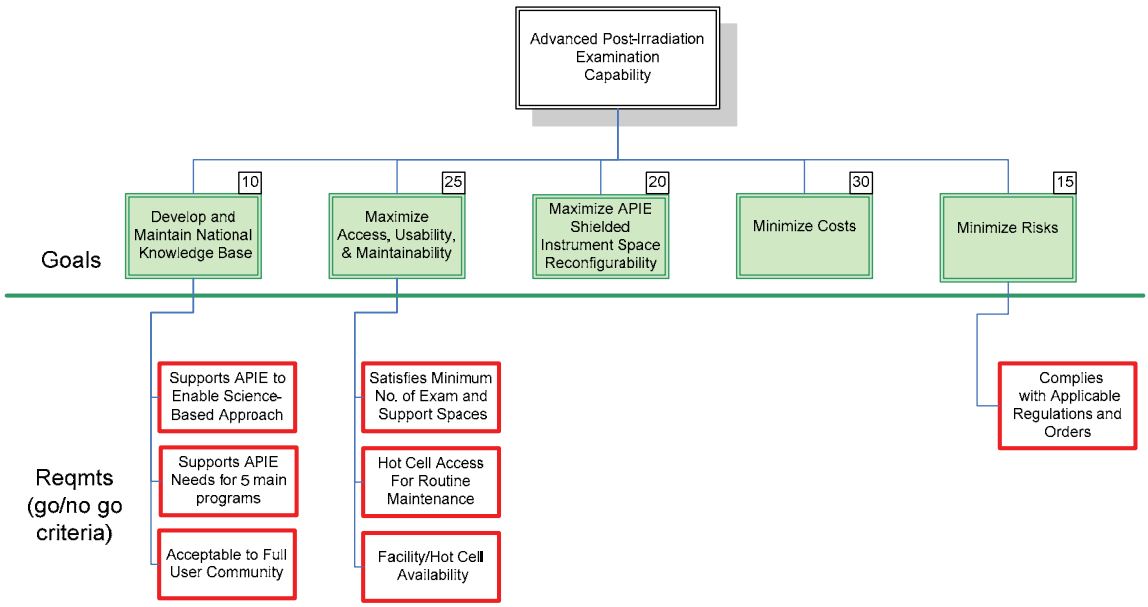


Figure 21. Goals and associated requirements for the APIEC Alternatives Analysis

3.1.1 Alternative 1: No Action

Each of the requirements associated with the various goals are evaluated below for Alternative 1:

- Goal 1, Requirement 1 – Supports advanced PIE to enable science-based approach

  GO – This alternative provides minimal support of advanced PIE using instrumentation that is or could be made available at IMCL, LANL, PNNL, SRNL and ORNL, but likely not on an equivalent production basis or for the full suite of anticipated characterization analyses. The IMCL's instrument development shielded cell capabilities are only expected to support small quantities of specimens which would limit throughput.

- Goal 1, Requirement 2 – Supports advanced PIE needs for the five main programs

  NO GO – Among other things, this alternative does not allow the necessary modifications to support installation of inert systems into existing facilities and therefore does not support the Fuel Cycle R&D (FCRD) program, which is expected to include pyrophoric fuel materials and sodium-bearing fuels that will require inert atmospheres for sample preparation and examination.

- Goal 1, Requirement 3 – Acceptable to the full user community

NO GO – Given that modifications cannot be made to provide the inert gas systems support the FCRD program, this alternative does not satisfy this requirement.

- Goal 2, Requirement 1 – Satisfies minimum number of examination and support spaces

  NO GO – None of these facilities provide the necessary number of shielded examination cells and support spaces, either individually or collectively.

- Goal 2, Requirement 2 – Hot cell access for routine maintenance

  GO – Most facilities considered in this alternative have access of some sort into the cells for routine maintenance, although the access may not be ideal (e.g., roof hatches).

- Goal 2, Requirement 3 – Facility and hot cell availability

  GO – It is assumed that the facilities identified in the alternative are available.

- Goal 5, Requirement 1 – Complies with Applicable Regulations and Orders

  GO – This alternative meets this requirement.

Based on the failure of this alternative to meet Goal 1, Requirements 2 and 3 and Goal 2, Requirement 1, this alternative is eliminated from further consideration.

3.1.2 Alternative 2: Modify Existing DOE Facilities – Distributed

Each of the requirements associated with the various goals are evaluated below for Alternative 2

- Goal 1, Requirement 1 – Supports advanced PIE to enable science-based approach

  GO – This alternative supports advanced PIE to enable the science-based approach through necessary facility modifications and new instrument installation.

- Goal 1, Requirement 2 – Supports advanced PIE needs for the five main programs

  GO – This alternative includes modifications to existing facilities (e.g., inert atmosphere capabilities and hot cell enhancements) that will support the needs of the DOE programs identified in the Mission Need document.

- Goal 1, Requirement 3 – Acceptable to the full user community

  GO – This alternative is expected to be acceptable to the full user community.

- Goal 2, Requirement 1 – Satisfies minimum number of examination and support spaces

  GO – The minimum number of examination and support spaces have been identified for this alternative.

- Goal 2, Requirement 2 – Hot cell access for routine maintenance

  GO – All hot cells identified for use in this alternative have or will be modified to have access for routine maintenance.

- Goal 2, Requirement 3 – Facility and hot cell availability

  GO – All the facilities identified in the alternative are reported to be available.

- Goal 5, Requirement 1 – Complies with Applicable Regulations and Orders

  GO – This alternative has been defined in a manner such that it will include necessary modifications or other attributes to meet this requirement.

This alternative meets all the identified requirements and will be evaluated against the criteria.

3.1.3 Alternative 3: Modify Existing DOE Facilities – Consolidated

Each of the requirements associated with the various goals are evaluated below for Alternative 3

- Goal 1, Requirement 1 – Supports advanced PIE to enable science-based approach

  GO – This alternative supports advanced PIE to enable the science-based approach through necessary facility modifications and new instrument installation.

- Goal 1 Requirement 2 – Supports advanced PIE needs for the five main programs

  GO – This alternative includes modifications to existing facilities (e.g., inert atmosphere capabilities and hot cell enhancements) that will support the needs of the DOE programs identified in the Mission Need document.

- Goal 1 Requirement 3 – Acceptable to the full user community

  GO – This alternative is expected to be acceptable to the full user community.

- Goal 2, Requirement 1 – Satisfies minimum number of examination and support spaces

  GO – The minimum number of examination and support spaces have been identified for this alternative.

- Goal 2, Requirement 2 – Hot cell access for routine maintenance

  GO – All hot cells identified for use in this alternative have or will be modified to have access for routine maintenance.

- Goal 2, Requirement 3 – Facility and hot cell availability

  GO – All the facilities identified in the alternative are reported to be available.

- Goal 5, Requirement 1 – Complies with Applicable Regulations and Orders

  GO – This alternative has been defined in a manner such that it will include necessary modifications or other attributes to meet this requirement.

This alternative meets all the identified requirements and will be evaluated against the criteria.

3.1.4 Alternative 4: Construct New Facility

Each of the requirements associated with the various goals are evaluated below for Alternative 4

- Goal 1, Requirement 1 – Supports advanced PIE to enable science-based approach

  GO – This alternative supports advanced PIE to enable the science-based approach through construction of a state-of-the-art hot cell laboratory and installation of advance PIE instruments.

- Goal 1 Requirement 2 – Supports advanced PIE needs for the five main programs

  GO – The new facility will be designed and constructed to specifically support the needs of the programs identified in the Mission Need document.

- Goal 1 Requirement 3 – Acceptable to the full user community

  GO – This alternative is expected to be acceptable to the full user community.

- Goal 2, Requirement 1 – Satisfies minimum number of examination and support spaces

  GO – The new facility will be designed with the minimum number of examination and support spaces and may also provide additional space for expansion.

- Goal 2, Requirement 2 – Hot cell access for routine maintenance

  GO – The hot cells in the new facility will be designed for routine maintenance as well as change-out of the inert confinement enclosures.

- Goal 2, Requirement 3 – Facility and hot cell availability

  GO – The new facility will be dedicated to the performance of advanced PIE.

- Goal 5, Requirement 1 – Complies with Applicable Regulations and Orders

  GO – This alternative has been defined in a manner such that it will include necessary features and attributes to meet this requirement.

This alternative meets all the identified requirements and will be evaluated against the criteria.

3.1.5 Alternative 5: Commercial Partnerships

Each of the requirements associated with the various goals are evaluated below for Alternative 5

- Goal 1, Requirement 1 – Supports advanced PIE to enable science-based approach

  GO – This alternative is assumed to support advanced PIE to enable science-based approach. The existing commercial facilities do not currently support advanced PIE but it is assumed that contractual agreements between the suppliers and DOE can be achieved to allow the commercial suppliers to modify their facilities to meet the advanced PIE requirements.

- Goal 1, Requirement 2 – Supports advanced PIE needs for the five main programs

  NO GO – The commercial suppliers do not currently handle irradiated nuclear fuels. Therefore, they cannot support the FCRD program.

- Goal 1, Requirement 3 – Acceptable to the full user community

  NO GO – This alternative is not expected to be acceptable to the full user community. There is a concern that some commercial entities will not use a competitor's facilities due to potential for loss of business sensitive information.

- Goal 2, Requirement 1 – Satisfies minimum number of examination and support spaces

  NO GO – The cells currently available from domestic commercial suppliers are not sufficient, on their own, to meet the minimum required number of cells.

- Goal 2, Requirement 2 – Hot cell access for routine maintenance

  GO – The hot cells in the commercial suppliers' facilities have access that can be used for routine maintenance

- Goal 2, Requirement 3 – Facility and hot cell availability

  GO – It is likely that the commercial suppliers will prefer to use their facilities to support both DOE and their own development programs. It is assumed that contractual agreements between the suppliers and DOE can be achieved to allow the DOE access to the hot cells in a timely manner.

- Goal 5, Requirement 1 – Complies with Applicable Regulations and Orders

  GO – It is expected that the commercial entities identified would fully comply with applicable federal, state, and DOE orders and directives such that this alternative would meet this requirement.

This alternative fails to meet Goal 1, Requirements 2 and 3 and Goal 2, Requirement 1 and is eliminated from further consideration.

3.1.6 Alternative 6: International Partnerships

Each of the requirements associated with the various goals are evaluated below for Alternative 6

- Goal 1, Requirement 1 – Supports advanced PIE to enable science-based approach

  GO – This alternative is assumed to support advanced PIE to enable science-based approach. There are existing international facilities that support advanced PIE.

- Goal 1, Requirement 2 – Supports advanced PIE needs for the five main programs

  GO – From a technical perspective, the international facilities can likely support the five main programs identified in the Mission Need document. However, it should be noted that the cost associated with international transportation of samples would make it difficult for University Programs to afford to use this alternative to achieve their research goals.

- Goal 1, Requirement 3 – Acceptable to the full user community

  NO GO – This alternative is not expected to be acceptable to the full user community. The Naval Nuclear Propulsion Program will not be able to use foreign facilities.

- Goal 2, Requirement 1 – Satisfies minimum number of examination and support spaces

  GO – A combination of cells from various international facilities can provide the minimum number of examination and support spaces.

- Goal 2, Requirement 2 – Hot cell access for routine maintenance

  GO – The hot cells in the international facilities have access that can be used for routine maintenance

- Goal 2, Requirement 3 – Facility and hot cell availability

  GO – It is likely that the international facilities will use their facilities to support both DOE and their own development programs. It is assumed that agreements between the operators of the international facilities and DOE can be achieved to allow the DOE access to the hot cells in a timely manner.

- Goal 5, Requirement 1 – Complies with Applicable Regulations and Orders

  GO – This alternative meets this requirement.

This alternative fails to meet Goal 1, Requirement 3 and is eliminated from further consideration.

3.2 Alternative Scoring – Initial

This section presents the basis for scoring the alternatives against the criteria. The criteria are either quantitative or qualitative. Quantitative criteria can be expressed in terms of a finite, measureable quantity (such as construction cost, staffing cost, number of handling events, or miles travelled) and will be scored using a scale that corresponds to the range of the measureable quantity. Section 3.2.2.2 is an example of a quantitative criterion. For these criteria, a discussion of the measures for scoring is provided in the following sections. For example, the discussion under the “Initial Capital Cost” criterion summarizes the costs estimates that were developed. Utility curves are defined and used to convert the raw measure to a utility value for purposes of rolling up an overall alternative score across all of the criteria.

Qualitative criteria are those criteria that are subjective and cannot be readily expressed with a measureable quantity. An example of a qualitative criterion is Criterion 1 for Goal 1, “Develop, Integrate,

and Retain Knowledge Capital". The qualitative criteria will be scored using six-point rating scale, as shown on the horizontal axes in Figure 22 and Figure 23. Again, utility curves are defined and used to convert this qualitative rating to a utility value which can be rolled up to an overall alternative score across all of the criteria.

Please note that, while the two utility curves in Figure 22 and Figure 23 have the same negative slope, the order of the ratings is reversed – in Figure 22, a High rating results in a high score while in Figure 23, a Very Low rating would result in a high score. The utility curve shown in Figure 22 (High is Good), would be used in the case of the "Develop, Integrate, and Retain Knowledge Capital" while the utility curve shown in Figure 23 (High is Bad), would be used in the case of the "Security Risk" criterion. This accommodation has been made to simplify the collection and analysis of SRC member alternative ratings in the Think Tank® tool and for data entry compatibility with the QuickCompare® tool.

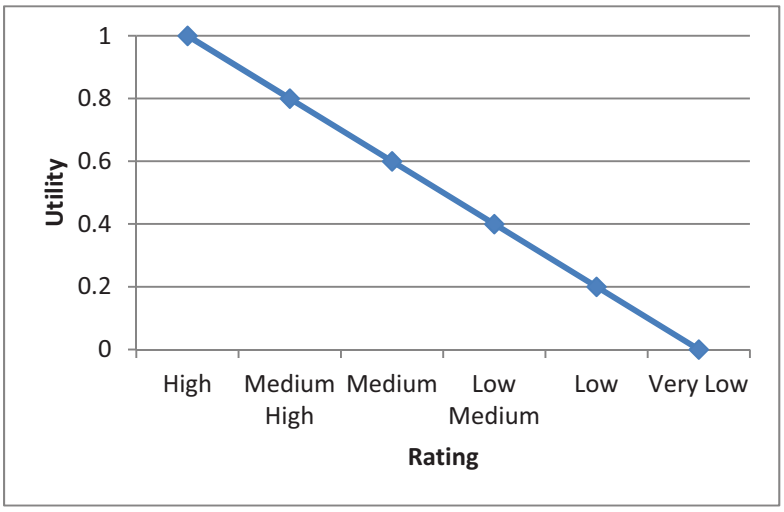


Figure 22. Utility Curve for rating criteria for which a high rating is "Good".

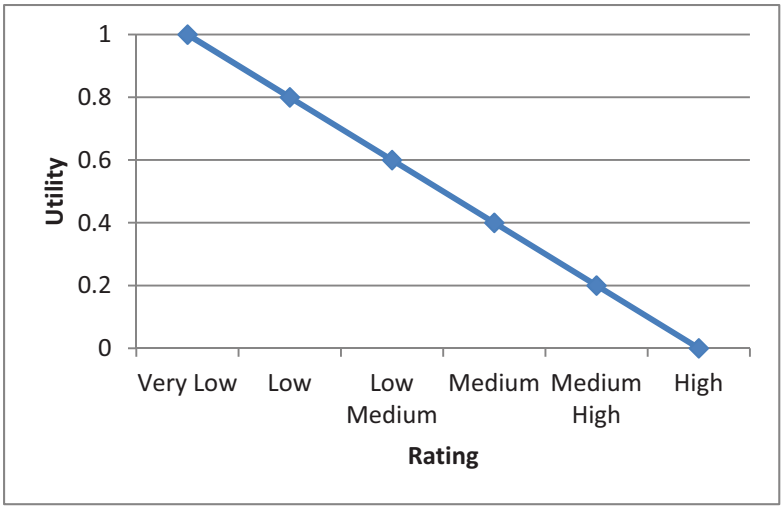


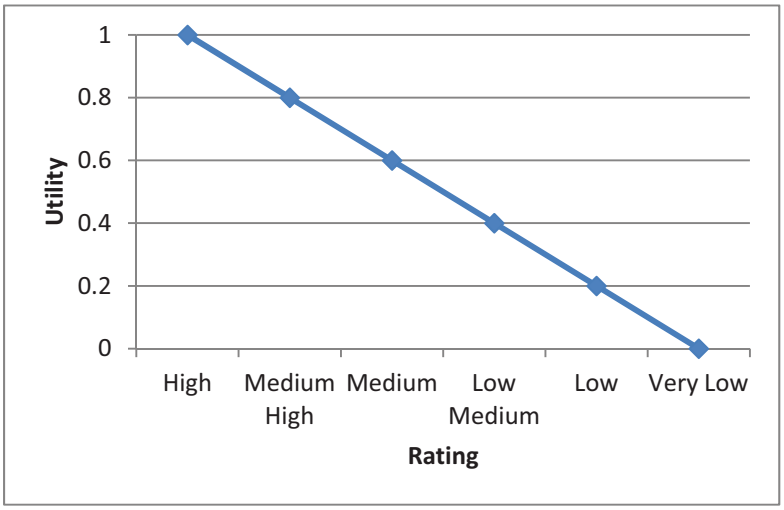
Figure 23. Utility Curve for rating criteria for which a high rating is "Bad".

The curves to be used for each of the qualitative criteria are presented in the following subsections. The scores will be determined based on input from the SRC members' qualitative assessment of the alternative relative to the criterion. Refer to Section 2.6 for the detailed descriptions of the criteria.

3.2.1 Goal 1 (Develop and Maintain National Knowledge Base)

3.2.1.1 Develop, Integrate, and Retain Knowledge Capital

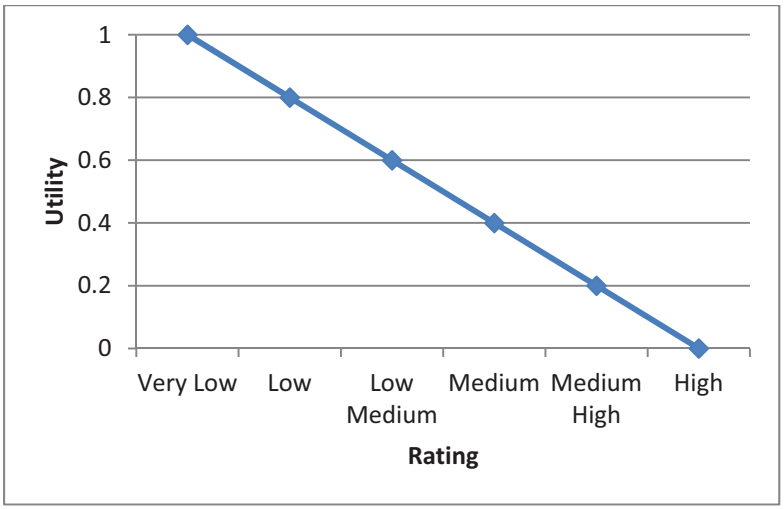
This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Considerations for scoring alternatives relative to this criterion include the number of location(s) where the PIE work will be performed (which implies additional interfaced to be created and maintained), access to personnel engaged in other nuclear development programs, and researcher access to experiment designers, safety analysts, and other PIE team members. The following utility curve will be used.



3.2.2 Criteria for Goal 2 (Maximize Access, Usability, and Maintainability)

3.2.2.1 Researcher Access Impediments

This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Things to be considered include the complexity of agreements to perform work, the access controls associated with each facility (e.g., clearances), and the amount of training needed to access each facility. It is expected that the use of multiple facilities implies additional barriers to researcher access. The following utility curve will be used.



3.2.2.2 Logistics (Type and Complexity of Initial Radioactive Material Transfers)

This criterion provides a quantitative measure of logistics burden for comparing the APIEC alternatives on a relative basis. It evaluates the numbers of international, on- and off-site transfers and destinations (i.e., stops in a circuit shipment) for analyzing irradiation experiments within each alternative. A logistics analysis was completed to support scoring of alternatives relative to this, as well as other, criteria and is included as Appendix F. The analysis assumes 100 experiments[u] are processed through the APIEC each year, or roughly 2 experiments per week. Other results and detailed assumptions are contained in Appendix F. For scoring purposes a difficulty weighting factor of 4[v] was applied to off-site (i.e., in-commerce) transfers as compared to on-site transfers and the number of destinations involved. Similarly, a difficulty factor of 16 was applied to international shipments as compared to on-site transfers.[w] Table 19 below provides the summary of results to be used for alternative scoring.

Table 19. Summary of results for logistical analysis

Alternative	Logistics Score
Alternative 2 – Use Existing DOE Facilities, Distributed	1178
Alternative 3a – Use Existing DOE Facilities, Consolidated; INL and LANL	863
Alternative 3b – Use Existing DOE Facilities, Consolidated; LANL and ORNL	793
Alternative 3c – Use Existing DOE Facilities, Consolidated; INL and ORNL	878

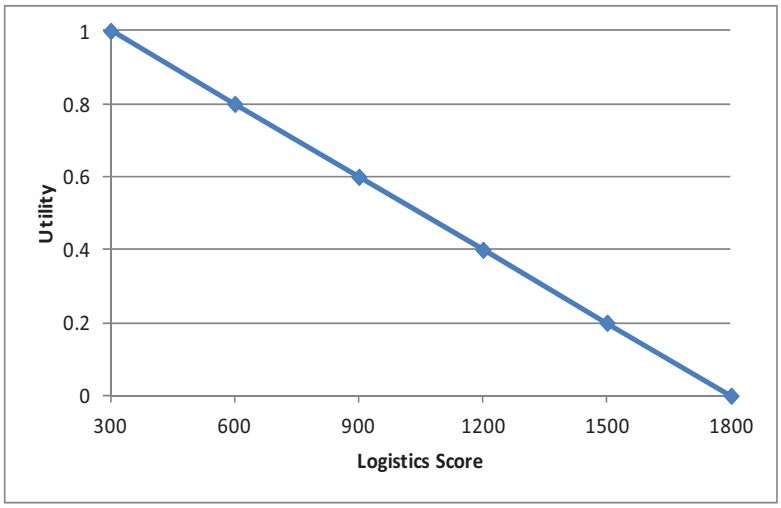
[u] Shipping data from 2009 to 2011 indicate an average of approximately 4 cask shipments between the ATR Complex and MFC supporting experiment transfers for PIE. For cost and logistical efficiency, the majority of these cask transfers include multiple experiments. For example, the cask transfer between ATR and MFC that occurred in the Spring of 2012 included about 35 experiments. The use of 100 experiments as a basis for analysis and comparison is reasonable given these transfer quantities as well as additional irradiation experiments occurring at HFIR and U.S. university locations which have not been researched.

[v] The difficulty weighting factor of 4 is based on engineering judgment and the work activities associated with making on- and off-site radiological shipments.

[w] At the request of the SRC, the range of the utility curve used to evaluate logistics scores was adjusted to include Alternative 6, use existing international PIE capabilities, which would represent a realistic worst case even though it was eliminated in the Go/No Go analysis. A difficulty factor of 16 was applied to the international shipments at the SRC's recommendation. The Alternative 6 logistics score was calculated at 1778. This value was rounded to 1800 and used as the "no utility" point for the logistics score utility curve.

Alternative 4a – Construct New Facility; INL	338
Alternative 4b – Construct New Facility; ORNL	618
Alternative 4c – Construct New Facility; LANL, PNNL, SNL, or SRNL	678

For this criterion, the following utility curve will be used. The "full utility" and "no utility" points on this curve are based on the best case and worst case alternative scores for Alternative 4a and Alternative 6, respectively.



3.2.2.3 *Intra-APIEC transportation mechanism (or complexity)*

This criterion provides a quantitative measure for comparing the APIEC alternatives based on the types of mechanisms available to perform intra-APIEC transfers of specimens within each alternative (i.e., from sample preparation to the examination instrument[s], between the shielded cells and non-shielded instrument spaces, and back to the prepared specimen storage). It evaluates these mechanisms based on an assigned point value for the mechanisms and the number of instances that mechanism is used within the alternative. Table 20 provides a summary to be used for alternative scoring.

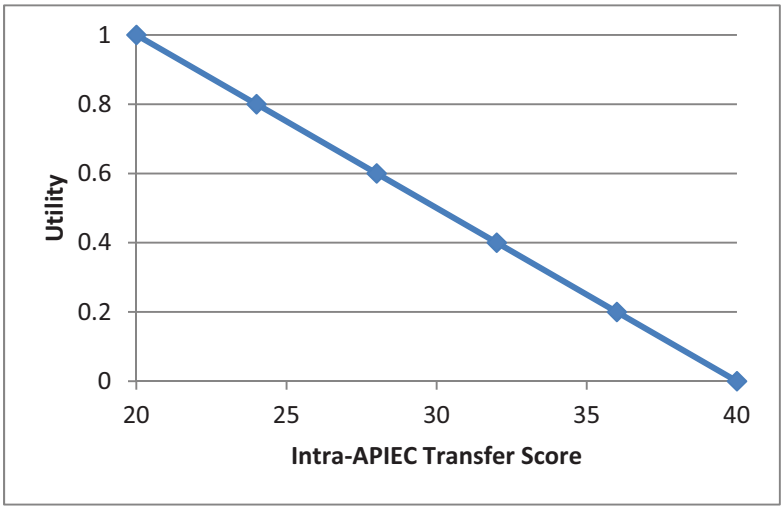
Table 20. Summary of results for Intra-APIEC transportation analysis

Alt #	Description	Sample Prep to Shielded Exam Cells	Sample Prep to Non-Shielded Instrument Space	Return to Storage from Shielded Exam Cells	Totals
2	IMCL @ INL CMR W9 @ LANL RPL @ PNNL REDC 7930 @ ORNL SCF @ SRNL	2 @ 2 pts = 4 pts 1 @ 2 pts = 2 pts 1 @ 2 pts = 2 pts 2 @ 1 pt = 2 pts 1 @ 2 pts = 2 pts Subtotal: 12 pts	1 @ 2 pts = 2 pts N/A 1 @ 2 pts = 2 pts 1 @ 4 pts = 4 pts 1 @ 2 pts = 2 pts Subtotal = 10 pts	2 @ 2 pts = 4 pts 1 @ 2 pts = 2 pts 1 @ 2 pts = 2 pts 2 @ 1 pt = 2 pts 1 @ 2 pts = 2 pts Subtotal: 12 pts	34
3a	IMCL @ INL CMR W9 @ LANL	4 @ 2 pts = 8 pts 3 @ 2 pts = 6 pts Subtotal: 14 pts	2 @ 2 pts = 4 pts 2 @ 2 pts = 4 pts Subtotal: 8 pts	4 @ 2 pts = 8 pts 3 @ 2 pts = 6 pts Subtotal: 14 pts	36
3b	CMR W9 @ LANL REDC 7930 @ ORNL	3 @ 2 pts = 6 pts 4 @ 1 pts = 4 pts Subtotal: 10 pts	2 @ 2 pts = 4 pts 2 @ 4 pts = 8 pts Subtotal: 12 pts	3 @ 2 pts = 6 pts 4 @ 1 pts = 4 pts Subtotal: 10 pts	32
3c	IMCL @ INL	3 @ 2 pts = 6 pts	2 @ 2 pts = 4 pts	3 @ 2 pts = 6 pts	32

	REDC 7930 @ ORNL	4 @ 1 pts = 4 pts Subtotal: 10 pts	2 @ 4 pts = 8 pts Subtotal: 12 pts	4 @ 1 pts = 4 pts Subtotal: 10 pts	
4a	APEX @ INL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
4b	APEX @ ORNL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
4c	APEX @ LANL, PNNL, SNL, or SRNL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
Mechanism Point Values: Intra-Facility Rabbit: 1 Manual Transfer Using Shielded/Unshielded Transfer Device - Intra-Building: 2 Manual Transfer Using Shielded/Unshielded Transfer Device - Inter-Building (same site Area): 3 Manual Transfer Using Shielded/Unshielded Transfer Device – Intra-Site (same Lab): 4					

For this criterion, the following utility curve will be used. The upper and lower limits to the scoring range of this utility curve are based on summations of the worst and best case scores, respectively, for each mechanism, independent of the alternative, and then rounded to the nearest 10 points. For example, the upper limit is calculated as follows (a similar calculation is performed using minimum point values to establish the range's lower limit):

- Maximum point value for transfers from sample preparation to the shielded examination cells (14 pts from Alt. 3a)
- Maximum point value for transfers from sample preparation to the non-shielded instrument spaces (12 pts from either Alt. 3b or 3c)
- Maximum point value for sample transfers back to storage or waste processing (14 pts from Alt 3a).
- Sum total (14 + 12 + 14) = 40 pts.



3.2.2.4 Hot Cells Support Routine Instrument Maintenance

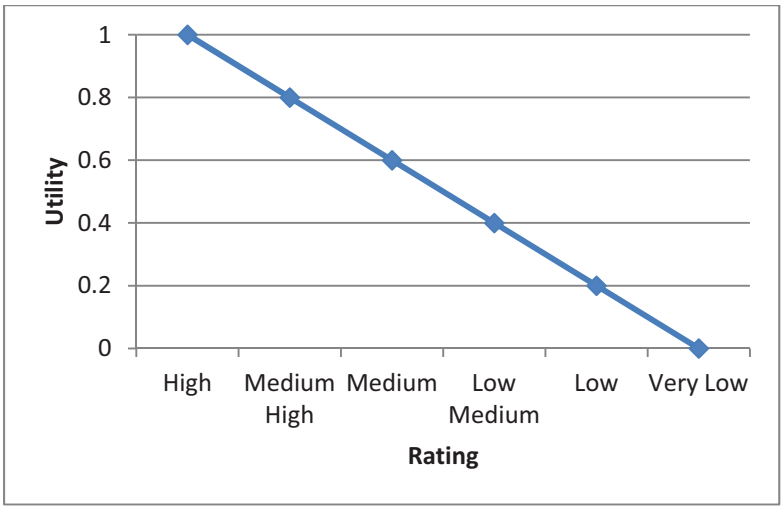
This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Cells that have doors that are readily accessible and easy to open would rate higher than cells that require a crane to remove a ceiling plug for access. Cells that facilitate removal of radioactive source material (e.g., have pass-throughs, pneumatic transport (rabbit) stations, or in-cell shielded storage) would rate higher than cells that only have a door. Finally, this criterion also considers the amount of cell space available in which to perform the maintenance. Cells that have space that allows the worker to easily move around the equipment would rate higher than smaller cells that would make maintenance activities

more difficult. Table 21 lists hot cell attributes to be considered for scoring the alternatives relative to supporting routine maintenance.

Table 21. Considerations for supporting routine instrument maintenance

Alt	Site	Facility	# of cells	Means of Routine Ingress	Specimen removal	Cell Size (W x L x H, ft)
2	INL	IMCL	2	Personnel door in MSE	Shielded Pig	9.75 x 9.75 x 11.75
	LANL	CMR W9	1	Hydraulically actuated back wall	Shielded Pig	6 x 12 x 11
	ORNL	7930	2	Door in concrete wall	Rabbit	16 x 9.5 x 21
	PNNL	RPL	1	Personnel door in MSE	Shielded Pig	12 x 6 x 8.5
	SRNL	SCF	1	Door in concrete wall	Shielded Pig	12 x 6 x 15
3A	INL	IMCL	4	Personnel door in MSE	Shielded Pig	9.75 x 9.75 x 11.75
	LANL	CMR W9	3	Hydraulically actuated back wall	Shielded Pig	6 x 12 x 11
3B	LANL	CMR W9	3	Hydraulically actuated back wall	Shielded Pig	6 x 12 x 11
	ORNL	7930	2 2	Door in concrete wall	Rabbit	16 x 9.5 x 21 15 x 9.5 x 13
3C	INL	IMCL	3	Personnel door in MSE	Shielded Pig	9.75 x 9.75 x 11.75
	ORNL	7930	2 2	Door in concrete wall	Rabbit	16 x 9.5 x 21 15 x 9.5 x 13
4	various	APEX	7	Personnel door in MSE	Rabbit	10 x 10 x 12

The following utility curve will be used



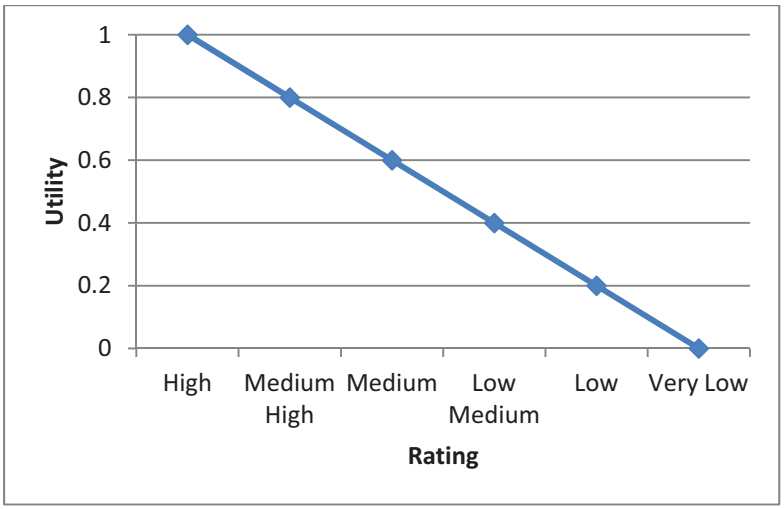
3.2.2.5 Ease of PIE Material Storage and Waste Disposition

This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Sites that have the ability for blanket acceptance of a wide range of fuels and materials and the ability for long-term on-site storage of these materials are rated higher than sites that require individual government approvals and short-term waste disposition. Table 22 lists laboratory considerations for scoring the alternatives relative to PIE material storage and disposition.

Table 22. Considerations for PIE material storage and disposition

Facility	Fuel Receipt	Interim Fuel Storage	Other Waste
INL	Existing agreement with state of Idaho to receive quantities of DOE and commercial fuel	Currently storing	Developing RH LLW disposal on-site. Can also ship to commercial LLW disposal sites
LANL	Case by case basis to receive	Not storing	Can ship to commercial LLW disposal sites
ORNL	Case by case basis to receive	Not storing	Limited on-site disposal. Can ship to commercial LLW disposal sites
PNNL	Case by case basis to receive	Currently storing, limited additional	On-site. Can also ship to commercial LLW disposal sites
SRNL	Case by case basis to receive	Currently storing	On-site. Can also ship to commercial LLW disposal sites

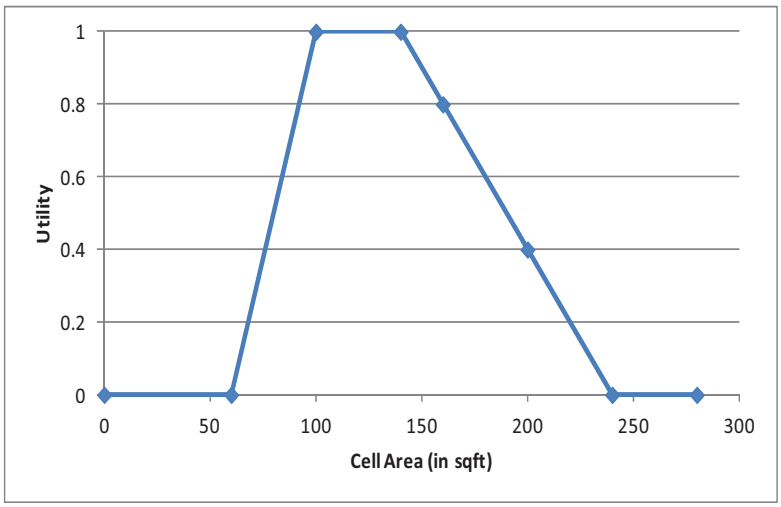
The following utility curve will be used.



3.2.3 Criteria for Goal 3 (Maximize APIEC Shielded Instrument Space Reconfigurability)

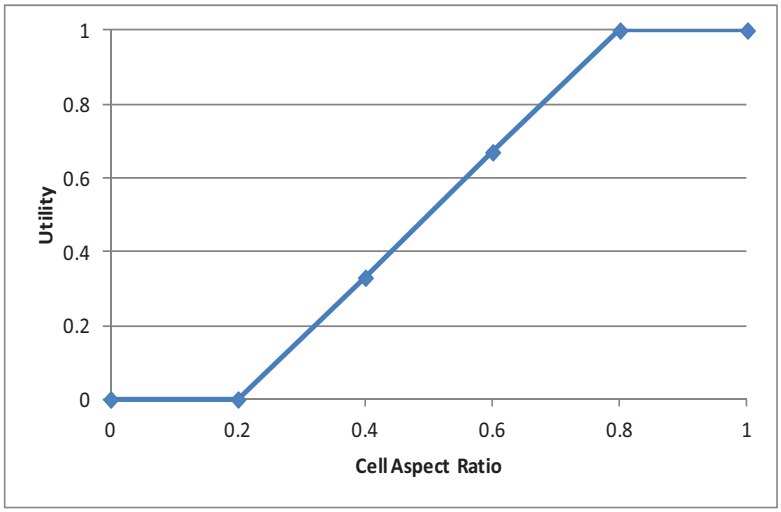
3.2.3.1 Hot Cell Size and Footprint

This criterion provides a quantitative measure of how well the shielded examination cells involved in each alternative meet the desired area, aspect ratio, and height objectives established for the APIEC. These three sub-criteria are evaluated for each hot cell included in an alternative using separate utility curves and then rolled up to a composite score for the alternative. The sub-criteria are weighted as follows for the roll-up calculation: Area – 30%; Aspect Ratio – 35%; and Height – 35%. This weighting is approximately equal with the Area sub-criteria having slightly less value because the minimum cell size has already been supported by go/no go requirements. Aggregate sub-criteria scores for an alternative are computed as a weighted averages of individual hot cell scores where each cell is given an equal weight (i.e., 1/7, or 14.3%, of the full capability). The utility curves for the sub-criteria are as follows.

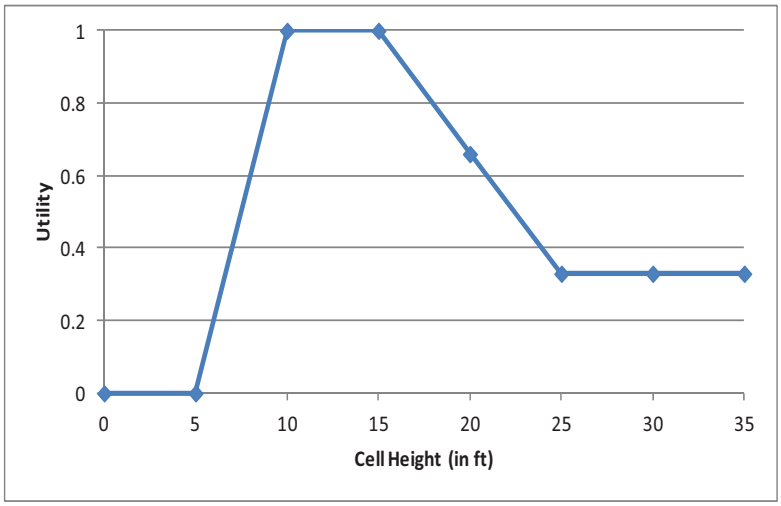


The shape of this utility curve reflects the need to provide a minimum amount of space to ensure adequate flexibility for current and future instruments. The peak between 100 and 144 ft^2 reflects the size that is considered to be optimal. The reduction in utility on the right side of the curve results from the increasing distances that support equipment will be installed away from the instrument (i.e., to be outside the

shielded cell walls). This increasing distance will tend to complicate the installation of the PIE instruments into the cell as associated physical limits associated with the support equipment and operation are reached.



The shape of this utility curve reflects the fact that a footprint that is close to being square will tend to reduce the distance between the instrument and the operator and/or support equipment located outside of the shielding wall as compared to more and more oblong, rectangular footprints. Aspect ratios below 0.2 are considered undesirable and should be avoided. A footprint that is closer to square is also deemed to better support flexibility for installation and ensuring adequate access around the installed instrument for maintenance.



The shape of this utility curve reflects the need to provide a minimum height to ensure adequate clearances and flexibility for the installation and maintenance of current and future instruments. The peak between 10 and 15 ft reflects the height that is considered to be optimal. The reduction in utility on the right side of the curve results from the increasing distances and space enclosed by the cell. Heights above the optimal can equate to longer lifts and a greater amount of space that must be temperature controlled.

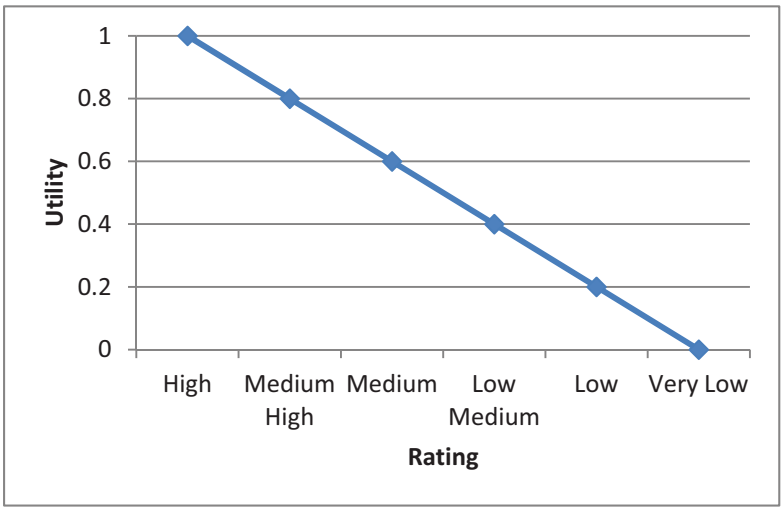
Table 23 summarizes the cell size information and the resulting sub-criteria scores.

Table 23. Cell size information and resulting sub-criteria scores

Alt. #	Description	W (in ft)	D (in ft)	H (in ft)	Area (in ft^2)	Area Score	Aspect Score	Height Score	Overal l Score
2.	1. IMCL MSE-1	9.75	9.75	11.75	95.1	0.88	1.00	1.00	**0.724**
	2. IMCL MSE-2	9.75	9.75	11.75	95.1	0.88	1.00	1.00	
	3. CMR W9 Cell 1	12	6	11	72.0	0.30	0.50	1.00	
	4. REDC-7930 E-1	16	9.5	21	152.0	0.88	0.66	0.59	
	5. REDC-7930 E-2	16	9.5	21	152.0	0.88	0.66	0.59	
	6. PNNL RPL MEC1	12	6	8.5	72.0	0.30	0.50	0.70	
	7. SCF Cell 1	12	6	15	72.0	0.30	0.50	1.00	
	Aggregate:					**0.63**	**0.69**	**0.84**	
3a.	1. IMCL MSE-1	9.75	9.75	11.75	95.1	0.88	1.00	1.00	**0.814**
	2. IMCL MSE-2	9.75	9.75	11.75	95.1	0.88	1.00	1.00	
	3. IMCL MSE-3	9.75	9.75	11.75	95.1	0.88	1.00	1.00	
	4. IMCL MSE-4	9.75	9.75	11.75	95.1	0.88	1.00	1.00	
	5. CMR W9 Cell 1	12	6	11	72.0	0.30	0.50	1.00	
	6. CMR W9 Cell 2	12	6	11	72.0	0.30	0.50	1.00	
	7. CMR W9 Cell 3	12	6	11	72.0	0.30	0.50	1.00	
	Aggregate:					**0.63**	**0.79**	**1.00**	
3b.	1. CMR W9 Cell 1	12	6	11	72.0	0.30	0.50	1.00	**0.720**
	2. CMR W9 Cell 2	12	6	11	72.0	0.30	0.50	1.00	
	3. CMR W9 Cell 3	12	6	11	72.0	0.30	0.50	1.00	
	4. REDC-7930 E-1	16	9.5	21	152.0	0.88	0.66	0.59	
	5. REDC-7930 E-2	16	9.5	21	152.0	0.88	0.66	0.59	
	4. REDC-7930 D-1	15	9.5	13	142.5	0.98	0.73	1.00	
	5. REDC-7930 D-2	15	9.5	13	142.5	0.98	0.73	1.00	
	Aggregate:					**0.66**	**0.61**	**0.88**	
3c.	1. IMCL MSE-1	9.75	9.75	11.75	95.1	0.88	1.00	1.00	**0.870**
	2. IMCL MSE-2	9.75	9.75	11.75	95.1	0.88	1.00	1.00	
	3. IMCL MSE-3	9.75	9.75	11.75	95.1	0.88	1.00	1.00	
	4. REDC-7930 E-1	16	9.5	21	152.0	0.88	0.66	0.59	
	5. REDC-7930 E-2	16	9.5	21	152.0	0.88	0.66	0.59	
	4. REDC-7930 D-1	15	9.5	13	142.5	0.98	0.73	1.00	
	5. REDC-7930 D-2	15	9.5	13	142.5	0.98	0.73	1.00	
	Aggregate:					**0.91**	**0.82**	**0.88**	
4a.	1. APEX MSE-1	10	10	12	100	1.00	1.00	1.00	**1.000**
	2. APEX MSE-2	10	10	12	100	1.00	1.00	1.00	
	3. APEX MSE-3	10	10	12	100	1.00	1.00	1.00	
	4. APEX MSE-4	10	10	12	100	1.00	1.00	1.00	
	5. APEX MSE-5	10	10	12	100	1.00	1.00	1.00	
	6. APEX MSE-6	10	10	12	100	1.00	1.00	1.00	
	7. APEX MSE-7	10	10	12	100	1.00	1.00	1.00	
	Aggregate:					**1.00**	**1.00**	**1.00**	
4b.	Same as 4a.								**1.000**
4c.	Same as 4a.								**1.000**

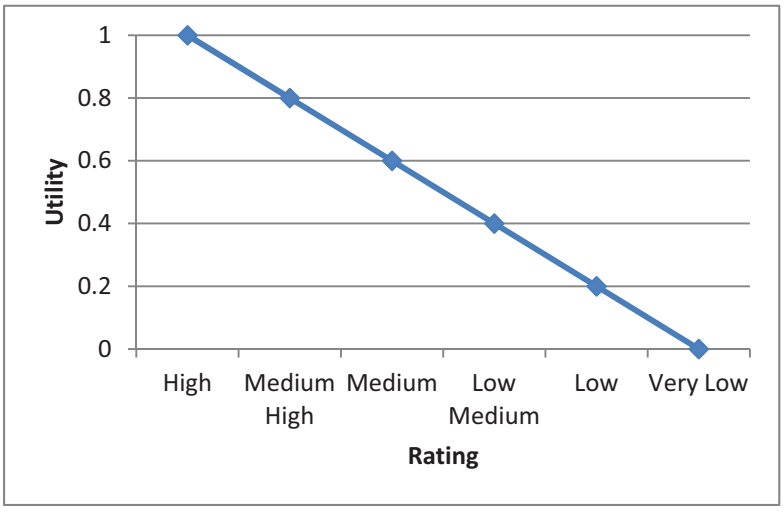
3.2.3.2 Exterior Equipment Space Availability

This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Considerations for evaluating an alternative relative to this criterion include the size, proximity, and location of available space for installing the instrument support system and radiation-sensitive components. Installations that allow the external equipment to be located within the parameters of the instrument requirements and in protected areas away from instrument operators and routine traffic patterns outside the cell will rate higher. The following utility curve will be used.



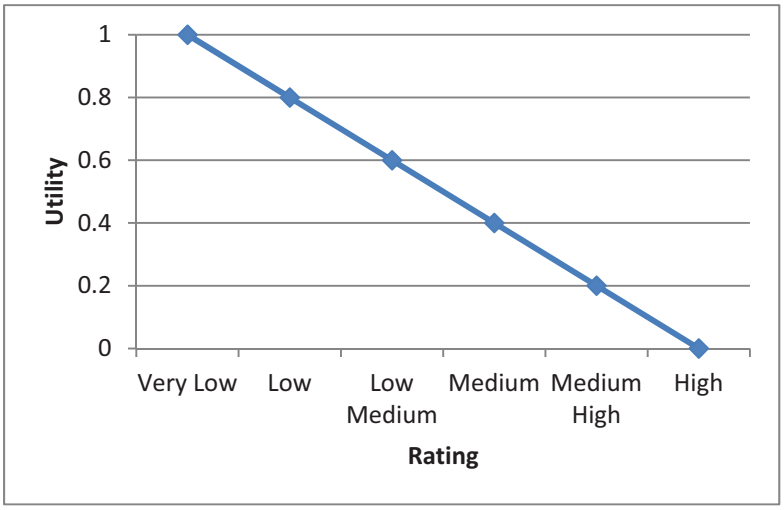
3.2.3.3 Feature Relocatability

This criterion is qualitative and the score will be based on input by the SRC during Workshop 2. Cells that can easily accommodate relocation of pass-throughs or telemanipulators will rate higher. Cells with the ability to change their footprint to accommodate deploying a new instrument will rate higher. The following utility curve will be used.



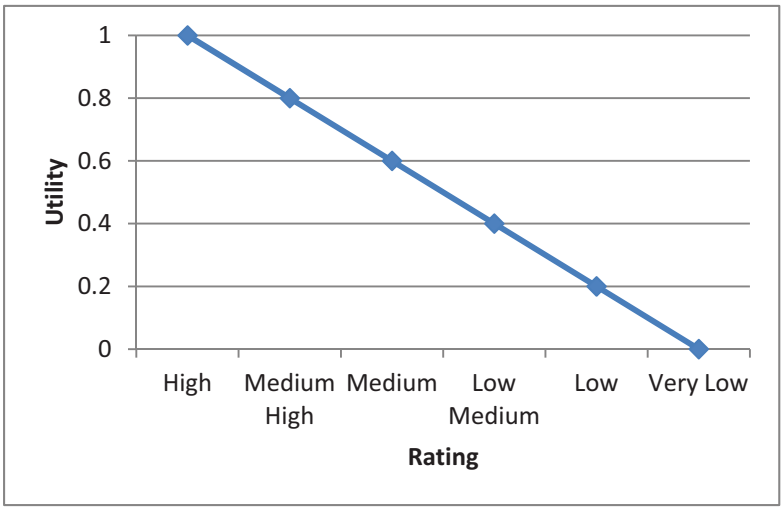
3.2.3.4 Cell Radiological Contamination Status

This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Cells that have minimal or no contamination will rate higher than contaminated steel-lined cells, which will rate higher than cells with contaminated concrete surfaces. The following utility curve will be used.



3.2.3.5 Ease of Equipment Ingress and Egress (Equipment Change-Out)

This criterion is qualitative and the score will be based on input from the SRC during Workshop 2. Cells that allow large components to be easily removed/installed (e.g., full-width removable walls) will rate higher than cells with only personnel access doors. The following utility curve will be used.



3.2.4 Criteria for Goal 4 (Minimize Costs)

3.2.4.1 Direct Experiment Cost

Direct experiment cost is a quantitative criterion that includes experiment/sample packaging and transportation (P&T) costs and staffing costs for sample receiving, preparation, specimen examination, results documentation, and waste processing.

Transportation and packaging costs were developed in conjunction with the logistics analysis. Details of this analysis, including assumptions and basis for cost estimates, are provided in Appendix F. Table 24 summarizes the estimated annual packaging and transportation costs for Alternative 2 and the sub-alternatives 3a, 3b, 3c, 4a, 4b, and 4c.

Table 24. Summary of Direct Experiment Costs – P&T Component

Alternatives	Annual P&T Cost (base, in $M)	Discounted 40-Year Cost (with 50% MR, in $M)
2.Distributed	$26.8	$956.1
3a.Consolidated (INL & LANL)	$15.3	$544.5
3b. Consolidated (LANL & ORNL)	$17.3	$619.3
3c. Consolidated (INL & ORNL)	$16.8	$599.7
4a. New Facility (INL)	$5.3	$189.5
4b. New Facility (ORNL)	$13.0	$462.6
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	$13.3 (range $12.8 to $14.8)	$476.2

Labor costs for staffing the APIEC were first developed for the new facility alternative. Estimates are based on SME opinion on the numbers of personnel (full-time equivalents [FTEs]) and disciplines necessary to fully staff the functions of the advanced PIE process. Average hourly rates (with overhead and appropriate adders) were determined for each discipline and then an annual cost calculated. The following assumptions were also used:

- Direct experiment labor costs start once the cask has been received and the lid is off. They end after all specimen have been characterized/examined, results documented, samples placed in the archive or storage, and any associated waste is processed or packaged.
- The facility is fully utilized (i.e., at 100% capacity) and experiments arrive approximately once per week – that is, the staff is fully engaged in productive work for the full year.
- Functions that require staffing in other than whole FTEs can be staffed by personnel who are assigned to more than one function (i.e., assigned to multiple part-time functions) as long as the functions required similar skills or disciplines. The total headcount, however, must be a whole number.
- Productivity is constant regardless of the location of the new facility.
- The average direct labor rates and associated overhead and adders, by discipline, for staffing the alternatives was assumed to be similar across the DOE complex.
- The staffing includes those performing the APIEC functions to perform experiments in a facility. It does not include operating and maintenance staff.

Labor costs for staffing the distributed and consolidated alternatives used the new facility staffing numbers and disciplines as a starting point with scaling adjustments made, as appropriate, for the distributed workload. Additional assumptions for alternatives included:

- Some loss of efficiency would naturally occur due to reverse economies of scale and limitations on using cross-training and resource sharing as a means to address less-than-full time positions thus resulting in increased staffing across the full alternative.

- In instances where APIEC elements were located in shared facilities, it was assumed that some resource sharing of certain disciplines could occur with other programs collocated in the facility.

Table 25 provides a summary of the staffing, annual costs, and life-cycle discounted costs for each alternative. Table 26 identifies the total direct experiment costs (discounted values with management reserve [MR]) for the 40-year evaluation period.

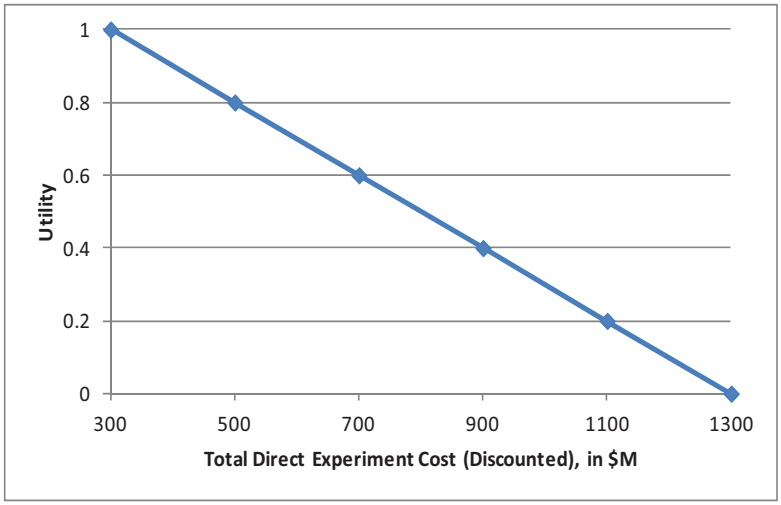
Table 25. Summary of Direct Experiment Costs – Staffing Component

Alternative	Staffing Summary (in FTEs)			Cost Summary	
	Skilled Techs	Tech Leads	Support Personnel (e.g., work planning)	Annual Staffing Cost (base, in $M)	Discounted 40-year Staffing Cost (with 50% MR, in $M)
2.Distributed	19.5	5.0	10.0	$8.1	$288.9
3a.Consolidated (INL & LANL)	16.0	2.0	4.0	$4.8	$173.1
3b. Consolidated (LANL & ORNL)	16.0	2.0	4.0	$4.8	$173.1
3c. Consolidated (INL & ORNL)	16.0	2.0	4.0	$4.8	$173.1
4a. New Facility (INL)	14.0	2.0	4.0	$4.5	$159.0
4b. New Facility (ORNL)	14.0	2.0	4.0	$4.5	$159.0
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	14.0	2.0	4.0	$4.5	$159.0

Table 26. Total Direct Experiment Costs – 40-Year Period; Discounted

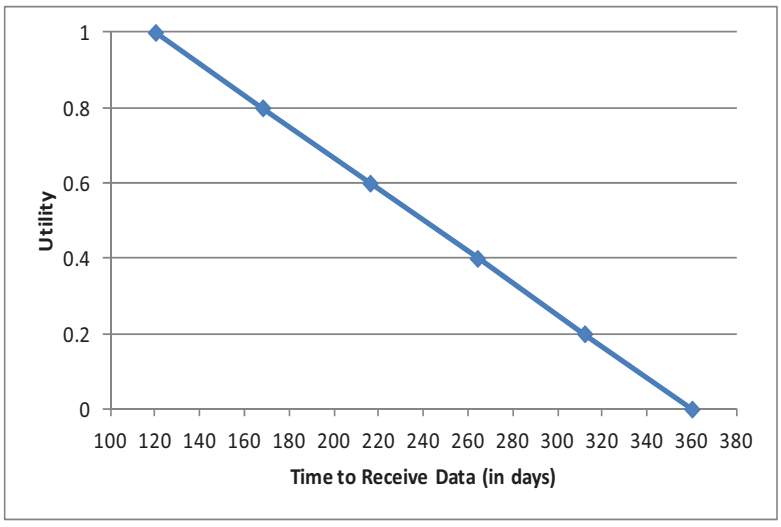
Alternative	Total Discounted 40-year Direct Experiment Cost (with 50% MR, in $M)
2.Distributed	$1,244.9
3a.Consolidated (INL & LANL)	$ 717.5
3b. Consolidated (LANL & ORNL)	$ 792.4
3c. Consolidated (INL & ORNL)	$ 772.8
4a. New Facility (INL)	$ 348.5
4b. New Facility (ORNL)	$ 621.7
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	$ 635.2

Scoring is based on the following utility curve with a range of $300M to $1,300M:



3.2.4.2 Time to Receive Data

Time to receive PIE data is a quantitative criterion which estimates the number of days it will take to obtain data from an experiment of average complexity for each APIEC alternative. It spans the duration from initial receipt at the NDE/sizing facility to completion of the examination data report. For this analysis, the durations for NDE, rough sizing, cask handling, sample preparation, examination, and preparing reports were consistent across all alternatives. No expected delays were included in this analysis. Transport times and the number of handling events varied appropriately by alternative. The following utility curve will be used in converting the overall durations to utility scores.



The range of this utility curve is continuous but changes only for values between 120 days (approximately equal to the best case alternative) and 360 days (the typical PIE turnaround time). Table 27 summarizes the anticipated time (in days) needed to receive APIE data for each alternative.

Table 27. Anticipated Time to Receive APIE Data

Alt #	Time to Receive APIE Data (in Days)
2. Distributed	155
3a.Consolidated (INL & LANL)	128
3b. Consolidated (LANL & ORNL)	129
3c. Consolidated (INL & ORNL)	128
4a. New Facility (INL)	122
4b. New Facility (ORNL)	125
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	124

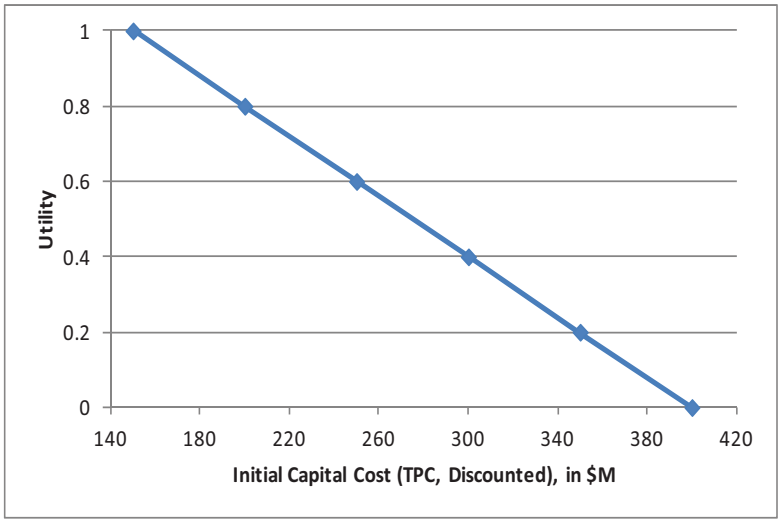
3.2.4.3 Initial Capital Cost of Providing the APIEC

Initial capital cost is a quantitative criterion based on the total project cost for implementing each of the APIEC alternatives. INL Cost Estimating was engaged to developed Class 5 estimates to support scoring of the criterion. These estimates are based on the alternative descriptions contained in Section 2.5 and assumptions about specific layouts and scope. Detailed results of these estimates are included in Appendix E. A summary of the costs is included in Table 28.

Table 28. Summary of Initial Capital Cost for APIEC Alternatives

Alternative	Total Discounted 40-year Direct Experiment Cost (with 50% MR, in $M)
2. Distributed	$381.5
3a.Consolidated (INL & LANL)	$ 247.5
3b. Consolidated (LANL & ORNL)	$ 277.1
3c. Consolidated (INL & ORNL)	$ 209.5
4a. New Facility (INL)	$ 196.2
4b. New Facility (ORNL)	$ 194.8
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	$ 207.4

Scoring is based on the following utility curve with a range of $150M to $400M. The curve is based on expectations of funding availability and the delivery of the APIEC within the $200M desired funding level. The upper limit, with a utility value of 0, is set at $400M which is approximately equal to the highest feasible project cost, as defined in the MNS. If none of the initial capital costs for the alternatives fell within this $400M value, the project likely would not go forward.



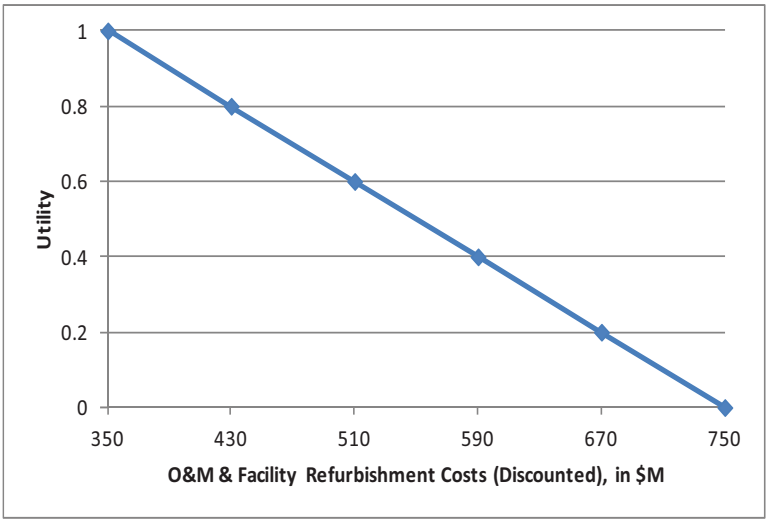
3.2.4.4 Operating, Maintenance, and Facility Refurbishment Costs

This criterion is measured quantitatively and is based on the total cost of operating, maintenance, refurbishment, and decontamination and decommissioning over the 40 year evaluation period. INL Cost Estimating was engaged to developed Class 5 estimates for each alternative to support scoring of this criterion. These estimates were based on the alternative descriptions and facilitating assumptions. Detailed results of these estimates are included in Appendix E. A summary of the costs is included in Table 29.

Table 29. Summary of Operating, Maintenance, and Facility Refurbishment Costs

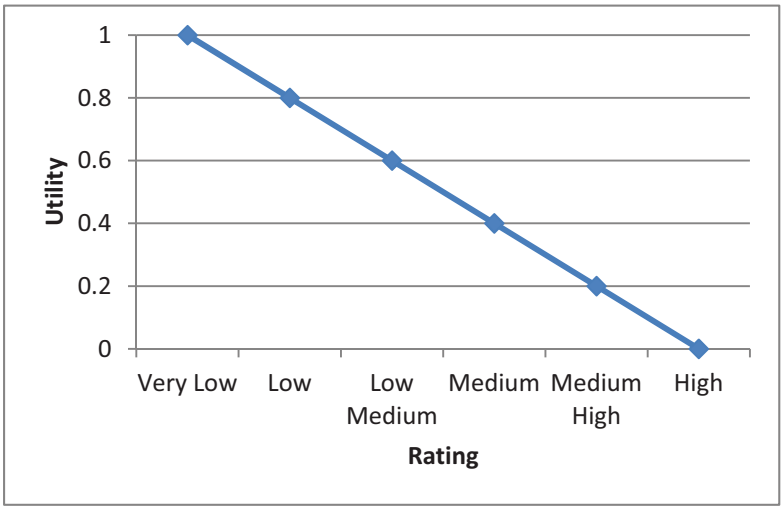
Alternative	Total Discounted 40-year O&M, Refurbishment, & D&D Costs (with 50% MR, in $M)
2. Distributed	$707.8
3a.Consolidated (INL & LANL)	$ 418.4
3b. Consolidated (LANL & ORNL)	$ 377.1
3c. Consolidated (INL & ORNL)	$ 398.9
4a. New Facility (INL)	$ 391.1
4b. New Facility (ORNL)	$ 391.0
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	$ 392.1

Scoring of this criterion is based on the following utility curve with a range of $350M to $750M, which represents the approximate costs associated with the best and worst alternative values.



3.2.4.5 Time to Construct Capabilities

Construction schedules were not developed for the alternatives so this criterion will be scored qualitatively. The scoring of alternatives relative to this criterion may include considerations such as new construction versus modification of existing facilities, levels of radiological contamination expected to be encountered, possible interference with collocated operations. New facilities typically require less time in design, field verification, and construction as compared to the retrofitting of existing facilities. The following utility curve will be used.



3.2.5 Criteria for Goal 5 (Minimize Risks)

3.2.5.1 Risk to Public and Environment

This criterion looks at the risk to the public due to APIEC operations. As mentioned previously, this risk stems primarily from the irradiated samples being shipped over the road. Based on input received from the SRC during Workshop 2, it was decided that this criterion should be measured quantitatively based on Waste Isolation Pilot Plant (WIPP) shipping experience (i.e., incidents per mile) and the effect alternatives have on reducing the expected number of traffic incidents from worst case. The expected

number of traffic incidents will be calculated for each alternative to determine the worst case. This calculation involves (1) the total in-commerce miles for each alternative over the full 40-year evaluation period and (2) the historical per mile incident rate for WIPP shipments: 17 incidents / 20 million miles = 8.5 x 10^{-7} incidents/mile. Table 30 identifies the number of expected incidents for each alternative as well as the expected number of reductions from worst case (Alternative 2).

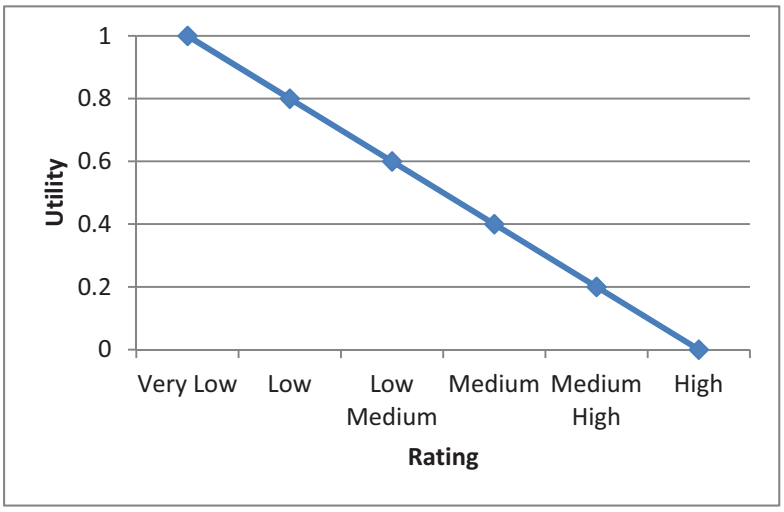
Table 30. Number of Expected Incidents for Each Alternative

Alternative	Annual In-Commerce Transport Miles	Total In-Commerce Transport Miles (over 40-year period)	Total Expected Traffic Incidents (based on 8.5x10^{-7} incidents per mile)	Reductions to Expected Number of Traffic Incidents (from worst case)
2	367,250	14,690,000	12.5	0.0
3a	121,500	4,860,000	4.1	8.4
3b	341,500	12,580,000	10.7	1.8
3c	202,000	8,080,000	6.9	5.6
4a	40,500	1,620,000	1.4	11.1
4b	173,500	6,940,000	5.9	6.6
4c	126,050	5,042,000	4.3	8.2

While there have been no fatalities to date, the WIPP incidents represent real events that could have resulted in public injuries, fatalities, and/or radiological material releases. Furthermore, it is apparent from the many sites on the internet that are related to the WIPP transportation that the public remains concerned about such transport events. Relative to the APIEC decision, every traffic incident that can be avoided results in a reduction to the public/environmental risk generated by the project. As such, the public/environment derives no utility (no risk reduction) from an alternative that maintains the worst case (maximum number) for expected traffic incidents, as defined by the range of alternatives being considered. Conversely, the public/environment would derive full utility (complete risk avoidance) from an alternative (albeit theoretical in this case) that avoids all expected traffic incidents. The utility curve representing this value proposition is as follows.

3.2.5.2 Security Risk

This criterion is qualitative, and the score will be based on input from the SRC during Workshop 2. Scoring should take into consideration the physical security measures (e.g., procedures and engineered barriers) in place at the facility(ies) involved. Sites providing higher levels of protection would result in lower risk. Scoring should also consider the amount of time that an alternative requires material to be off-site and, thus, vulnerable to attack. Alternatives that result in shorter times will have lower risk. For this criterion, the following utility curve will be used.



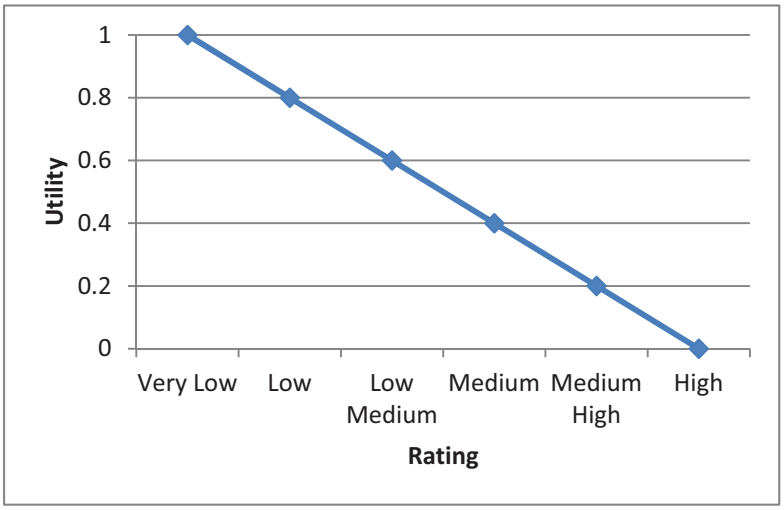
3.2.5.3 Risk to Workers

This criterion evaluates the risk to facility workers. For this criterion, radiation doses during sample preparation and specimen examination are assumed to be compliant with federal regulations and essentially equivalent for all alternatives. Therefore, the risk to workers will primarily relate to the number of handling operations, which will differ by alternative. Each transport-related loading or unloading operation is a point where worker dose is incurred and where accidents could occur that result in harm to a worker. Thus, this risk to workers component can be assumed to be directly proportional to the number of times an experiment must be packaged/unpackaged throughout the PIE process. Using the same assumptions as previously discussed in the logistics criterion section, the total number of experiment handling events has been estimated and is provided in Table 31.

Table 31. Environmental Risk Criterion Scores

Alternative		Estimated Number of Handling Events (annually)
Distributed	Alternative 2 – INL, LANL, ORNL, PNNL, SRNL	738
Consolidated	Alternative 3a – INL & LANL	423
	Alternative 3b – LANL & ORNL	353
	Alternative 3c – ORNL & INL	438
New Facility "APEX"	Alternative 4a – INL	238
	Alternative 4b – ORNL	238
	Alternative 4c – Other	238

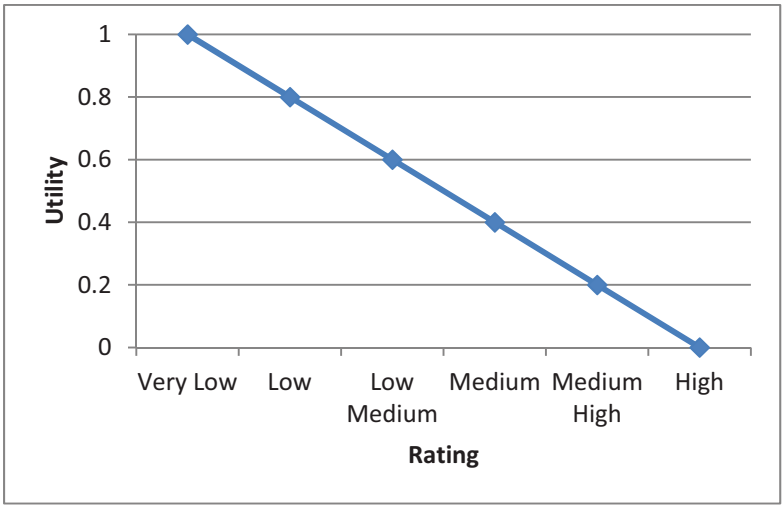
Based on input received from the SRC during Workshop 2, it was decided that this criterion would be scored qualitatively, but informed by the number of operator handling events as well as other worker risks typical for PIE activities. For this criterion, the following utility curve will be used.



3.2.5.4 Risk to Data Acquisition

This criterion is qualitative and the alternative's scores will be based on input from the SRC during Workshop 2. This criterion evaluates the potential for data to be unavailable due to damage to or loss of the experiment or prepared specimen. It is assumed that the component of this risk that stems from sample preparation activities is equivalent for all alternatives and is not a discriminator. However, the potential for data unavailability is increased for some alternatives due to factors such as the number of handling events, mode and distance of transport, delicacy of the item being transported, and time that the material or fuel is under transport. Alternatives that reduce such handling and transport will pose a lower risk.

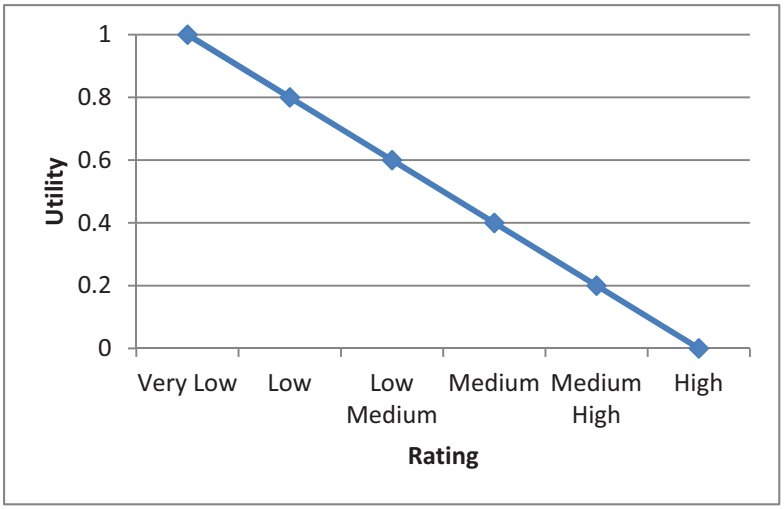
The types of transports that might be involved are inter-site (or inter-state), intra-site (i.e., within a DOE laboratory), inter-building (within a building complex like MFC), and intra-building. The modes of transports available are rabbit, carry/cart, and/or vehicle. Some experiments could use more than one mode per transport based on the alternative. For this criterion, the following utility curve will be used.



3.2.5.5 Impact of Facility Shutdown

This criterion is considered to be qualitative and the alternative's scores will be based on input from the SRC during Workshop 2. Considerations should include the impacts of having the APIEC facility(ies) enter a shutdown status for unplanned maintenance or as the result of an incident that could negatively impact the processing of experiments through the capability. A "very low" assessment implies a low impact to experiment processing and a "high" assessment would imply that the impact to experiment processing is high.

For this criterion, the following utility curve will be used.



3.3 Results Evaluation – Initial

During Workshop 2, qualitative criteria were presented, alternative attributes were discussed, and raw scores of alternative performance against qualitative criteria were obtained from the SRC. These scores were collected using Think Tank® decision support software during the meeting or by electronic spreadsheet files via email after the meeting. Adjustments were made to various criteria, as described in Appendix B, as a result of SRC comments and prior to the initial scoring evaluation. Table 32 shows the average scores and standard deviation for the qualitative criteria.

The quantitative criteria scores for each alternative and bases were also presented during Workshop 2 for comment by the SRC. Where appropriate, SRC comments on quantitative criteria scores have been incorporated into preceding sections of this report. Specific comments from the SRC relative to both qualitative and quantitative scoring are documented in Appendix B.

Both the qualitative and quantitative scores for each alternative were compiled and entered into the QuickCompare® tool. Then, with the goal and criteria weights entered previously, the tool calculated an overall weighted utility score for each alternative. Figure 24 shows the combined scores for these alternatives. Note that Alternatives 1, 5, and 6 were eliminated at the Go/No Go analysis phase and were not scored against the qualitative and quantitative criteria, resulting in zero overall weighted utility scores.

Table 32. SRC Qualitative Raw Scores

	Alt 2 - DOE Facilities (Distributed)		Alt 3a - IMCL (INL) & CMR (LANL)		Alt 3b - CMR (LANL) & REDC (ORNL)		Alt 3c - REDC (ORNL) & IMCL (INL)		Alt 4a - New Facility at INL MFC		Alt 4b - New Facility at ORNL		Atl 4c - New Facility at Other DOE Lab (No irradiation)	
Criteria:	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Develop, Integrate and Retain Knowledge Capital	3.43	1.72	2.86	0.90	3.29	0.95	3.00	0.82	1.29	0.49	1.71	0.76	2.00	0.82
Researcher Access Impediments	3.71	1.11	2.71	0.76	2.71	0.76	2.43	0.53	1.43	0.53	1.57	0.53	1.71	0.49
Hot Cell Support Routine Instrument Maintenance	4.29	1.11	3.57	0.53	3.29	0.49	2.86	0.90	1.29	0.76	1.29	0.76	1.29	0.76
Ease of PIE Material Storage & Waste Disp.	4.43	0.53	3.43	0.98	4.57	1.13	2.86	0.90	1.00	0.00	3.86	1.57	3.86	1.46
Exterior Equipment Space Avail.	4.00	1.29	3.14	0.38	3.71	0.76	3.00	0.58	1.29	0.49	1.29	0.49	1.29	0.49
Feature Relocatability	3.86	1.21	2.57	0.79	3.71	1.25	2.43	0.79	1.00	0.00	1.00	0.00	1.00	0.00
Cell Radiation Contamination Status	4.57	0.98	3.14	1.07	3.29	0.95	1.57	0.53	1.00	0.00	1.00	0.00	1.00	0.00
Ease of Equip. Ingress/Egress	4.00	1.15	2.14	0.90	3.14	0.90	3.14	0.69	1.00	0.00	1.00	0.00	1.00	0.00
Time to Construct Capabilities	4.60	1.14	3.20	0.45	4.00	0.71	3.00	0.71	1.60	0.89	1.60	0.89	1.60	0.89
Security Risk	3.71	2.06	2.57	1.27	2.57	1.27	2.43	1.13	1.86	1.21	1.86	1.21	1.86	1.21
Risk to Workers	3.60	1.67	2.60	0.55	3.00	1.00	2.60	0.55	1.60	0.55	1.80	0.84	1.80	0.84
Risk to Data Acquisition	3.86	1.07	2.86	1.07	3.29	1.11	2.71	0.95	1.29	0.49	1.86	1.07	2.00	1.29
Impact of Facility Shutdown	2.43	0.98	2.86	0.69	2.86	0.69	2.86	0.69	3.71	1.38	3.71	1.38	3.86	1.07

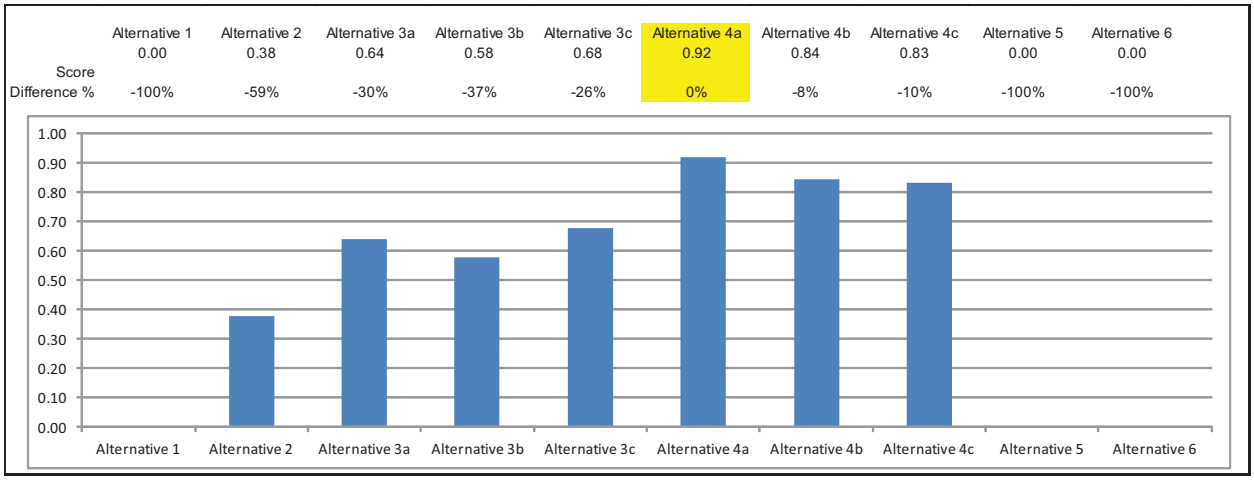


Figure 24. Combined Scores for All Alternatives

Figure 25 shows the results of alternative ranking based on this overall score. The colored bars indicate goal contributions to the alternative's overall score.

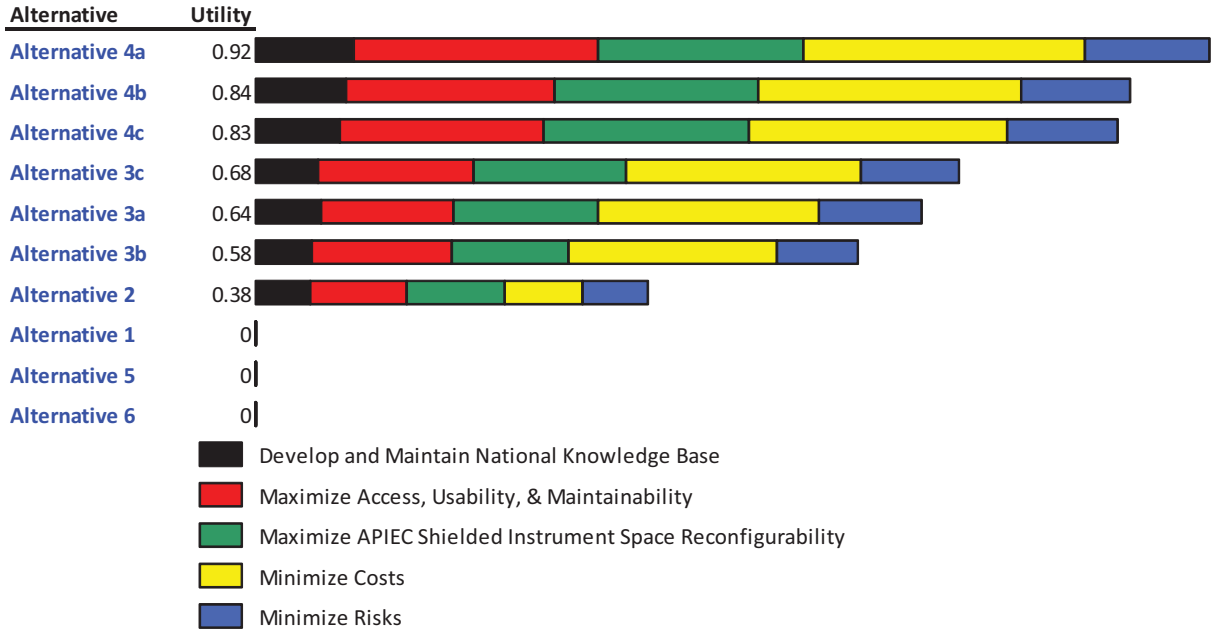


Figure 25. Alternative Ranking by Goal

A further breakdown is provided in Figure 26 which illustrates the alterative ranking with criteria contribution to overall score.

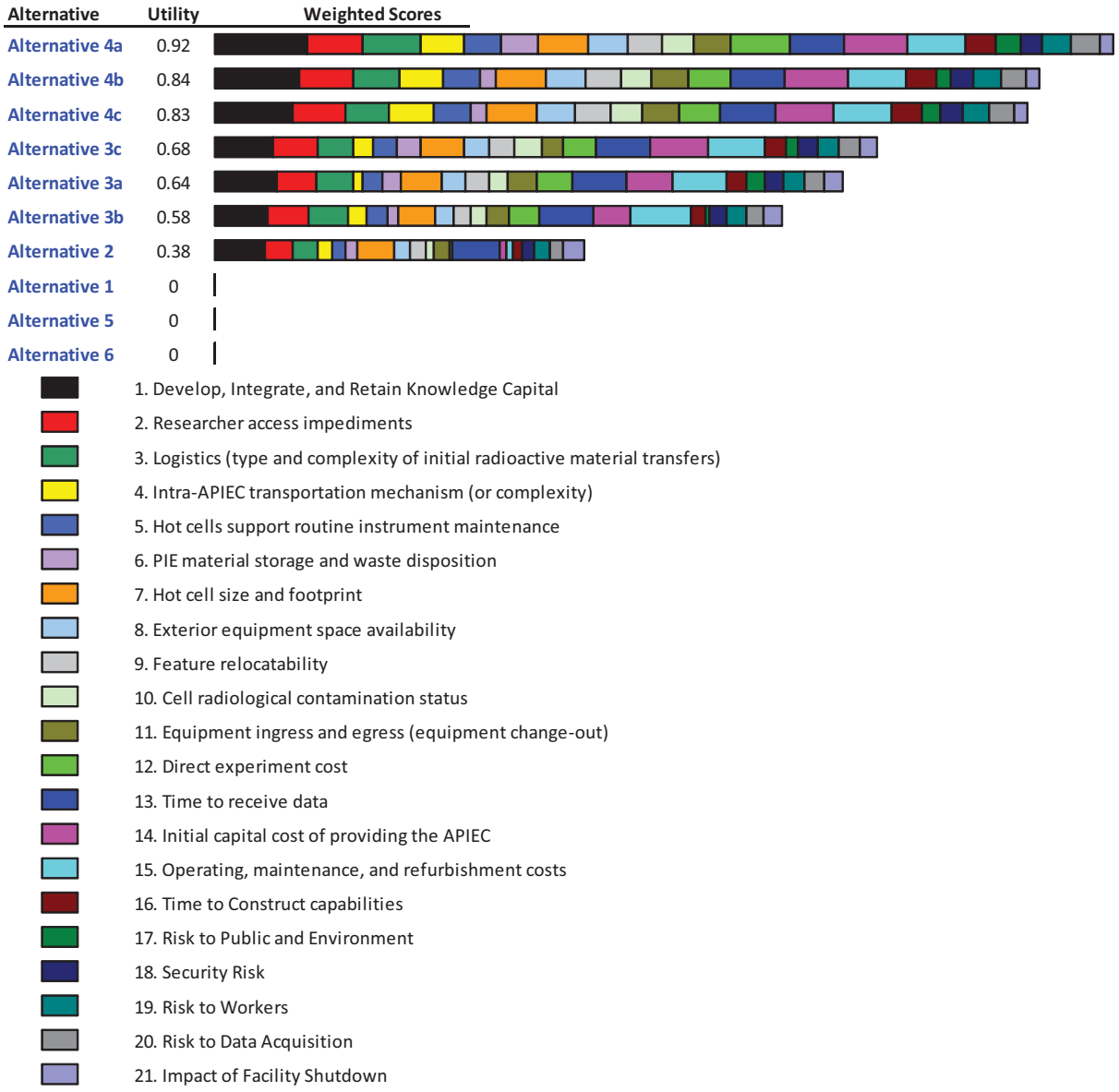


Figure 26. Ranking of Alternatives Based on Criteria (Bar Chart)

These results provide an initial indication of alternative ranking as to the best system architecture choice for implementing the APIEC. However, prior to establishing any alternative as the "preferred" alternative to be recommended to DOE, refinement of these results and evaluation of their sensitivity to uncertainties and risk is necessary. These analyses verify the robustness of the ranking, including Alternative 4a as the highest scoring alternative, and are documented in Sections 4 and 5, respectively.

4. STAGE 3 – QUANTITATIVE ANALYSIS

Original planning for the APIEC alternatives analysis assumed that qualitative criteria would be used exclusively during Stage 2, as this is a normal starting point for such analyses. Then, during Stage 3, these criteria would be refined, as necessary, to ensure adequate differentiation of the alternatives. The refinement step typically involves converting some of the criteria to quantitative measures and gathering additional information so support alternative scoring.

Early in Stage 2 (during Workshop 2 preparations), the APIEC Project team adjusted this approach and made several of the criteria quantitative from the start. This was justified, in part, due to the practical complexity of assigning accurate qualitative scores for certain criteria (e.g., hot cell size, because many of the alternatives represented a collection of facilities and/or hot cells with differing attributes). In other cases, the supporting data was already available or already being developed (e.g., initial capital cost to implement). As a result, the scope of Stage 3 has been revised accordingly and documented below.

4.1 Alternative Scoring – Refinement

Based on the initial scoring results obtained in Stage 2, which included consideration of both qualitative and quantitative criteria, refinement of the alternative scoring is not deemed necessary. Specifically, adequate differences exist in the overall weighted utility scores of the various alternatives to discriminate between the proposed system architectures and allow identification of a preferred architecture/location for recommendation to DOE-NE. The robustness of this selection with regard to uncertainties and risk is discussed in Section 5.

4.2 Results Evaluation – Refinement

As discussed in the previous section, a refinement to the alternative scoring obtained in Stage 2 was not deemed necessary. As shown in Figure 25 and Figure 26, a scoring separation exists between Alternative 2 (i.e., distributed alternative) and the Alternative 3 (i.e., consolidated) sub-alternatives. Similarly, another separation exists between these alternatives and the Alternative 4 new facility sub-alternatives. A smaller, but noticeable, separation exists between Alternative 4a (i.e., APEX at INL), the top-ranked alternative, and the other two new facility alternatives. Based on the rankings shown, it is evident that new facilities score higher than existing facilities, and collocation with irradiation facilities scores better than non-collocated locations. These conclusions will be validated in Section 5.

A refinement of these results evaluates whether the ranking of the Alternative 4 sub-alternatives is impacted if all but the discriminating criteria are removed from consideration. For this evaluation, the weighting associated with removed criteria is flowed to the remaining discriminating criteria (see Table 33) based on the original goal and criteria weight factors.

Figure 27 shows the effect of this change on the overall scores for the new facility alternatives. As evidenced by the chart, the overall scores fall slightly (and in differing amounts), and the spread of the sub-alternatives increases somewhat (e.g., score difference between Alternative 4a and Alternative 4b moves from -8% to -14%). Regardless, the rank order of the alternatives does not change.

Table 33. Weighting of Discriminating Criteria

Criteria	Old Weight	New Weight
1. Develop, Integrate, and Retain Knowledge Capital	0.100	0.125
2. Researcher Access Impediments	0.063	0.122
3. Logistics (type and complexity of initial radioactive material transfers)	0.060	0.117
6. PIE Material Storage and Waste Disposition	0.038	0.073
12. Direct Experiment Cost	0.063	0.089
13. Time to Receive Data	0.057	0.081
14. Initial Capital Cost of Providing the APIEC	0.078	0.111
15. Operating, Maintenance, and Refurbishment Costs	0.066	0.094
17. Risk to Public and Environment	0.029	0.043
19. Risk to Workers	0.033	0.050
20. Risk to Data Acquisition	0.032	0.048
21. Impact of Facility Shutdown	0.030	0.046

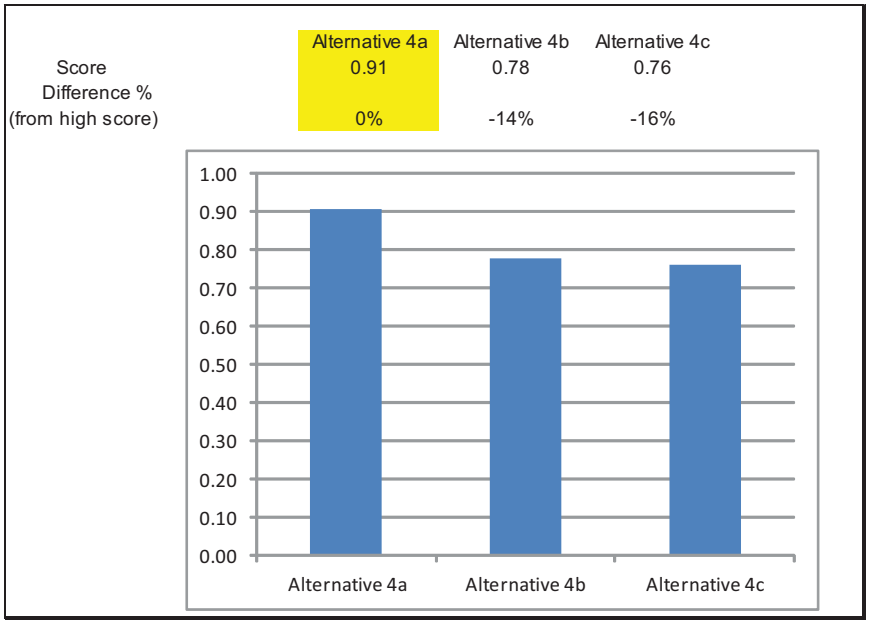


Figure 27. Effect of Criteria/Weighting Change on Overall Alternative Scores

5. STAGE 4 – RISK AND UNCERTAINTY SENSITIVITY ANALYSIS

Uncertainties in the criteria scores (or weights), if sufficiently large, have the ability to impact the ranking of alternatives or the identification of a clear choice (i.e., creating decision risk). Thus, the sensitivity of the highest scoring alternative to these uncertainties requires evaluation to determine the conditions under which the ranking changes. Section 5.1 documents the results of the goal and criteria weighting sensitivity analyses as well as results for the qualitative and quantitative scoring sensitivity analyses.

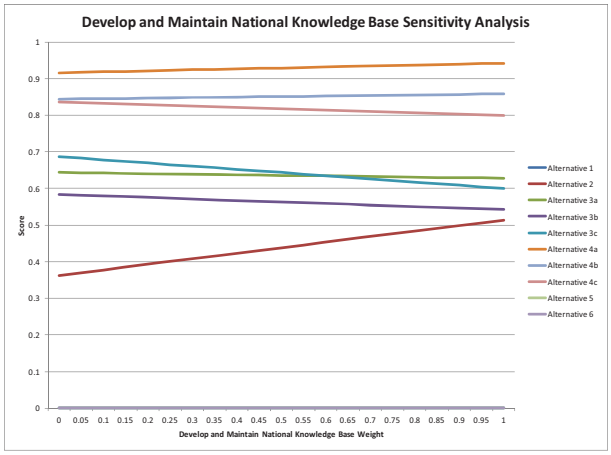
A risk analysis has also been performed to further understand the effects of selecting a particular alternative for recommendation as the preferred choice. This risk analysis is documented in Section 5.2 and expands on the risks covered within the decision criteria. Section 5.2 is organized according to the risk areas defined in DOE G 413.3-13, "Acquisition Strategy Guide for Capital Asset Projects."

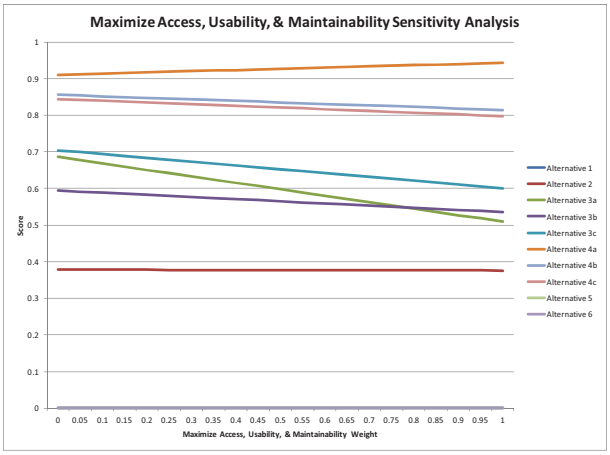
5.1 Uncertainty Sensitivity Analysis

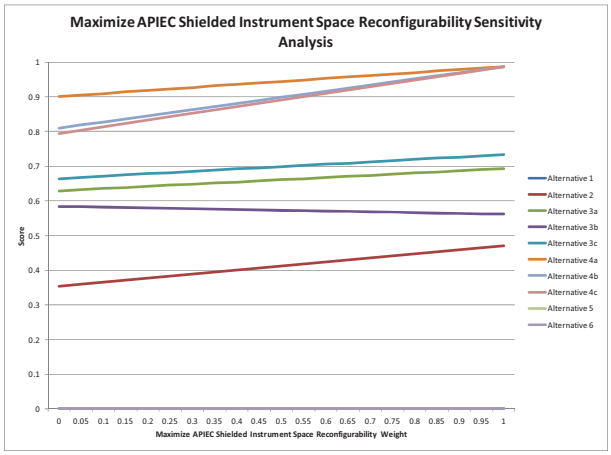
The following subsections document the results of analyses that evaluate the sensitivity of the overall weighted scores for each alternatives relative to changes in goal weights, criteria weights, qualitative scoring, and quantitative scoring. As such, these analyses help the decision-maker understand the conditions under which the highest scoring alternative might be replaced by a competing alternative. If the highest scoring alternative remains on top over a broad range of changes, the alternative is considered a "robust" solution with less uncertainty about that alternative being the best decision.

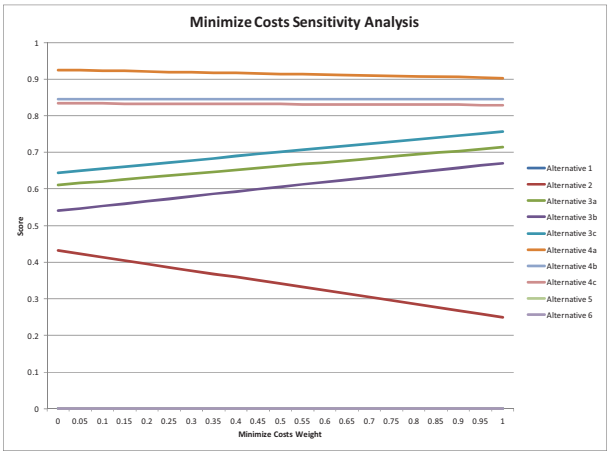
5.1.1 Goal Weighting Sensitivity Analysis

The goal weighting sensitivity analysis was performed by parametrically varying (in 5% increments) each goal weight, one-at-a-time, from 0 to 100% of the total goal weight. When the goal being analyzed carried less than 100% of the total weight, the other goals were allocated the remaining weight proportional to their originally assigned weight values. The overall alternative scores were recalculated for each incremental change and charted so that changes in the highest scoring alternative could be easily identified. This type of analysis is a standard output of the QuickCompare® tool. The following charts depict the results of the parametric goal weighting sensitivity analysis.









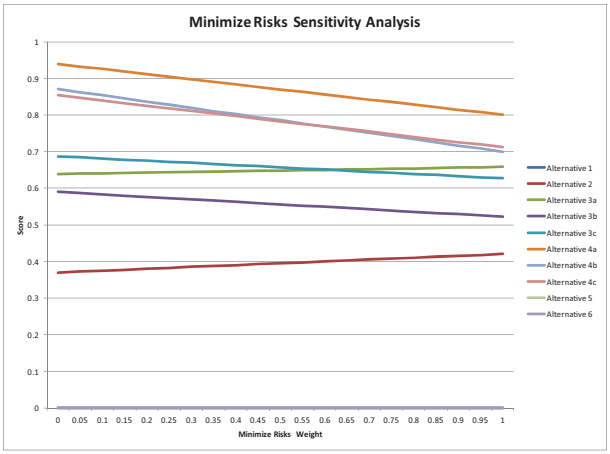


Table 34 summarizes the results of this analysis. From a goal weighting sensitivity perspective, Alternative 4a (i.e., APEX at MFC) is a robust solution and remains the top scoring alternative regardless of changes in goal weight.

Table 34. Goal Weighting Sensitivity Analysis Results

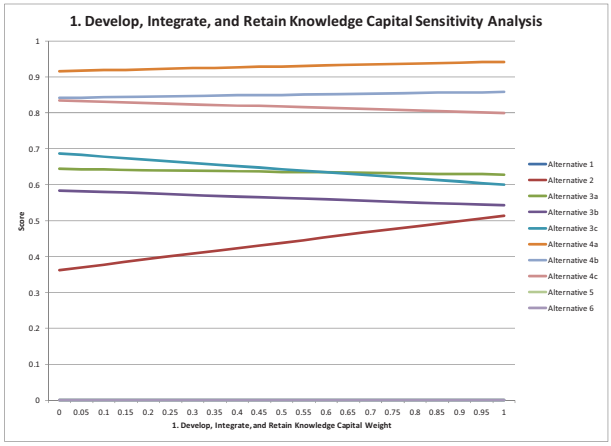
Goal	Normalized Goal Weight (in %)	High Score Alternative	Sensitivity
Develop and Maintain National Knowledge Base	10	Alt 4a – APEX at MFC	Completely Insensitive – No change from 0 to 100%
Maximize Access, Usability, and Maintainability	25	Alt 4a – APEX at MFC	Completely Insensitive – No change from 0 to 100%
Maximize APIEC Shielded Instrument Space Reconfigurability	20	Alt 4a – APEX at MFC	Insensitive – No change from 0 to 100%; Tie only at 100% for Alternatives 4a, 4b, and 4c
Minimize Costs	30	Alt 4a – APEX at MFC	Completely Insensitive – No change from 0 to 100%
Minimize Risks	15	Alt 4a – APEX at MFC	Completely Insensitive – No change from 0 to 100%

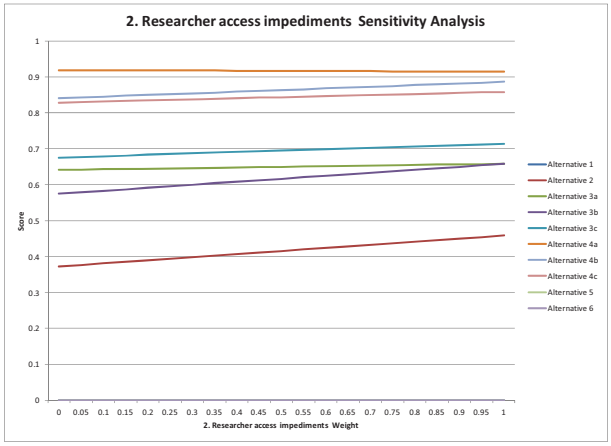
5.1.2 Criteria Weighting Sensitivity Analysis

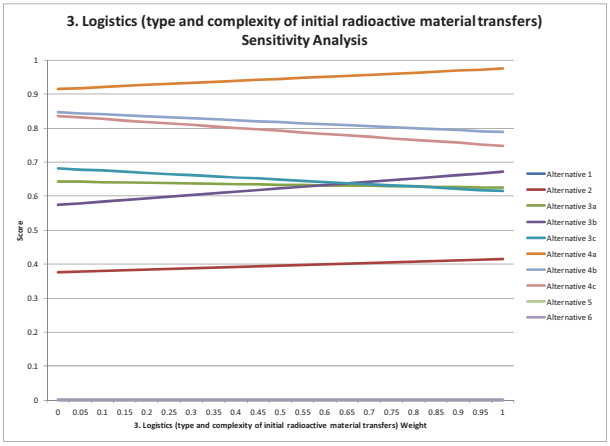
Similar to the goal weighting sensitivity analysis, the criteria weighting sensitivity analysis was performed by parametrically varying (in 5% increments) each criterion weight, one-at-a-time, from 0 to 100% of the total weight. When the criterion being analyzed carried less than 100% of the total weight, the other criteria are allocated the remaining weight proportional to their originally assigned weight values. The overall alternative scores were recalculated for each incremental change and charted so that changes in the highest scoring alternative could be easily identified.

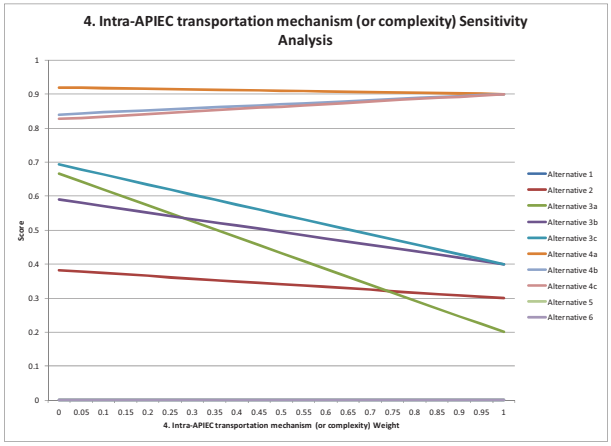
Note: *Switching out of the high scoring alternative is an expected event in this analysis because it is not typical for one alternative to be the best performer relative to every criterion. What is undesirable is for the transition to occur in a region close to the originally assigned criteria weight.*

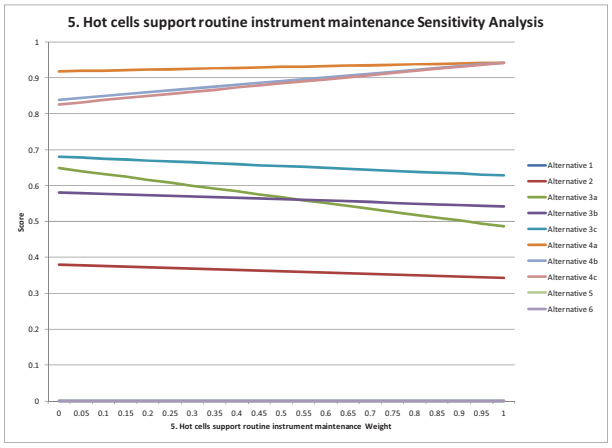
The following charts depict the results of the parametric criteria weighting sensitivity analysis.

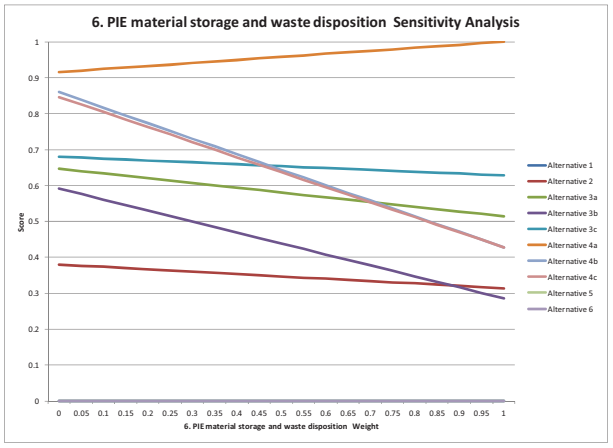


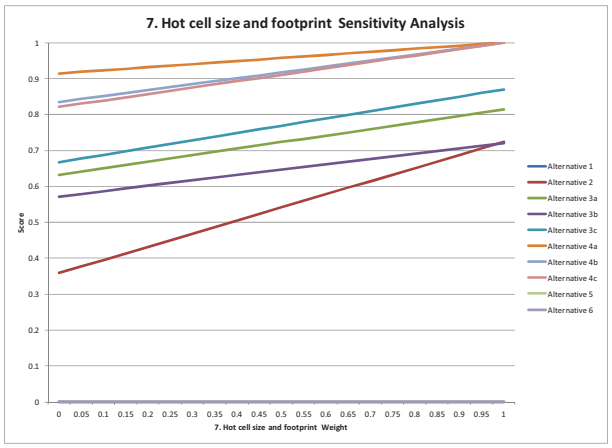


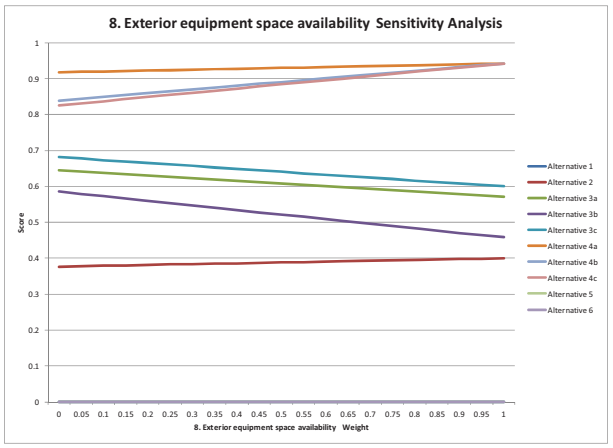


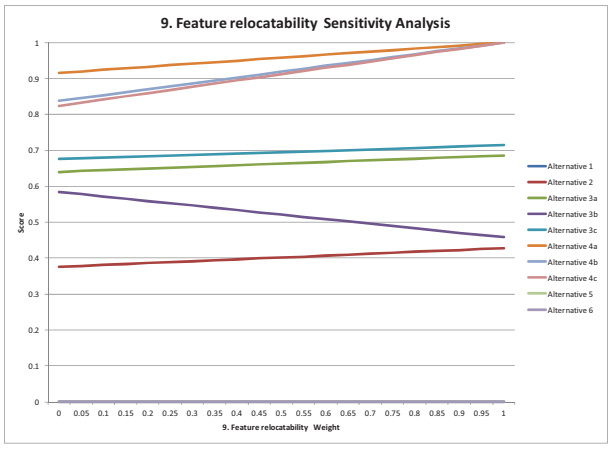


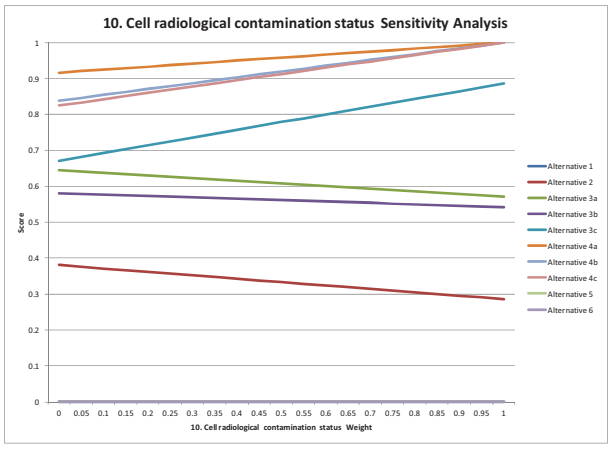

5. Hot cells support routine instrument maintenance Sensitivity Analysis
Score
5. Hot cells support routine instrument maintenance Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

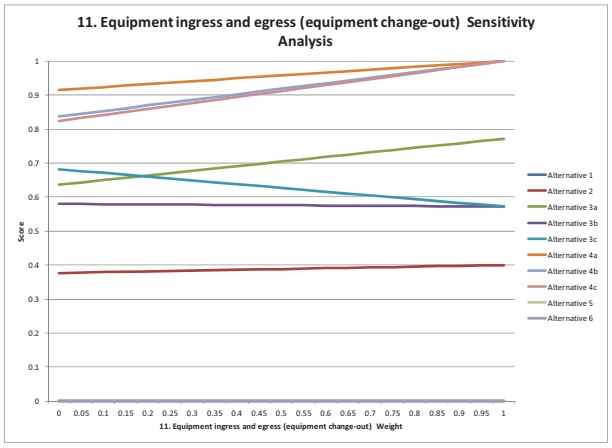

6. PIE material storage and waste disposition Sensitivity Analysis
Score
6. PIE material storage and waste disposition Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

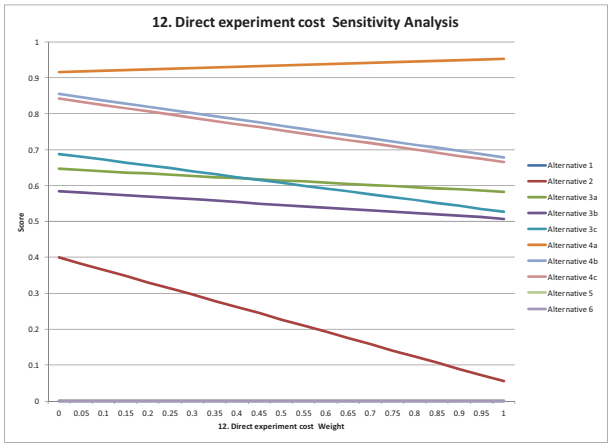

7. Hot cell size and footprint Sensitivity Analysis
Score
7. Hot cell size and footprint Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

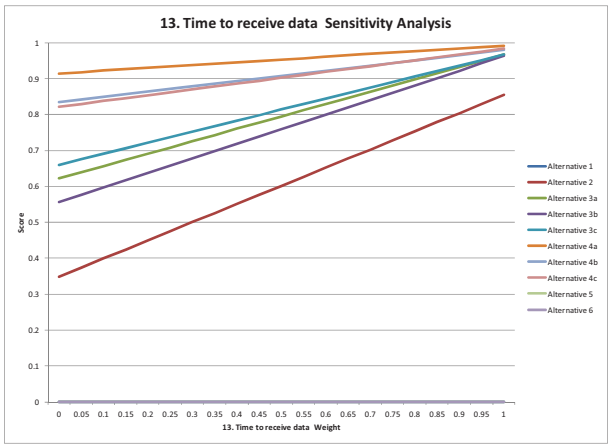

8. Exterior equipment space availability Sensitivity Analysis
Score
8. Exterior equipment space availability Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

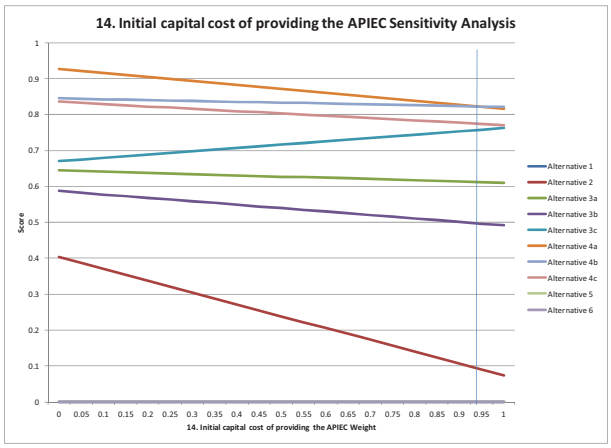

9. Feature relocatability Sensitivity Analysis
Score
9. Feature relocatability Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

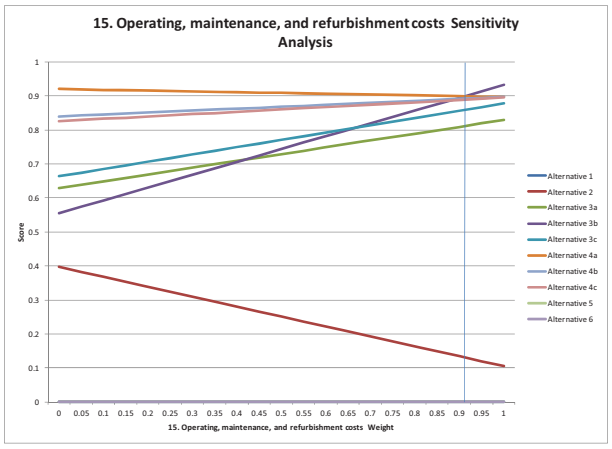

10. Cell radiological contamination status Sensitivity Analysis
Score
10. Cell radiological contamination status Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

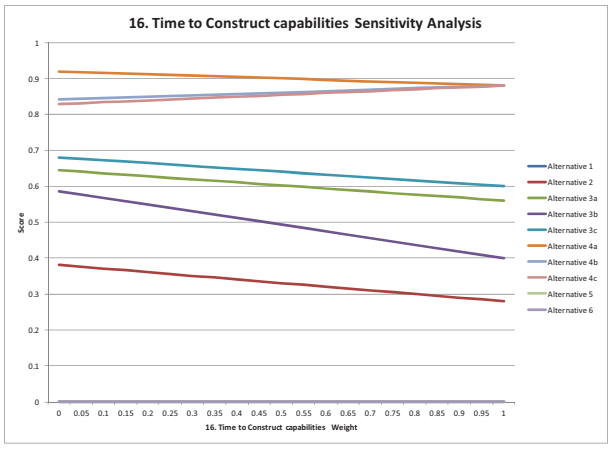

11. Equipment ingress and egress (equipment change-out) Sensitivity Analysis
Score
11. Equipment ingress and egress (equipment change-out) Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

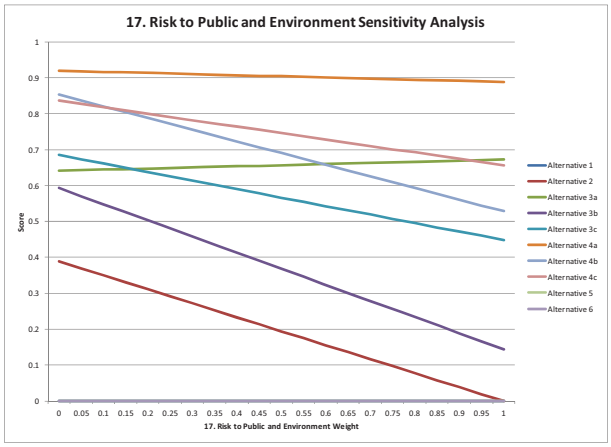

12. Direct experiment cost Sensitivity Analysis
Score
12. Direct experiment cost Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

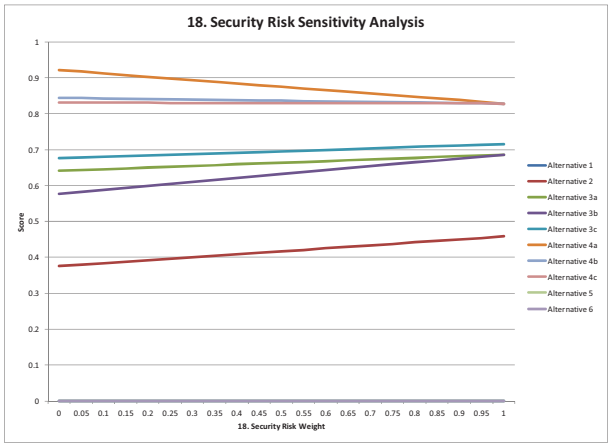

13. Time to receive data Sensitivity Analysis
Score
13. Time to receive data Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

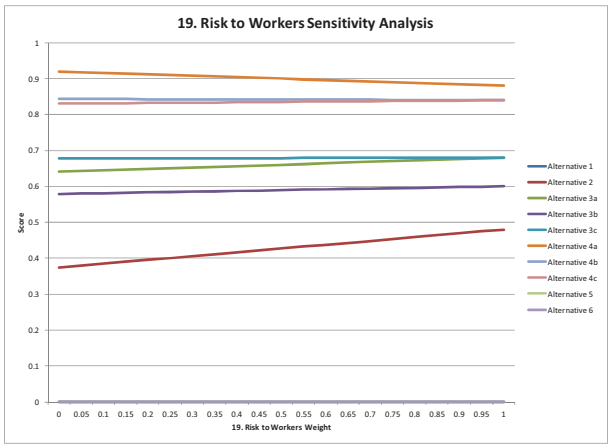

14. Initial capital cost of providing the APIEC Sensitivity Analysis
Score
14. Initial capital cost of providing the APIEC Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6

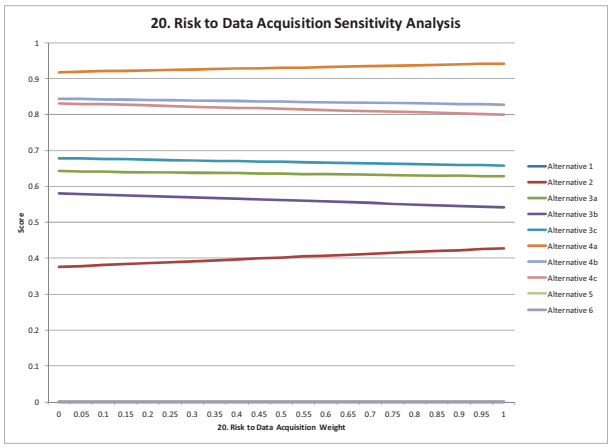

15. Operating, maintenance, and refurbishment costs Sensitivity Analysis
Score
15. Operating, maintenance, and refurbishment costs Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6


16. Time to Construct capabilities Sensitivity Analysis
Score
16. Time to Construct capabilities Weight
Alternative 1
Alternative 2
Alternative 3a
Alternative 3b
Alternative 3c
Alternative 4a
Alternative 4b
Alternative 4c
Alternative 5
Alternative 6









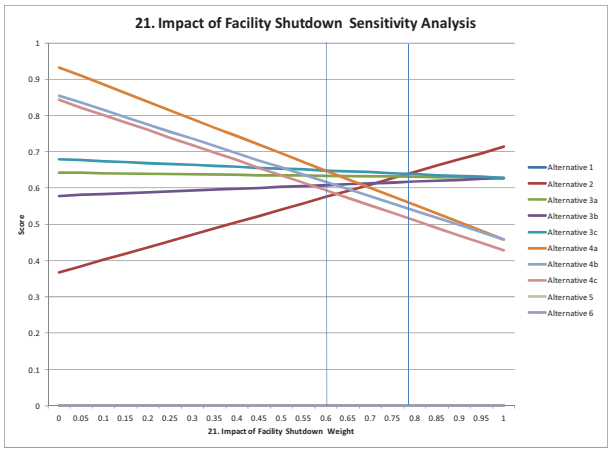


Table 35 summarizes the results of this analysis. From a criteria weighting sensitivity perspective, Alternative 4a (i.e., APEX at MFC) is a robust solution (e.g., there are no transitions within a 50%-reallocation of the original assigned criterion weight).

Table 35. Criteria Weighting Sensitivity Analysis Results

Criterion	Normalized Criterion Weight (in %)	High Score Alternative	Sensitivity
Develop, Integrate, and Retain Knowledge Capital	10.0	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Researcher Access Impediments	6.3	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Logistics (Rad material transfers and Type)	6.0	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Intra-APIEC Transportation Mechanism (or complexity)	5.0	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Hot Cells Support Routine Instrument Maintenance	4.0	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
PIE Material Storage and Waste Disposal	3.7	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Hot Cell Size and Footprint	5.2	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Exterior Equipment Space Availability	4.2	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Feature (e.g., window, MSM penetration) Relocatability	3.6	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Cell Radiological Contamination Status	3.2	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Equipment Ingress and Egress	3.8	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Direct Experiment Cost	6.3	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Time to Receive Data	5.7	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Initial Capital Cost of APIEC	7.8	Alternatives 4a / 4b	Alt. 4a from 0 to 93%; Alt. 4b from 93% to 100%
Operating, Maintenance, and Upgrade Costs	6.6	Alternatives 4a / 3b	Alt. 4a from 0 to 91%; Alt. 3b from 91% to 100%
Time to Construct Capabilities	3.6	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Risk to Public and Environment	2.8	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%

Criterion	Normalized Criterion Weight (in %)	High Score Alternative	Sensitivity
Security Risk	2.7	Alternative 4a only (APEX at MFC)	Insensitive – No change from 0 to 100%; Tie only at 100% - Alts. 4a, 4b, and 4c
Risk to Workers	3.3	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Risk to Data Acquisition	3.2	Alternative 4a only (APEX at MFC)	Completely Insensitive – No change from 0 to 100%
Impact of a Facility Shutdown	3.0	Alternatives 4a / 3c / 2	Alt. 4a from 0 to 60%; Alt. 3c from 60% to 78%; Alt. 2 from 78% to 100%

5.1.3 Qualitative Scoring Sensitivity Analysis

This sensitivity analysis evaluates the scoring uncertainty introduced by variations in scorer judgment and perspective, and applies only to the qualitative criteria scored by the SRC members. Errors in score assignment have not been analyzed. Uncertainty bars for each alternative (see Figure 28) were determined by calculating the overall weighted utility scores by individual SRC member then plotting the minimum and maximum of these values.

	Alternative 1	Alternative 2	Alternative 3a	Alternative 3b	Alternative 3c	Alternative 4a	Alternative 4b	Alternative 4c	Alternative 5	Alternative 6
Score	0.00	0.38	0.64	0.58	0.68	0.92	0.84	0.83	0.00	0.00
Score Difference %	-100%	-59%	-30%	-37%	-26%	0%	-8%	-10%	-100%	-100%
Uncertainty Bar High	0	0.53	0.71	0.65	0.73	0.95	0.90	0.90	0	0
Low	0	0.24	0.59	0.51	0.62	0.88	0.81	0.78	0	0

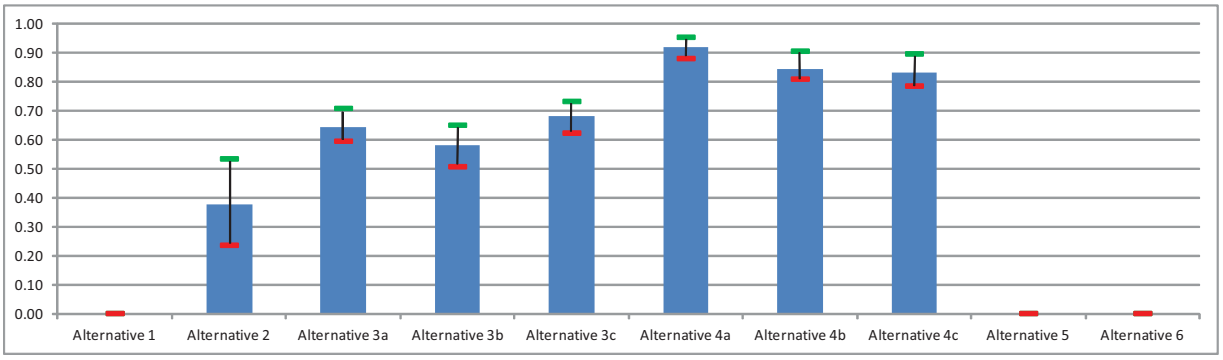


Figure 28. Comparison of Scoring Uncertainty Ranges

In comparing two competing alternatives, decision uncertainty is absent if one alternative's entire uncertainty range outscores the upper limit of the other alternative's uncertainty range—in other words, if there is no overlap in these ranges. As shown in Figure 28, Alternative 4 (i.e., any sub-alternative) outscores Alternative 2 and all of the Alternative 3 sub-alternatives. This is true even with consideration for the observed qualitative scoring uncertainty ranges. Thus, this analysis supports a conclusion that Alternatives 2, 3a, 3b, and 3c no longer need to be considered, as these represent inferior choices to Alternative 4 (i.e., construct a new facility [APEX]).

As for the Alternative 4 sub-alternatives, Figure 28 shows Alternative 4a is the highest scoring new facility alternative. At first glance, overlaps in the uncertainty ranges for these alternatives might suggest a degree of uncertainty exists for this ranking since the upper limit of both the Alternative 4b and 4c ranges are higher than the lower limit of the Alternative 4a range. However, upon detailed analysis, the

following observations confirm that, relative to the qualitative scoring, this ranking is consistent and robust:

- Generally, raw scores for the alternatives (as aggregated across criteria for individual scorers) were positively correlated with the alphabetical order of these sub-alternatives[x] (i.e., Alternative 4a rated better than 4b and 4b rated better than 4c). Two exceptions to this general rule were noted. In one case, a scorer gave Alternative 4c a better score than Alternative 4b (by 1 point). In the second case, a scorer rated Alternative 4b and Alternative 4c as equal (a tie). In all cases, scorers rated Alternative 4a better than either Alternative 4b or Alternative 4c.
- Generally, raw scores for the alternatives (as aggregated across scorers for individual criterion) were either equal for the Alternative 4 sub-alternatives (i.e., no difference for 4a, 4b, and 4c) or were positively correlated with the alphabetical order of these sub-alternatives (i.e., Alternative 4a being better than 4b and 4b being better than 4c). Specifically, out of the 13 qualitatively scored criteria:
  - Seven aggregated criteria scores reflected a tie across all three sub-alternatives
  - Three aggregated criteria scores reflected Alternative 4a as being better than 4b and 4b as being better than 4c
  - Two aggregated criteria scores reflected Alternative 4a as being better than both 4b and 4c, with a tie between the Alternatives 4b and 4c scores
  - One aggregated criterion score reflected a tie for Alternatives 4a and 4b, with these two rating better than Alternative 4c.

Based on these observations, it was concluded that the rollup of the alternatives' weighted utility scores was not masking any switching behavior for the alternatives—either from one scorer to the next or from one criterion to the next. Thus, with respect to the qualitative scoring results and the associated uncertainty, this sensitivity analysis demonstrates the ranking shown in Figure 28 is robust and validates Alternative 4a (i.e., construct a new facility [APEX] at MFC) as the highest scoring alternative. This ranking is examined further in the next section relative to robustness against quantitative criteria scoring uncertainties.

5.1.4 Quantitative Scoring Sensitivity Analysis

The sensitivity of the Alternative 4 sub-alternative rankings to changes in quantitative criteria metric value was analyzed as part of Stage 4. First, a parametric analysis was performed to evaluate the sensitivity of the highest ranked alternative (i.e., Alternative 4a) to potential metric estimation errors relative to the other alternatives (i.e., 4b and 4c). In this portion of the analysis, an Alternative 4a scoring value for one quantitative criterion was adjusted in 25% increments, in a direction to produce an adverse impact on overall score, to determine the point at which the alternative ranking was adversely affected. This process was repeated, one-at-a-time, for each quantitative criterion.

The second phase of this analysis involved adjusting multiple metric values for Alternative 4a simultaneously for quantitative criteria that were deemed to be somewhat dependent. As described above, adjustments were made in 25% increments to produce an adverse impact on the overall score. The point at which the alternative ranking was affected was recorded. Two groups of quantitative criteria were examined in this second phase:

[x] For the qualitatively scored criteria, a higher raw score equates to a reduced utility value and, thus, a lower weighted utility score.

- First, the logistics score, direct experiment cost, and risk to public and environment were evaluated simultaneously due to the use of common assumptions for the number and distribution of irradiation experiments requiring PIE.
- Second, the direct experiment cost; initial capital cost; and operating, maintenance, and refurbishment cost criteria were evaluated simultaneously due to the use of common assumptions supporting these cost estimates and to account for other potential estimation errors, such as unintentional bias introduced by INL cost estimating.

The results of these sensitivity analyses are as follows:

- Any single quantitative criterion's contribution to Alternative 4a's overall weighted utility score can be completely zeroed out and Alternative 4a remains the top ranked alternative. Thus, Alternative 4a is a robust solution given potential quantitative metric estimation errors relative to the values estimated for the other sub-alternatives (i.e., 4b and 4c).
- Simultaneously, the Alternative 4a metric values for logistics score and direct experiment cost can be increased by 100% of their original values (where higher values produce lower utility scores for both of these metrics) and the original metric value for risk to public and environment can be reduced by half (where lower reductions in traffic incidents produces a lower utility score) with Alternative 4a remaining the top ranked alternative.
- The Alternative 4a metric values for direct experiment cost; initial capital cost; and operating, maintenance, and refurbishment cost can simultaneously be increased by 50% of their original values (where higher values produce lower utility scores for these metrics), at which point Alternative 4a and 4b tie for the top ranking.

Based on these findings, and the extremely low probability for such relative errors of these magnitudes to occur between the Alternative 4 sub-alternatives, this sensitivity analysis demonstrates that the ranking shown in Figure 24 is robust and validates Alternative 4a (i.e., construct a new facility [APEX] at MFC) as the highest scoring alternative.

5.2 Risk Evaluation

The risks associated with the various alternatives are discussed below in the context of DOE G 413.3-13, *Acquisition Strategy Guide for Capital Asset Projects*. The risks identified in this Guide are as follows:

- Scope and definition
- Function as it relates to the facility, technology, or system to perform or meet the project requirements
- Environment, safety, and health
- Cost and schedule
- Workforce issues (i.e., cost, availability, legacy transitions)
- Funding and budget
- Technology and engineering
- Interfaces and integration
- Safeguards and security
- Location and site conditions

- Legal and regulatory
- Stakeholder issues
- Existence of metrics for performance measurement
- Required government-furnished property/information and its availability
- Expertise and human resources–from DOE's perspective–and the management expertise required to perform the work.

As previously discussed, the three new facility alternatives (i.e., Alternatives 4a, 4b, and 4c) scored significantly higher than Alternatives 2 and 3. Therefore, this risk assessment only considered the new facility alternatives. Based on the assessment, Alternative 4a is deemed to have the least overall risk, mainly due to the following:

- Reduced risks in the areas of legal and regulatory risk (as a result of INL's agreement with the state of Idaho regarding acceptance of used nuclear fuel)
- Scope and definition risk and funding and cost risk (due to the ability to leverage IMCL to provide additional capability at the least cost)
- Interfaces and integration risk (based on the co-location of the irradiation, NDE, and examination facilities).

While the probability of injury to the public due to transportation accidents may be small, Alternative 4a has the least risk in this category because the number of miles travelled on public highways is much less than the other two alternatives.

5.2.1 Scope and Definition Risk

The scope and definition are still being clarified at this stage of the APIEC project. However, one scope uncertainty is that more specimen preparation and examination capability may be needed than was anticipated or than could be afforded in the new facility design. That uncertainty could be mitigated by building additional facilities or modifying existing facilities in the future to complement the new facility. INL has the IMCL, which is designed to meet the environmental requirements for the types of instruments involved and could be re-purposed to provide the additional examination capability. Up to six shielded examination cells could be quickly commissioned in IMCL by installing the required modular cells.[y] ORNL could re-purpose existing hot cells or modify the REDC 7930 facility, as described in the Alternative 2 or Alternative 3 descriptions, but these cells were not designed for the strictly controlled environmental conditions, which would result in higher conversion costs. PNNL could re-purpose their existing fixed or modular cells, but again, these cells were not designed for the strictly controlled environmental conditions, thus resulting in higher conversion costs. Furthermore, as discussed in the scoring section of this report, the costs for transportation of the additional experiments would be higher for Alternatives 4b and 4c than they would be for Alternative 4a.

5.2.2 Functional Risk

The functional risks, as defined in the DOE G 413.3-13, address the ability of the facility, technology, or system to perform or meet the project requirements. The ability of the facility to meet the actual throughput requirements was addressed in Section 5.2.1. A second significant area of functional risk is the ability of the facility to provide the proper operating environment, for example, vibration isolation, temperature control, and shielding from electromagnetic interference (EMI). Given that a new facility can be designed to incorporate the latest technology to meet these operating environment requirements, no significant differences between the three new facility alternatives have been identified.

[y] The six spaces assumes specimens are prepared in the APEX for examination in the IMCL.

A third area of function risk is the inability to effectively deploy the desired sample preparation equipment and, more importantly, the examination instruments in a shielded environment, even if the previously discussed environmental conditions are met. This inability could be due to any number of reasons, such as limited separation distance for support equipment cables, inability to maintain the required level of vacuum, or radiation effects on critical components. The INL will establish an expertise in the deployment of this equipment and instruments in high-radiation environments in the IMCL. The lessons learned from IMCL will be disseminated to other laboratories, but Alternative 4a will retain a slight advantage regarding this aspect of the functional risk because it will have the personnel who actually deployed the equipment and instruments.

5.2.3 Environment, Safety and Health Risk

The environmental, safety, and health risks of the new facility alternatives are similar in that all alternatives are expected to meet applicable regulations and DOE Orders. From a radiological perspective, calculations of hypothetical exposures at the site boundaries have not been performed, but the INL and PNNL sites are large and the new facility could be located at some distance from the public, which might make the design of safety-related systems easier. Distances to public roads for the LANL and ORNL new facilities are probably less than those for INL, but safety-related systems could be employed to mitigate the hypothetical exposures to acceptable levels. Therefore, there is no significant discrimination between the alternatives relative to the risk of radiation exposure to the public. Similarly, relative to risk to co-located workers, all the new facility alternatives are deemed to be the same.

From a NEPA perspective, the expected required level of NEPA documentation is an Environmental Assessment resulting in a Finding of No Significant Impact (FONSI), which if not issued, will require an Environmental Impact Statement (EIS). This could significantly affect costs and schedule. However, the probability of needing an EIS is very low, and the risks for all the new facility alternatives are considered to be the same.

As mentioned in the discussion on the “Risk to Public and Environment” criterion (see Section 3.2.5.1), there is a perceived risk on the part of the public related to shipment of radioactive materials as well as a real risk of causing injury due to traffic accidents. Both of these risks are related to the number of miles travelled. Alternative 4a, which requires the least “in-commerce” transportation, would have the lowest risk in this category.

In summary, for the environment, safety, and health risk, Alternative 4a is deemed to have slightly less risk due to the reduced amount of transportation.

5.2.4 Cost and Schedule Risk

There are many ways in which costs could increase and schedules lengthen on a capital project of this type, but no significant differences have been identified between the new facility alternatives. Therefore, there is no discrimination between the alternatives relative to this risk.

5.2.5 Workforce Issues Risk

No workforce issues have been identified that would distinguish between the three new facility alternatives. The construction of a new facility would be a multi-million dollar effort, but all the sites that have been identified for the new facility have demonstrated the ability to perform efforts of this magnitude. The INL is in the process of commissioning the Integrated Waste Treatment Unit (DOE’s Sodium Bearing Waste project), PNNL has recently completed the Physical Sciences Facility research complex, and ORNL has fielded large projects as well. These projects demonstrate that all the sites will be capable of obtaining and deploying the necessary resources to construct the new facility. Therefore, there is no discrimination between the alternatives relative to construction force availability.

With respect to personnel to operate the facility, no differences have been identified between the alternatives. Any of the proposed sites currently employ these types of personnel and are capable of attracting and deploying the personnel needed to operate and maintain the facility.

With respect to research personnel, again no differences have been identified between the alternatives. Any of the proposed sites currently employ these types of personnel and are capable of attracting and deploying additional personnel, if needed, to support the research programs.

5.2.6 Funding and Budget Risk

This risk addresses shortfalls in funding and limitations on budget. In the event that the cost of the required scope outweighs available funding, the assessment is similar to that regarding changes in the scope to require additional throughput, i.e., more space for sample preparation and examination cells (see Section 5.2.1). If budget is limited, alternatives with the ability to provide additional capability at the lowest cost would have less risk. Again, due to the presence of the IMCL at the INL, the alternative to construct the new facility at INL has the lowest risk. In the case of limited funding or budget, the IMCL could be repurposed to provide additional examination capability at the lowest cost because it is already designed to meet the operating environment requirements and would have the lowest transportation costs.

5.2.7 Technology and Engineering Risk

The major technical risk associated with the APIEC project is the ability to deploy the advanced instrumentation in shielded environments that meet the strict operating environment (i.e., vibration, EMI, and temperature) requirements. As discussed in Sections 5.2.1 and 5.2.2, the option to construct a new facility at INL is deemed to have an advantage over new facilities at other sites because of the lessons learned from deployment of instruments in the IMCL. In addition, INL has commenced work on a technology maturation roadmap that will support the various programs requiring PIE toward reducing this risk. The IMCL plays a major role in this risk reduction effort, and its co-location with the new facility would improve communications and coordination between the researchers, engineers, and technicians.

5.2.8 Interfaces and Integration Risk

The significant interfaces and integration risks related to the APIEC project can be categorized as programmatic, technical, or operational. The programmatic interfaces and integration include coordination between the program managers, researchers, and support personnel. As the lead laboratory for nuclear energy, INL is best suited to support this programmatic integration. The technical interfaces and integration include designing, analyzing, and fabricating the tests prior to irradiation as well as coordinating sample preparation and the actual examination of the specimen. Operational interfaces and integration include coordinating personnel and equipment to support the irradiation, transportation, sample preparation, and examination activities. In both the technical and operational categories, co-location of the irradiation, NDE, and examination facilities will enhance communications and improve understanding, which will reduce risks. By having ATR, HFEF, and the new facility located on the same site, Alternative 4a is best suited to reduce these risks. This co-location also allows researchers easier access to and communication with engineers who are designing the experiments to be placed in the reactor and with the nuclear safety analysts who are analyzing the installation. This increased coordination will minimize the chance that the experiment design or irradiation conditions are not what the researcher expected. It also improves communication between the shipping and receiving groups when transferring the experiment or samples between facilities, which will minimize potential delays.

5.2.9 Safeguards and Security Risks

The safeguards and security risks of the new facility alternatives are similar in that all the alternatives are expected to meet the applicable regulations and DOE orders. Regarding physical protection of the material at the site, all the sites that have been considered for the new facility are capable of providing the proper security environment. The INL and PNNL are large sites that currently have the isolation, designs,

policies, and procedures in place to securely store used nuclear fuel. There is also a risk that the material could be damaged or stolen while in transit between sites. Regarding this scenario, the new facility at INL would have the least risk because all the transfers from ATR would remain on the INL site. Therefore, there is a slight advantage for Alternative 4a.

5.2.10 Location and Site Conditions Risk

Alternative 4a will be located at MFC, although the specific location at MFC has yet to be determined. Specific locations have also not been identified for Alternatives 4b and 4c. There are no significant risks associated with the possible locations at MFC for Alternative 4a. All the reasonable candidate sites are well characterized, and there are no identified issues regarding contaminated soils or significant amounts of basalt requiring removal. Alternative 4b is assumed to be located at a suitable site at ORNL and again, no significant issues with soil or rock are anticipated that could not be worked around during conceptual design. The same is expected of Alternative 4c located at PNNL. Locations at LANL for the new facility would likely be the most problematic, given the relatively limited space available and the local geography and geology.

Alternatives 4a and 4b are considered to be essentially equal, with no significant risk. Alternative 4c, if it were to be located at LANL, is deemed to have slightly higher risk in this category; however, other DOE laboratories (e.g., PNNL, SRNL, SNL) may also be considered.

5.2.11 Legal and Regulatory Risk

The most significant regulatory risk associated with the APIEC is the management of the used nuclear fuel. INL is the only site with a written agreement with the state regarding the acceptance and storage of used nuclear fuel for research purposes. Other sites will have to deal with acceptance of irradiated fuel on a case-by-case basis, which introduces a risk that a shipment may be denied, thus preventing examination of the fuel, or that the researcher organization will be required to take back the waste and residuals.

5.2.12 Stakeholder Issue Risk

Each site for the new facility will have its own stakeholder groups. Generally, INL, ORNL, and PNNL have good relations with their stakeholders, and no significant differences in the risks posed by stakeholder involvement are expected.

5.2.13 Existence of Metrics for Performance Measurement Risk

No differences have been identified for the three new facility alternatives regarding the risk of not having metrics for performance measurement available when required. Therefore, there is no discrimination between the alternatives relative to this risk.

5.2.14 Availability of Government-furnished property/information Risk

No differences have been identified for the three new facility alternatives regarding the risk of not having government furnished equipment available when required. Therefore, there is no discrimination between the alternatives relative to this risk.

5.2.15 Expertise and Human Resources Risk

No differences have been identified for the three new facility alternatives regarding the availability of management expertise and human resources. Therefore, there is no discrimination between the alternatives relative to this risk.

6. SUMMARY

This alternatives analysis has evaluated a ten alternatives and sub-alternatives (including the No Action alternative), namely:

1. No Action (i.e., status quo)
2. Modify Existing DOE Facilities – Distributed (i.e., various facilities across five laboratories)
3. Modify Existing DOE Facilities – Consolidated
    a. IMCL at INL paired with the CMR Wing 9 Facility at LANL
    b. CMR Facility at LANL paired with REDC 7930 and IFEL at ORNL
    c. REDC 7930 and IFEL at ORNL paired with IMCL at INL
4. Construct New Facility
    a. New facility sited at MFC at the INL
    b. New facility sited at ORNL
    c. New facility sited at a DOE laboratory with only pre- and post-irradiation capabilities and no irradiation facility
5. Commercial Partnership
6. International Partnerships.

Alternatives 1, 5, and 6 were eliminated because they did not meet one or more of the threshold requirements for consideration. Alternatives 2, 3a, 3b, 3c, 4a, 4b, and 4c were evaluated against the qualitative and quantitative criteria that had been developed by the APIEC project team and reviewed with the SRC, a group of experts from other national laboratories, industry, and universities. The results, as discussed initially in Section 3.3 and shown in Figure 24 through Figure 26, clearly indicated that the New Facility options outperform other alternatives that involve modifying existing facilities. Therefore, it is recommended that Alternatives 2 and 3a, 3b, and 3c be removed from further consideration. The weighted scores for Alternatives 4a, 4b, and 4c provide discrimination between the new facility sub-alternatives, with Alternative 4a being ranked highest, followed by Alternative 4b and finally 4c. A sensitivity analysis was performed, as described in Section 5.1. This sensitivity analysis indicated that Alternative 4a was a robust solution in that the competing alternatives could not surpass it even with the weights and scores being varied over a wide range of values.

Therefore, the conclusion of this alternatives analysis is that a new facility should be built at MFC at INL to provide the needed advanced PIE capability that the United States needs to support science-based R&D of new nuclear fuels and materials.

7. REFERENCES

1. DOE, *Mission Need Statement for Advanced Post-Irradiation Examination Capability*, U.S. Department of Energy, January 31, 2011.
2. DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, U.S. Department of Energy, Approved November 29, 2010.
3. PLN-4187, "Advanced Post-Irradiation Examination Capabilities Alternatives Analysis," Revision 0, Project No. 31348, Idaho National Laboratory, May 9, 2012
4. DOE G 413.3-13, "Acquisition Strategy Guide for Capital Asset Projects," U.S. Department of Energy, July 22, 2008.
5. *National Postirradiation Examination Workshop Report,* Revision 0, INL/EXT-11-21922, Idaho National Laboratory, June 2011.
6. *International Workshop on Characterization and PIE Needs for Fundamental Understanding of Fuels Performance and Safety*, Revision 0, INL/EXT-11-23544, Idaho National Laboratory, September 2011.
7. *Memorandum of Agreement Concerning Receipt, Storage, and Handling of Research Quantities of Commercial Spent Nuclear Fuel at the Idaho National Laboratory*, January 6, 2011.
8. *AFCF Existing Facilities Data Report*, GNEP-AFCF-PMO-AI-EA-2008-000205, March 27, 2008.
9. *Seismic and Wind Evaluation of Building 325 at Pacific Northwest National Laboratory*, Report No. 063480111-002, Revision 1, Applied Research and Engineering Corporation, Santa Ana, CA, July 2007.
10. *Seismic and Wind Evaluation of Building 325 at Pacific Northwest National Laboratory*, Calculation No. 0634801.12-S-003, Revision 0, Applied Research and Engineering Corporation, Santa Ana, CA, September 2007.
11. TEV-1634, "Advanced PIE Capabilities Transportation Activities and Cost Basis," Revision 0, Project No. 31348, Idaho National Laboratory, September 18, 2012.

This page intentionally left blank.

Appendix A

Workshop 1 – SRC Review and Comments

Appendix A
Workshop 1 – SRC Review and Comments

Advanced PIE Capabilities Alternatives Analysis
Workshop 1 Meeting Minutes and Resolutions

July 24-25, 2012

Overview

Idaho National Laboratory (INL) is currently identifying and evaluating alternatives for providing Advanced Post-Irradiation Examination Capabilities (APIEC) for the Department of Energy's Office of Nuclear Energy (DOE-NE) in accordance with DOE Order DOE-O-413.3B, "Program and Project Management for the Acquisition of Capital Assets". As part of the alternatives analysis effort, a Stakeholder Review Committee (SCR) has been assembled to review and comment on the analysis as it proceeds. A series of workshops are planned during which the SRC members' comments will be obtained. These meeting minutes document the notes taken during Workshop 1.

Attendees

The attendees at the workshop are listed below.

Name	Organization	Role
Lori Braase (introduction)	INL Systems Engineering	Observer
Jeffrey Bryan	INL Systems Engineering	Systems Engineer
Michael Cappiello	Consultant	SRC member
Kenneth Geelhood	Pacific Northwest National Laboratory	SRC member
Andrew Griffith	DOE-NE	SRC member
Steven Hayes	INL Nuclear Fuels and Materials	Subject Matter Expert
Jody Henley	INL Systems Engineering	Meeting Facilitator
Porter Hill	INL Systems Engineering	Systems Engineer
Collin Knight	INL Nuclear Science and Technology	Scientific Coordinator
William Landman	INL Facilities Engineering	APIEC Project Engineer
Keith Lockie	DOE-ID	Observer
Erik Mader	Electric Power Research Institute	SRC member
Darcie Martinson	S.R. Martin Group	Meeting Facilitator
Mary McCune	DOE HQ	Observer
Mitchell Meyer	INL Nuclear Fuels and Materials	SRC member representing SRC chair
Kemal Pasamehmetoglu (introduction/conclusion)	INL Nuclear Science and Technology	SRC chair
Michael W. Patterson	INL Project Management	INL APIEC Project Manager
Dr. Jeff Terry	Illinois Institute of Technology	SRC member

Name	Organization	Role
Vince Tonc	INL Project Management	APIEC Program Manager
Steven Zinkle	Oak Ridge National Laboratory	SRC member

Workshop Objective

The objective of Workshop 1 was to review the APIEC Alternatives Analysis Report (progress to date) and solicit input from the Stakeholder Review Committee (SRC) to ensure the alternative descriptions and decision framework's goals, requirements, criteria and weights will provide the necessary information by which the preferred alternative can be identified.

Workshop Products

The products to be produced during Workshop 1include:

- SRC comments on alternative descriptions
- SRC comments on goals, requirements, criteria and weights
- Refined set of goals and criteria
- Revised weights for goals and criteria based on SRC member input.

Workshop Presentations

The following presentations were delivered during Workshop 1 and appear at the end of this appendix:

- APIEC Workshop 1 Welcome – Kemal Pasamehmetoglu
- APIEC Alternatives Analysis and Project Overview – Mike Patterson
- APIEC Alternatives Analysis Overview – Jeff Bryan
- APIEC Scope and Alternatives Analysis Assumptions – Jeff Bryan
- Alternative Descriptions:
  - Alternative 1: No Action – Bill Landman
  - Alternative 2: Modify Existing DOE Facilities – Distributed – Jeff Bryan
  - Alternative 3: Modify Existing DOE Facilities – Consolidated – Jeff Bryan
  - Alternative 4: Construct New Facility – Bill Landman
  - Alternative 5: Commercial Partnerships – Porter Hill
  - Alternative 6: International Partnerships – Porter Hill
- Overview of Goals, Requirements and Criteria – Jeff Bryan
- APIEC Goals and Requirements – Jeff Bryan
- APIEC Criteria and Weights – Bill Landman.

Actions

1. Document workshop (Darcie Martinson)

   Action completed with email from Darcie Martinson to Bill Landman on 8/1/12, draft minutes issued for review

2. Distribute list of new PIE capabilities to SRC (Porter Hill)

   Action complete. The SRC was given a hard copy of the equipment that was part of the PIE LIB report. The APIEC equipment is also listed in Section 2.2.

3. Distribute summary of national workshops (Porter Hill)

   Action completed with email from Bill Landman to SRC on 7/24/12.

4. Distribute international PIE workshop report and equipment/instrument list (Porter Hill)

   Action completed with email from Porter Hill to SRC on 7/26/12.

5. Distribute PLN-4187, Advanced Post-Irradiation Examination Capabilities Alternatives Analysis Plan (this document was previously included in Bill Landman's e-mail to SRC and project team on June 27, 2012)

   Action pending.

6. Document the basis for down selecting first to eight international options and ultimately the four options listed in the alternatives analysis report (note: contact Andrew Griffith and Steve Hayes for background information) (Porter Hill)

   Action pending. Basis will be added to next revision (Workshop 2) of the Alternatives Analysis report.

7. Obtain goal and criteria weights from Erik Mader (Bill Landman)

   Action completed with email from Erik Mader to Bill Landman, 7/26/12.

8. E-mail SRC comments to Jeff Bryan or Darcie Martinson (Mike Cappiello)

   Action completed with email from Mike Cappiello received by Bill Landman on 7/30/12. Email forwarded to Jeff Bryan and Darcie Martinson 7/30/12.

9. Compose narrative describing basis of how space needs, footprint and design specifications were derived/translated from mission need, science-based approach and other information (Porter Hill)

   Action pending. Basis will be added to next revision (Workshop 2) of the Alternatives Analysis report.

10. Include University Programs in listing of major programs using APIEC (Jeff Bryan)

    Added reference to University Programs.

11. After scoring has been completed for each alternative, distribute results to SRC and then make decision about timing and location (potentially virtual) for next workshop (Bill Landman)

    Note: Due to scheduling issues, holding the second workshop after September TBD, 2012, was preferred by the majority of SRC members.

Comments on APIEC Scope and Assumptions[26]

APIEC Scope Comments

- Why is chemical/elemental not included in PIE functions scope? (Jeff Terry)

  Chemical analysis such as wet chemistry is not included in the scope of the advanced PIE functions

- Is there a specific list of new capabilities? (Ken Geelhood)
  - ACTION: See item 6 above
- If everything is so small, is dose low enough that we can use space outside to hot cell? (Ken Geelhood)

  There are instruments such as the transmission electron micro-scope that use small, thin samples that do not require shielding. These types of instruments will be installed in the non-shielded spaces. However, not everything will be that small, hence the shielded cells.

- Would like a summary from the national and international workshops to refresh our memories. (Steve Zinkle)
  - ACTION: Porter Hill will e-mail reports to SRC – Completed as noted previously
- What is the vision for how this integrates with future plans for HFEF, IMCL, etc.? What is appropriate handoff between these facilities and APEX? (Steve Zinkle)

  HFEF will continue to provide the capability for receiving large experiments, performing a wide variety of NDE, and sizing material. HFEF would "hand off" to the APIEC after the material was sized (if necessary) and placed in the appropriate shipping container. Note that this discussion is directed at support the APIEC. HFEF can also support a number of other functions.

  IMCL is most likely to be used as a development center for deployment of new APIEC instruments, although it may also directly support some examinations.

  The APIEC will provide the world leading examination capability for the DOE.

- What benchmark cost was used for APEX? (Jeff Terry)
  - Costs ranged up to $395M
- Is there an operational requirement to allow for operation at a higher security level? (Mike Cappiello)

  While not explicitly depicted in the preconceptual design, the technical and functional requirements for the APIEC will identify the needs for security levels based on the classification of the material (e.g., naval reactors) and the quantity and attractiveness of the fissionable material.

- Do all cells have remote capability? (Mike Cappiello)

  The seven shielded cells have remote capability. Space is also allocated for four non-shielded instruments that examine small specimens that do not require shielding or remote handling.

- Do you have a summary for the basic set of instruments? (Steve Zinkle)

[26] Comments captured in the overall workshop documentation include written comments received by SRC members

The report has been updated to include discussion on this topic.

- With respect to programmatic configurable space, is there a basis for current and future space needs and assumptions? What is justification? (Steve Zinkle and Mike Cappiello)
  - NO ACTION – This area was dropped from the alternatives analysis as it was not needed to support comparisons between the various system architectures being considered.
- What is plan for maintenance and accessibility (Steve Zinkle)
  - Covered in later presentations
- Why is the APEX facility floor plan shown in the APIEC Alternatives Analysis Report Draft H (Figure 15) different than what is shown in the presentation? (Jeff Terry)

  NO ACTION – The presentation depicts the PIE LIB as it was envisioned. The report depicts changes made for using the previous PIE LIB as a benchmark for the APEX facility and comparisons to the other alternatives. It should also be noted that the APEX facility, if recommended as the preferred alternative and constructed, will not necessarily look like the PIE LIB preconceptual design.
- In case we need additional space in the hot cells in the future, can two cells be combined? (Jeff Terry)
  - Yes – the plan is to design for modularity.
- Results of a gap analysis would be useful for the SRC to review
  - No formal gap analysis was completed. However, elements of a gap analysis can be found in the Mission Need Statement (MNS) and reports from the national and international workshops.
- Page 7 of the alternatives analysis report states, "The APIEC scope does not include examination/characterization of pre-irradiation or conditioned specimens. The APIEC scope also excludes other PIE capabilities such as those used for non-destructive examination (NDE), chemical, isotopic, and radiological analyses or any method involving sample dissolution (i.e., wet chemistry)."
  - Is there a reason for this exclusion (e.g., DOE orders)? It is difficult to perform science based examinations if samples in the pre-irradiated condition are not examined using the same equipment that is used to examine the irradiated samples. Also, these other PIE capabilities mentioned have been very useful in confirming the results from new techniques and can be costly and difficult to obtain at other locations. (Ken Geelhood)

    The APIEC scope is focused on post-irradiation examination and requires remotization of this specialized equipment. That equipment could also be used to examine specimens that have not been irradiated but there are other instruments with less overhead costs that could perform that function. Conditioned (i.e., irradiated to achieve a certain condition before subjecting the experiment to more irradiation such as a transient test) fuel or material would be a likely candidate for the APIEC and is not meant to be excluded from the potential scope.
- A key justification for the added capabilities is that the issues that impede both evolutionary and revolutionary advancements in nuclear fuel will be helped by the APIEC. Current commercial LWRs aren't the primary customers of the APIEC, but they would certainly want to use such a facility since their options are severely limited in the U.S. For cladding and structural fuel assembly components, hydrogen and irradiation creep and growth (and their

synergies) and transient behavior (LOCA, RIA and Beyond DBA) are issues that need advanced techniques. For UO2 fuels, they need to better understand additives and transient behavior (especially fuel fragmentation). For materials, fatigue testing w/ aggressive environments, careful grain boundary and metal/oxide interface studies, and weld residual stress analyses are needed. These things were not mentioned in the Mission Need Statement but maybe they're there and you're well past that point with the CD-0 (if that's the right terminology) decision. (Erik Mader)

- Shielded cask receiving/unpacking/packing is listed as a support and infrastructure function in the APIEC scope. Shielded cask shipping should be included as well. It may be necessary to conduct some PIE measurements elsewhere no matter how good the facility. Shipping should be included in other pertinent areas of the document (Jeff Terry)

  ACTION – Shielded cask shipping is included for the types of casks identified in the report. The same hot cell is used for both the receiving and shipping functions. The next update will clarify that this function is included in the capability scope.

APIEC Assumptions Comments

- A comprehensive advanced PIE capability does not exist (Steve Zinkle)

  True

- Are any instruments in alpha-confined hot cells? (Mike Cappiello)

  Each instrument in the shielded cells is in an inert confinement enclosure (ICE) (glovebox) that will provide alpha containment. Non-shielded instruments may be installed in ICEs as well, depending on the types of specimens to be examined.

- How hard have we looked at what is absolutely needed for a comprehensive advanced PIE capability versus what is desired for a comprehensive capability? (Steve Zinkle)
  - Would expect to see a graded approach
  - For purposes of comparison, workshops have provided us a reasonable basis for a benchmark
  - Real tradeoffs will occur during conceptual design (Andrew Griffith)
  - ACTION: Prepare a brief summary of how design specifications were gleaned from the workshops.

  A discussion regarding the types and numbers of instruments that would be desired to provide the APIEC has been added to this report.

- Why isn't NEUP or ATR NSUF listed under major programs using APIEC? Student support is needed to gain university support. (Jeff Terry)

  University Programs were included in the list of major programs using APIEC (Jeff Bryan)

- What about including industry input on licensing and new fuel design? (Ken Geelhood)

- The approximate area needed for final prepared sample/specimen storage and archive is shown as 250 ft2 – this seems low for archiving (Jeff Terry)

  This will be considered during conceptual design.

- Should archival storage be farmed out or should it be the responsibility of one site?

  This has not been evaluated. It will be considered during conceptual design.

- Should minimum shielding values held in the case of remote operations? (Jeff Terry)

Comments on APIEC Alternatives

New Facility Alternative Comments

- Was the Material Test Station at LANL taken into account? (Andrew Griffith)

  No.

- For the option of building a new facility at INL, why not place the new facility next to ATR? (Erik Mader)

  Co-location with HFEF is more advantageous than co-location with ATR because there will be many more shipments from HFEF to APEX than from ATR to HFEF. Furthermore, the HFEF-APEX collocation will facilitate the interaction between the NDE and the advanced PIE activities.

- Why can't you duplicate IMCL as an alternative? (Mike Cappiello)

  A duplicate of IMCL would not provide all the capacity or the capabilities needed for APIEC.

- Do most of experiments coming out of ATR have to go to HFEF? (Erik Mader)

  Not all but most experiments (Steve Hayes). Note that experiments less that 24 inches in length could go directly to APIEC.

- Are goals tied to TREAT? (Mike Cappiello)

  Not at this time. If the transient test capability project alternatives analysis determines that restart of TREAT is the preferred alternative, that will be factored into the design.

- A DOT certified container/cask must be used on public roads

  True.

- If ACRR is selected for transient testing, would that change identification or selection of alternatives? (Andrew Griffith)

  – Are we missing a sub-alternative?

  At the request of the SRC, the hot cells at ACRR were evaluated for potential use within APIEC Alternatives 2 and 3. Based on information received from Dr. Billy Martin from SNL, the INL team determined that the Hot Cell Facility would have enough space for one examination cell (i.e., after allocation of hot cell space for cask receiving, sample prep, storage and waste packaging). With respect to the consolidated Alternative 3, the ACRR does not provide enough space for three instrument cells which are required to make it a viable candidate in that alternative. Thus, similar to the PNNL and SRNL facilities, ACRR must be excluded from consideration there.

  From the perspective of the distributed Alternative 2, several criteria were analyzed for the addition of another (i.e., sixth) location and, for these criteria (logistics and cost related), six locations underperformed five locations. The team believes adding a six location to the distributed alternative adds complexity and does not favorably improve that alternative. The team suggests that a follow-on evaluation be performed, if Alternative 2 is the recommended alternative, to determine if the ACRR should replace PNNL or SRNL in the APIEC system to be designed.

- Was any thought given to how easy it would be to build a new facility in different locations (e.g., is the political climate more favorable for building a new PIE facility in some states/areas better than others)? (Ken Geelhood)

  Political considerations were not addressed.

- Shipping should also be considered as part of the shielded cask receiving/unpacking/packing hot cell. Even a single facility will likely need to send samples elsewhere for some PIE. (Jeff Terry)

  Shipping costs are addressed in the transportation costs.

- In reference to Section 2.4.4.6, Sample Archival and Waste Disposition, an example was given for Idaho. What about other states? (Jeff Terry)

  To our knowledge, Idaho is the only state that has a general agreement with the DOE regarding the quantities and types of fuels that can be stored. As noted in the text of the report, disposal or storage at other sites will have to be addressed on a case-by-case basis.

- In reference to Section 2.4.4.8, NSUF Considerations, it is unclear if co-location of APEX with any of the ATR NSUF partners is an actual benefit. The reasons that it would be beneficial should be spelled out. Most users will not spend significant time at the reactor during irradiation. There is likely to be a cool down time between irradiation and PIE, anyway. (Jeff Terry)

- Also in reference to Section 2.4.4.8, a single, dedicated facility could mitigate many of the access issues for students but only if access was designed in from the start. This is a major issue and needs to be spelled out. (Jeff Terry)

  We agree that this is an important consideration. Accessibility will be addressed in the F&ORs.

- In reference to Section 2.4.4.10, Funding Implications, there are some significant staffing issues that need to be considered. There would be significant localization of skilled personnel at this facility. This could lead to the withering of expertise at the facilities that are not chosen to host APEX. This may be balanced out by increased university participation in Advanced PIE but should not be discounted. (Jeff Terry)

  This should be considered when scoring Goal 1.

Modifying Existing DOE Facilities – Distributed Alternative Comments

- Was HFEF (and other hot cell facilities at other labs) considered as part of this option? (Steve Zinkle)
  - Availability concerns
  - Doesn't meet requirements
  - Should we specify in the report why this was eliminated for further consideration?
  - Is there available hot cell space that can be slightly reconfigured for use as part of the distributed capability?

  Based on the INL team's familiarity with HFEF, it was not considered a viable option for housing the examination instruments. Regarding other sites, the team considered a representative sample of the available cells and contacted personnel at each site. There may be other cells available but it is not likely that use of other cells would significantly affect the results.

- Could another option include ATR NSUF hub for preparing samples and then spokes go out to other facilities? (Steve Zinkle)
  - This would be a hub and spoke option where there is centralized sample prep and distributed examination (Jeff Terry)
  - ACTION: Evaluate whether a "hub and spoke" concept for sample prep would benefit the distributed alternative (Bill Landman)

  A hub-and-spoke approach for sample preparation would reduce the overall cost of the distributed alternative by about $6M (for sample preparation equipment). However, these savings would be more than offset by the cost of shipping and rework that could be expected.
- How were distributed options downselected (e.g., why were HFEF and ACRR eliminated)? (Ken Geelhood)
  - Downselection was based on availability and other decision criteria

  Based on the INL team's familiarity with HFEF, it was not considered a viable option for housing the examination instruments. Regarding other sites, the team considered a representative sample of the available cells and contacted personnel at each site. There may be other cells available but it is not likely that use of other cells would significantly affect the results.

- Is there no funding for fully populating IMCL? (Mike Cappiello)
- What was IMCL total cost? (Mike Cappiello)
  - IMCL was within GPP limits
- In Table 4 of the APIEC Alternatives Analysis Report, the desired states set the benchmark high enough that only one alternative appears to be viable. We need to reevaluate whether the square footage specified is truly an accurate number/benchmark. (Mike Cappiello, Andrew Griffith, Steve Zinkle)

  Additional discussion has been added to the report to provide the basis for the required number of cells. The preconceptual design was reviewed by a number of experts and was deemed to be a reasonable design so the required areas are deemed to be reasonable.
- Has permission been received to consider repurposing hot cells at the various sites? (Jeff Terry)

  Yes, discussions with site personnel indicated that these cells could be considered in developing the alternatives.
- Schedule is a big concern, especially for commercial customers, so is there a criterion that evaluates the time it takes to get from one facility to another? (Erik Mader)

  That time is considered in the "Time to Receive data" criterion.
- A downside to setting aside hot cell space for APIEC purposes is that if the hot cells are not being used they will likely be repurposed (Ken Geelhood)

  True.
- This project should justify/verify that current hot cells are not available for APIEC purposes, e.g., the hot cells at Sandia National Laboratories' Annular Core Research Reactor (ACRR) (Mike Cappiello/Andrew Griffith)

  - ACTION: Determine whether the ACRR hot cells at SNL can be included in the distributed alternative and include justification in the alternatives analysis report if they are not included.

  At the request of the SRC, the hot cells at ACRR were evaluated for potential use within APIEC Alternatives 2 and 3. Based on information received from Dr. Billy Martin from SNL, the INL team determined that the Hot Cell Facility would have enough space for one examination cell (i.e., after allocation of hot cell space for cask receiving, sample prep, storage and waste packaging). With respect to the consolidated Alternative 3, the ACRR does not provide enough space for three instrument cells which are required to make it a viable candidate in that alternative. Thus, similar to the PNNL and SRNL facilities, ACRR must be excluded from consideration there.

  From the perspective of the distributed Alternative 2, several criteria were analyzed for the addition of another (i.e., sixth) location and, for these criteria (logistics and cost related), six locations underperformed five locations. The team believes adding a six location to the distributed alternative adds complexity and does not favorably improve that alternative. The team suggests that a follow-on evaluation be performed, if Alternative 2 is the recommended alternative, to determine if the ACRR should replace PNNL or SRNL in the APIEC system to be designed.

- Will the facilities selected for APIEC be required to hire people to support the assigned work? (Jeff Terry)

  It is likely that some additional personnel will be needed but it is hard to predict so far in the future.

- In reference to the assumption that each of the advanced PIE instruments will be housed within a shielded cell, or non-shielded space, will be unique; if multiple techniques are available at each facility they should be grouped into similar probes so the workers have similar skill sets. It would not make sense for spectroscopy to be paired with tomography, for example. Too divergent. (Jeff Terry)

  The grouping of instruments will be considered during the Conceptual Design. The assumption of unique instruments will be maintained for the Alternatives Analysis.

- In the second paragraph of Section 2.4.2.5, APIEC Process Flow, it is stated that distribution of the APIEC instruments characterization type or other strategy might help minimize the total number of shipments required, but that such analysis is beyond the scope of the alternatives analysis effort. However, beyond shipping it plays a personnel role as well. I am not sure that it can be ignored in this analysis. Poor choice of allocated techniques among the facilities could lead to excess competition for workers with the same skill set. This should be avoided. (Jeff Terry)

  The distribution of instruments will be evaluated in more detail in the Conceptual Design. There is not enough information to allow a realistic initial distribution of specific instruments or a schedule for shipping samples to those facilities for this analysis. Assignment of specific instruments to various facilities will not be attempted.

- In reference to Section 2.4.2.9, Information and Material Security and Protection, by utilizing hot cells in existing facilities, it clearly makes it difficult if not impossible to bring in students who are foreign nationals. This makes it very difficult for universities to make use of these facilities. (Jeff Terry)

True. The intent is that these types of issues should be considered when scoring the alternatives.

Modifying Existing DOE Facilities – Consolidated Alternative Comments

- What is DOE's thought on consolidation? (Jeff Terry)
  - DOE has no overall policy – we are looking at what will work best for the application and do not endorse any one site. NE wants a good, rational analysis for either distributing or consolidating. It is not a foregone conclusion that the capability will be located at the INL. (Andrew Griffith)
- In the second paragraph of Section 2.4.3.5, APIEC Process Flow, it is stated that distribution of the APIEC instruments characterization type or other strategy might help minimize the total number of shipments required, but that such analysis is beyond the scope of the alternatives analysis effort. The personnel implications of this analysis again suggests that this analysis should at a minimum state that similar techniques should be grouped at the facilities unless it is specifically decided that the knowledge base should be spread around. (Jeff Terry)

  See previous resolution regarding section 2.4.2.5
- As with the Distributed Alternative, the use of shared, pre-existing facilities will likely lead to significant difficulties for student access. (Jeff Terry)

  True, see previous resolution.

Commercial Partnership Alternative Comments

- What is the typical commercial charge rate? (Jeff Terry)
  - Probably cheaper than national laboratories (Erik Mader)
- Can charge rate be collected from commercial entities in order to compare this alternative to others? (Andrew Griffith)

  We were not able to obtain estimates for examinations from the commercial suppliers.
- Porter Hill noted that some commercial entities said they would use the advanced PIE capabilities but not if these capabilities were located at a competitor's facility (this may be showstopper)
  - Commercial entities will want to protect their intellectual property but this will be on a case-by-case basis and this should not be an all or nothing option (Erik Mader, Ken Geelhood)
- This option will first need to be compared against the go/no go requirements and it appears there may not be enough cells available to make this a viable alternative (Jeff Bryan)
- The commercial alternative combined with the international alternative may meet the go/no go requirements (Andrew Griffith)
  - ACTION: Evaluate a whether a hybrid alternative of commercial/international would meet the go/no go requirements. (Jeff Bryan)

  During Workshop 1, a hybrid of alternatives 5 and 6 was proposed in order to keep a "buy" alternative available for comparison in the alternatives analysis. This was necessary because alternative 5 and alternative 6 would likely be screened out during evaluation of those alternatives against the screening (i.e., go/no go) requirements. Alternative 5 did not appear

to meet the required minimum number of shielded instrument cells and Alternative 6 did not appear to support the intended programmatic customer set. Thus, a hybrid between alternatives 5 and 6 to achieve both the minimum number of shielded instrument cells and provide a location where certain customers (e.g., U.S. Navy) could have their PIE work performed by U.S. nationals only was evaluated.

Relevant to this alternative is the assumption regarding limited or no duplication of PIE instruments within the set of APIEC shielded instrument cells. Thus, certain customers who cannot allow foreign nationals to have access to their material or design information would not have the full suite of APIEC instruments available for their research.

Also relevant is a comment made by SRC member Erik Mader of EPRI, regarding the identified commercial entities (i.e., B&W, GNF, Westinghouse) getting out of the irradiated fuel examination business. This would effectively limit the scope of samples for certain customers (e.g., DoD, U.S. Navy) to only irradiated materials and, considering the instrument allocation discussed above, limit the results to a subset of the full APIEC suite of analyses.

Based on the discussion above and the identified limitations, the reduced scope and limited set of analyses for certain customers fail to meet the intended performance objectives for the main programs to be supported by the APIEC. Thus, this hybrid alternative would not satisfy the mission for the APIEC. This hybrid, like the alternatives from which it is comprised, must be screened out and does not need to be considered relative to the other evaluation criteria.

- What about equipment with this option? Would we need to supply it? (Erik Mader)

  Determination of who supplies the equipment (DOE government furnished equipment or supplier be the commercial entity) would be addressed in the development of the contractual requirements.

- The potential issue of indemnification would need to be resolved upfront (Erik Mader)

  True.

- If the market grows beyond what we envision, commercial entities may decide to get back into the fuel marker

  True but we cannot make that assumption at this time.

- Could this alternative by combined with other alternatives? (Erik Mader)

  – Yes, we could have hybrid alternatives

- With regards to the Global Nuclear Fuels (GNF) Facility, the floor plan including radiochemistry should not be discounted for APEX. It is not clear that having radiochemistry onsite would be a problematic. It would likely be beneficial. (Jeff Terry)

  True.

- Regarding the Westinghouse hot cells, it is stated the cells cannot be dedicated solely for the use of any single customer, but can be made available to support DOE on an as-needed basis. Why consider an already full facility? (Jeff Terry)

  There is no commercial facility that has empty cells.

- Regarding Information and Material Security Protection, and concerns regarding access to proprietary information and intellectual property, students still need some hands-on access to equipment. (Jeff Terry)

This will be identified in the F&ORs.

International Partnerships Alternative Comments

- Was the list of international PIE capabilities distributed? (Ken Geelhood)
  - This can be found in PLN-4187, Section 7.7., page 35
- Comments on the international options selected
  - There were probably more than eight international candidates, but is the basis for downselecting to eight international options, and then four options at three facilities documented? (Andrew Griffith)
  - It would be valuable to list the eight international PIE facilities identified in the MNS as well as provide some justification for the downselecting to three facilities. Also, is there a reason that the three selected facilities are all European facilities? For example, KAERI has quite extensive hot cell capabilities. (Ken Geelhood)
  - The eight international options came from the mission need statement but is this documented? It is probably important to document the basis. (Steve Zinkle)
  - Will need to point back to the importance and goal of maintaining world leading capabilities when thinking about the international options

  Additional discussion was added to the report to address the first three bullets.

  The scoring of the first goal should address the concerns in bullet 4.
- From the commercial perspective, they have had good experience with timeliness and cost effectiveness of using international capabilities (Ken Geelhood)
- Are any U.S. national laboratories able to provide the services provided by Studsvik? (Andrew Griffith)
- For clarification, Studsvik can provide cost effective and timely PIE and waste disposal because they have focused on a specific category of PIE work, namely LWR fuels. Having them do PIE research work on advanced fuels would be considerably more difficult. (paraphrased, Steve Hayes)
- You could identify that the fact that Studsvik can dispose of the waste in Sweden is very favorable to the NSUF as you have stated earlier that universities will have a very difficult time accepting waste back from a PIE facility. (Ken Geelhood)
- We should assume a fuel disposal plan is in place for all the DOE alternatives

No Action Alternative Comments

- Consider an additional alternative as part of "no action" or as part of the distributed alternative - could be a project within GPP limits that populates IMCL with already existing equipment and instruments (Steve Zinkle)
  - Could be a 1a no action alternative

    The No Action alternative description has been updated to reflect using IMCL.
- Add IMCL to list of facilities considered for this option

  Done.
- Should we quantify opportunity cost for no action alternative? (Jeff Bryan)

  - Don't have proof that science-based approach is cheaper (Steve Zinkle)
  - Could be a useful approach but difficult to get a handle on cost savings
  - It may be more like "will existing capabilities provide us the information we need?" – can we meet mission with no action? (Andrew Griffith)
  - SRC members thought it would not be practical to do cost estimate

  No resolution required.

- Is this for current LWRs or for Gen IV type reactors? (Jeff Terry)
  - All of the above
- For non-shielded instrument spaces, exceptions are made to the requirement for the equivalent of 12 inches steel walls. An exception should also be made for remote operation as well. (Jeff Terry)

  The exception is implied in the fact that the instrument is not shielded.
- It should be noted that almost all of the existing facilities have exceeded the planned 40 year life of the APIEC facility. (Jeff Terry)

  That is true but the requirement in the T&FRs is 40 years.
- In Section 2.4.1.5, APIEC Process Flow, the statement, "Other mismatches or capability shortfalls create the need for workarounds and/or case-by-case experiment processing," raises a very important issue and should be given more attention than one sentence. (Jeff Terry)

  The problems with the No Action alternative are well understood.
- In reference to the second paragraph in Section 2.4.1.6, Sample Archival and Waste Disposition Considerations, archival storage is critical to make the best use of the expensive irradiation whether performed under operational condition in a LWR or at a test reactor. It is critical to have an archival storage location. (Jeff Terry)

  Archival storage requirements will be addressed in more detail during the development of the F&ORs.
- In reference to Section 2.4.1.7, Partnering Arrangements, duplication of capability is far too costly. In addition, competition, while burdensome, certainly does provide some useful benefits. It should not be removed entirely. (Jeff Terry)

  True.
- In reference to Section 2.4.1.8, NSUF Considerations, access controls must be dealt with to allow students access to the PIE capability. Many students will be foreign nationals unless something changes drastically in the near future. (Jeff Terry)

  Access controls will be addressed in the next version of the F&ORs.
- In reference to the last sentence in Section 2.4.1.9, Information and Material Security and Protection, if the APIEC program is to be of benefit to U.S. Universities, something must be done to ensure access to foreign nationals or alternately drive U.S. students to the NE fields. (Jeff Terry)

  Access controls will be addressed in the next version of the F&ORs.

Comments on Goals and Requirements

General Comments

- The term "outlays" is not clear – consider changing this term to be more descriptive (Andrew Griffith)

  Term changed per later discussion.

- Strong correlation between Goals 4 and 5 – make distinction more clear

  Goals were combined per later discussion.

- Consider clarity of terminology

  Goals and criteria were revised.

- Are maximize and minimize the right terminology to use?

  We believe so.

- Does minimize safety and health risks belong as a separate goal or should it be part of design requirements?

  Changed to a higher level goal of minimizing risks.

- A possible go/no-go requirement Erik frequently encounters with doing PIE work at various facilities around the world is the ability to sign a contract. This exercise is DOE-focused and it is doubtful that would be a hurdle within the DOE family. But for the commercial industry the ability to sign a contract is paramount. The issues that often kill an option are indemnification, limits of liability and insurance. You may want to consider that for the Alternatives that go outside of DOE facilities. EPRI and INL/DOE have not been able to sign a standard contract since Erik starting at EPRI in 2006 due to these issues. CRADA's have been used but those really aren't appropriate for many projects. It may be different if DOE spends money at a commercial facility but it's something to investigate. (Erik Mader)

Goal 1 and Requirements Comments

Goal 1: Maximize Accomplishment of DOE-NE Mission Objectives

Requirement 1: Supports advanced PIE to enable science-based approach

Requirement 2: Supports advanced PIE needs for the four main programs

Requirement 3: Acceptable to the full user community

- Should we add/highlight education mission? (Mike Cappiello)

  Education mission is included in the change adding NSUF.

- Clarify what we mean by "accomplishment of DOE-NE mission objectives"

  Description of goal was revised per later SRC comments.

- The underlined portion of the statement "Goal 1 evaluates the ability of the alternative to provide the advanced PIE capabilities that will be needed for a science-based approach to develop new nuclear fuels and materials and to support a variety of programs," is clearly the necessary goal (Jeff Terry)

- Requirement 1 – Supports advanced PIE to enable science-based approach
  - Is the ability to routinely collect data at the 10^{-9} to 10^{-10} meter resolution scale in addition to the meso-scale measurements currently performed on irradiated material?

There may be some specific capabilities in the international community but it is not routinely performed in the U.S.

- Requirement 3 – Acceptable to full user community
  - How do we define the requirement, "acceptable to full user community?" This requirement could cause issues if we get an off-the-wall user. (Steve Zinkle)

    For the purposes of this analysis, the user community is the programs that have been identified. No "off-the-wall" users will be considered.
  - Should this requirement be "accessibility" versus "acceptability" (Mike Cappiello)

    Accessibility is included in the acceptability of the alternative.
  - Reword/clarify "acceptable to full user community" or change criteria
  - Consider changing to "maximize user community acceptability"

    This is a requirement, maximize is typically used with goals or criteria.
  - Strike this requirement (Jeff Terry)

    Disagree that acceptability to the full user community can be deleted.
- Pages 3 to 5 of the alternatives analysis report (Draft H) describe the requirements for elimination of dust, noise, and vibration, the desire to collect data on the 10^{-9} to 10^{-10} m scale, and the requirements of six hot cells for micro-structural/mechanical examinations, one hot cell for thermal instruments, and four spaces for non-shielded instruments, but no indication of what these instruments might be or what information would be measured by these instruments. Would it be possible to include discussion of what instruments will be needed and/or what quantities will be measured with these instruments? (Ken Geelhood)

  Additional discussion regarding the basis for the instruments has been provided in the report.

Goal 2 and Requirements Comments

Goal 2: Maximize Access, Usability, and Maintainability

Requirement 1: Satisfies minimum number of examination and support spaces

Requirement 2: Hot cell access for routine maintenance

- Modify Requirement 2, Hot cell access for routine maintenance (Steve Zinkle, Jeff Terry, et al)
  - For example: Must maintain serviceability of "delicate" instruments (would typically require human interface but not in all cases)
  - Most equipment will be serviced by vendors
  - Must be serviceable in place

  We believe the discussion is adequate as-is. The discussion states that hands-on activities will be required and that access is provided. Furthermore, a specific requirement is stated that work can proceed in one cell without impacting operations in adjacent cells.

Goal 3 Comments

Goal 3: Maximize APIEC Shielded Instrument Space Reconfigurability

No requirements identified

- Surprised to not see some set of minimal requirements, e.g., conditioned space (Steve Zinkle)

  - Assumed all facilities could be upgraded but should have a requirement

    This requirement was implicitly applied in developing the alternatives.

  - Add a requirement that instrument cell must be bigger than 6'x10'(H)

    This requirement would eliminate PDC1 and PDC2 at PNNL. Rather than eliminate these cells, their sizes should be considered in when scoring the "hot cell size and footprint" criterion.

- Consider adding requirements for this criterion, for example: (Ken Geelhood)
  - Easy large equipment access in and out of hot cells
  - Cells shielded from neighboring cells
  - Cranes available to move equipment
  - Required high voltage, cooling, and HVAC in place with appropriate feed throughs

  The above are excellent design requirements and were considered in developing the cell designs. They do not need to be added as specific requirements in the analysis.

- The introductory statement to Goal 3 says the APIEC is expected to operate for 40 years – is the 40 year lifetime reasonable? Are there any nuclear facilities that have been retired after 40 years? Can this be expanded with minimal effort? (Jeff Terry)

  Nuclear facilities quite often have very long life-times but the requirements for this facility have been set at 40 years.

Goal 4 Comments

Goal 4: Minimize R&D Program Outlays

No requirements identified

- Two different types of storage – short-term while experiment is underway and long-term archival storage
- Clarify this is a cost to the USER
  - Consider changing to "Minimize programmatic user costs"
- Consider combining Goal 4 and Goal 5 (Minimize APIEC Outlays) into one goal, "Minimize total life cycle cost"
- Consider adding requirements for this criterion, for example: (Ken Geelhood)
  - Criticality concerns covered for anticipated material shipments
  - Waste disposal pathway predetermined
  - Receiving plans in place

Goal 5 Comments

Goal 5: Minimize APIEC Outlays

No requirements identified

- Consider combining with Goal 4 (All)
- Consider adding requirements for this criterion, for example: (Ken Geelhood)

  - Fully designed
  - No scope creep
  - All federal state and local paperwork in place

Goal 6 (Minimize Safety and Health Risks) Comments

Goal 6: Minimize Safety and Health Risks

Requirement 1: Complies all applicable regulations and orders

- Use ALARA terminology

  The requirement to comply with DOE Orders implies that 10 CFR 835 must be complied with.

Goal Weights

- Why is weight for Goal 1, Maximize Accomplishment of DOE NE Mission Objectives, so low?
  - See alternatives analysis report, Section 2.5.1
    - Accomplishment of DOE NE Mission should not be a big discriminator because the alternatives were designed to provide reasonably equivalent technical performance
  - This goals has the potential for being a bigger discriminator and should be more heavily weighted (Steve Zinkle)
  - Doesn't look right optically to see a weighting of only 10% on meeting the mission
  - Could separate each mission area and make into individual criteria
  - Once you clear the Goal 1 requirements bar, then by how much is the bar cleared? Seems like there should be additional criteria related to this goal.

  Goal 1 was completely revised based on later discussions.

Comments on Criteria

Criteria for Goal 1, Maximize Accomplishment of DOE NE Mission Objectives

Criterion 1: Ability to protect information and material

Criterion 2: Develop, integrate, and retain knowledge capital

- Add a new criteria associated with delivery of validation data to modelers/researchers (Steve Zinkle)

  We have a criterion for "time to receive data".

- Consider moving the criterion, "Ability to Protect Information and Material" to Goal 6, "Minimize Safety and Health Risks"

  Goal 5 and 6 were combined per SRC recommendations.

- Once you clear the bar, then how well do you clear the bar? In addition to a requirement, should also have a criterion related to supporting the DOE mission. (Steve Zinkle)

  Goal 1 was completely revised based on later discussions.

Criteria for Goal 2, Maximize Access, Usability and Maintainability

Criterion 1: Researcher access impediments

Criterion 2: Logistics (type and complexity of initial radioactive material transfers)

Criterion 3: Intra-APIEC transportation mechanism (or complexity)

Criterion 4: Hot cells support routine instrument maintenance

Criterion 5: PIE material storage and waste disposition

- More facilities should equate to additional complexity
- Researcher access impediments is definitely a valid criterion
  - Access control will be key for University use of the facility. Without easy access for students, the University NE community who may view it as competition for scarce resources from which they see no benefit. Goal 2 weight should be higher. (Jeff Terry)
- Is the second criterion (Logistics) double-dipping?
  - No, this is a separate criteria and a big deal (Jeff Terry, Erik Mader, et al)
  - Big user headaches with packaging, etc.

Criteria for Goal 3, Maximize APIEC Shielded Instrument Space Reconfigurability

Criterion 1: Hot cell size and footprint

Criterion 2: Exterior equipment space availability

Criterion 3: Feature relocatability

Criterion 4: Cell radiological contamination status

Criterion 5: Equipment ingress and egress (equipment change-out)

- No comments

Criteria for Goal 4, Minimize R&D Program Outlays

Criterion 1: Cost of Advanced PIE

Criterion 2: Time to receive data

Criterion 3: Risk to data acquisition

- Criterion 1, Cost of Advanced PIE

This criterion has been replaced with three cost measures.

  - Transportation costs are the least of our concerns but still need to be included (Ken Geelhood)

    A measure of the expected transportation costs has been developed.

  - Transportation alone is not the primary factor – don't expect it to be the primary discriminator as is stated in the criterion description
  - As stated in the description, "…evaluates the cost to the Programs…" should be modified to state "…evaluates the cost to DOE…"
  - Will need to evaluate by cost of "paying by the drink"
  - Improve metrics for capturing costs
  - Assumption: lab-to-lab costs are approximately equivalent
  - Address differences in operations costs
    - Between international, commercial, labs

        - Assume same operational costs between labs?

- Time to receive data criterion
    - Time factors could include history of site shutdowns – probability of cell being unavailable could be part of risk analysis (Ken Geelhood)
        - Craft language to take into account facility availability

    A criterion for "impact of a facility shutdown" was added per SRC suggestions.

- It was noted that past performance is no guarantee of future performance

  True.

- Consider adding a new criterion for potential facility shutdown impacts

  Criterion added.

Criteria for Goal 5, Minimize APIEC Project Outlays

Criterion 1: Initial capital cost of providing the APIEC

Criterion 2: Operating, maintenance, and refurbishment costs

Criterion 3: Time to construct capabilities

- No comments.

Criteria for Goal 6, Minimize Safety and Health Risks

Criterion 1: Risk to Public

Criterion 2: Risk to Workers

- Take into account ALARA

  ALARA, like other DOE requirements are assumed to apply and be complied with. As noted in the criteria discussion, transportation and handling will be used as the metrics for scoring these criteria.

- Take into consideration planned as well as accidental dose

  Without specific designs, there is no way to address planned dose. The planned doses are assumed to be equal and all facilities will comply with ALARA requirements.

General Comments on Criteria

- The criteria and weights seem very heavily biased to give a large score to a single site co-located or close to a reactor. 43% of the total score is based on number of handling events and distance of transportation. (Ken Geelhood)

  Agreement has been reached on the definitions and weights for the criteria.

- It is important to stress the importance of the expertise of the facility's researchers (more than Research Access Impediments). Having fabulous equipment in the hands of inexperienced people often raises more questions than the data answers. I think the single facility is better suited to maintain expertise and it should be factored into the equation so that it's given its just due. (Erik Mader)

- Some of the considerations for criterion seem overly simplified. For example: (Ken Geelhood)

- Goal 2, Criterion 1: rather than just base this on the number of sites, each site should be examined to determine the ease of access of various individuals (DOE employees and contractors, US citizens, Foreign Nationals) to each site. For example, DOE office of science sites may have easier access than weapons labs.
- Goal 4, Criterion 1: You state that the only discriminator is the transportation costs. However it is known that each of the DOE and private labs in the analysis has different charge out rates for their scientists and technicians. These differences will likely be the largest difference in cost.
- Goal 4, Criterion 2: Perhaps a better metric of time to receive data would be historical data on analysis time and number of recent stop work orders for the lab in question.
- Goal 6, Criteria 1 and 2. Maybe the distance traveled and number of handling events should be combined with the probability of accidental release based on recent site specific information.
- How were the criteria for each goal selected? It may be prudent for the SRC to review these criteria and determine if these are the best criteria for evaluating the stated goals.

The criteria have been reviewed by the SRC.

Additional Comments

- No need for Cat-2 facility for items f) and g) on instrument list (Steve Zinkle)
  - Keep these in mind when looking at alternatives – could use Butler-type buildings to examine these (e.g., TEM)
- Combine workshop comments with written comments already provided by SRC members
- Use Studsvik as model when looking at alternatives (gets the data needed for NRC licensing, cost effective, disposal pathway)
- What should we assume happens with residuals for each alternative? May need input from SRC. Or do we even need to do this?
- APIEC Process Flow
  - The lack of a prequalified acceptance policy for irradiated nuclear fuel (SNF/UNF) strongly argues against a multi-site collaborative virtual laboratory. There must be some guidelines for guaranteed acceptance for a virtual laboratory to be successful. (Jeff Terry)
- Returns of fuel samples and fuel waste to their owners are a major concern for the U.S. universities since they are not well equipped to store these items upon their return. (Jeff Terry)
- While advanced PIE is clearly warranted, it is surprising the alternatives analysis document did not make a stronger case for science based reactor stewardship. Each of the paths forward with the exception of the No Action plan requires significant capital outlay. Recommend spelling out the reasons that a scientific understanding of irradiation effects justifies this outlay. It would also be useful to have some ballpark cost estimates of the different alternatives. (Jeff Terry)
- Cost estimate discussion
  - The stand alone facility used as a benchmark was a very rigorous estimate

  - Probably won't be spending up to $395K but $200M is a fairly good estimate for what we have done so far
  - All things depend on how much funding is available
  - Using IMCL as a basis, the cost to build a new facility and add equipment is approximately $ 45M for new 30,000ft2 facility (just using this info as basis for comparison)

Closing Remarks and Comments

- The SRC has recommend we look at link between science-based approach and APIEC – that can be used to translate requirements for instruments, space requirements, etc.
- Mission need statement document helped – had some gap analysis information
- All information is there – just needs to be articulated by project
- We think no action alternative needs to add IMCL so can add that distinction to the no action
- Jeff Terry would like to get list of capabilities from other European facilities. Would be nice to know what capabilities exist and how far behind we are in some of these areas.
- Personnel development – needs to be some criteria on personnel expertise and staffing and how that is affected by this activity – always have a paragraph of importance of people
  - This facility will build this technical expertise
  - Could be a driver for a standalone facility
  - Didn't see any areas for control space – needs to be designed in from the beginning and this alone could almost justify building a new facility
- We are slogging along with current capabilities
- We need to use a graded approach – the reference case was more of the Christmas list of capabilities. Unlikely that will have equipment and need everything in one bay. May not be reasonable approach for reference condition. Some equipment/instruments do not belong in hot cell facilities. Greatest question is where these should be located. For example, close to town vs. site. Small advantage being close to source material versus other advantages. (Steve Zinkle)
- Underlying question: Is less than 7 the right number of hot cells? It seems like 7 is the bare minimum. Do we need to evaluate alternatives that give us less than 7 cells?
- Would be useful to summarize (approximately less than 2 pages) the working assumptions for how this facility will operate and the heavy users – would like to see reference list of assumptions to get to where we made a decision that this is the footprint we need to be world class
- Discussion on weights
  - Cost is still highest weighted goal
  - May not be appropriate to make cost an overwhelming discriminator during option screening
  - Will round to nearest integer on weights
- Path Forward

  - Beef up tie between science-based approach to space requirements
  - Next meeting likely in September (probably virtual) – will send out scores and then decide on date.
  - Will need to beef up optic.
- Other alternatives we will consider
  - 1a alternative for IMCL (part of no action)
  - 5/6 hybrid? Keeps a "buy" alternative
    - Kemal thinks that need to use capabilities internationally that we do not intend on duplicating – sheer science – no reason for us to build this capability
    - Hybrid needs to be more further defined
    - Beam lines exist but cannot put irradiated materials into those lines as they exist today.
- The APIE capability would give us global leadership so it is highly valuable for us to have invested our time in this workshop (Andrew/Kemal)

Additional SRC Comments

Comments on the APIEC Workshop
Mike Cappiello, member of Stakeholder Review Committee

General

The project is following the process outlined in DOE order 413 for establishing a new capability for advanced post irradiation examination. Part of that process dictates a comprehensive analysis of reasonable alternatives. It is obvious that the project is doing adequate job in this area, applying an appropriate level of diligence and gathering stakeholder input. Specific comments and recommendations were given to the project during the course of the workshop, and incorporated by the project in real time. Some of the major comments and recommendations are summarized below:

Alternatives

The alternatives the project has chosen to analyze seem to represent a reasonable set. However, with respect to the no action alternative, it is recommended to add the IMCL facility as it will be available within the next year. Also, the project needs to provide some justification why the SNL-ACRR hot-cells were taken off the alternatives list. DOE-NE spent several million dollars refurbishing the cells for the isotope production mission but then dropped the project. They may be available for use.

Functional Requirements Definition

A strong link exists between “science based approach” data needs and the capabilities of the APIE. This can then be translated in to the instruments that we need, and the environmental and the square footage requirements. The mission need statement document contains some information related to this issue. It is recommended that the project articulate the link more completely to better justify the need for new capabilities. To further demonstrate this link, you may want to define two or more initial experiments to provide examples of how the various instruments would be used to provide the data we need for meso-scale and nano-scale science. This will also help the modelers define better what data they really need.

Goals and the Go/No-go Requirements

The goal related to meeting the mission objectives has several go/no-go requirements. Likewise the goal on access and usability, and the safety/health risks must be met as a go/no-go discriminator. Another approach for the project to consider for the alternative analysis is to perform the go/no-go requirement screening up front on the various alternatives, and then for the remaining alternatives perform the goal and criteria analysis. If this is done, then the goal on meeting the mission could be changed so that it related to the development and preservation of knowledge.

With respect to the other goals, it is recommended to combine the two outlay goals into one.

Revised Goals and Criteria

The goals and criteria that were developed by the APIEC team were reviewed with the SRC. Some of the goals were redefined and some criteria were added, revised and/or collected under a different goal. The resulting goals and criteria are shown in Figure A-1.

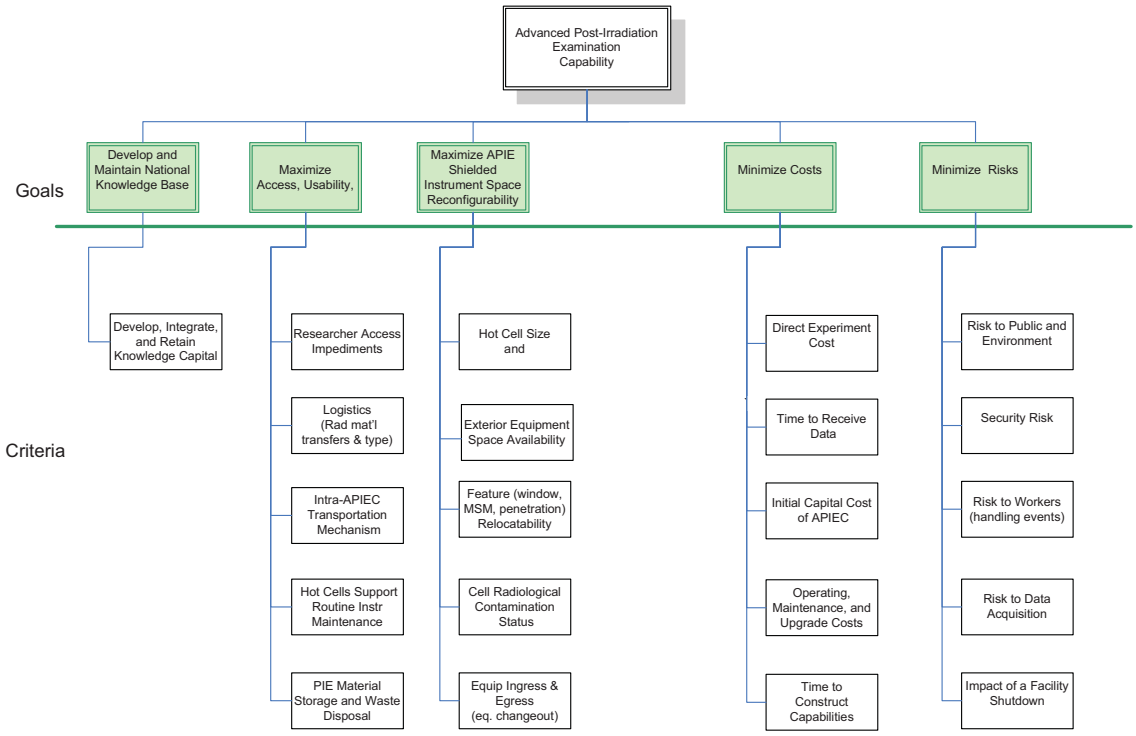


Figure A-1. Goals and evaluation criteria as revised in Workshop 1

After the goal and criteria were agreed upon, the members of the SRC were asked to individually assign weights to the goals and criteria. As shown in Table A-1, both the goal and criteria weights varied from SRC member to SRC member but the agreement between the SRC members was generally good. These individually assigned goal and criteria weights were multiplied to obtain individual computed criteria weights. The average values of the individual computed criteria weights were then calculated. These average values of the computed criteria weights were considered to be more representative of the intent of the SRC members and were used to "back-fit" a set of goal and criteria weights. The adjusted (revised) goal weights were rounded to the nearest 5 to the average goal weights and the total of the goals was still 100%. The adjusted criteria weights were set to integers such that the computed weights of the adjusted goals and criteria were as close as possible to the average computed criteria weights calculated from the SRC input and the sum of criteria under a given goal was 100%. The results are shown in Table A-2.

The adjusted weights to be used in the scoring of the alternatives are shown in Figure A-2.

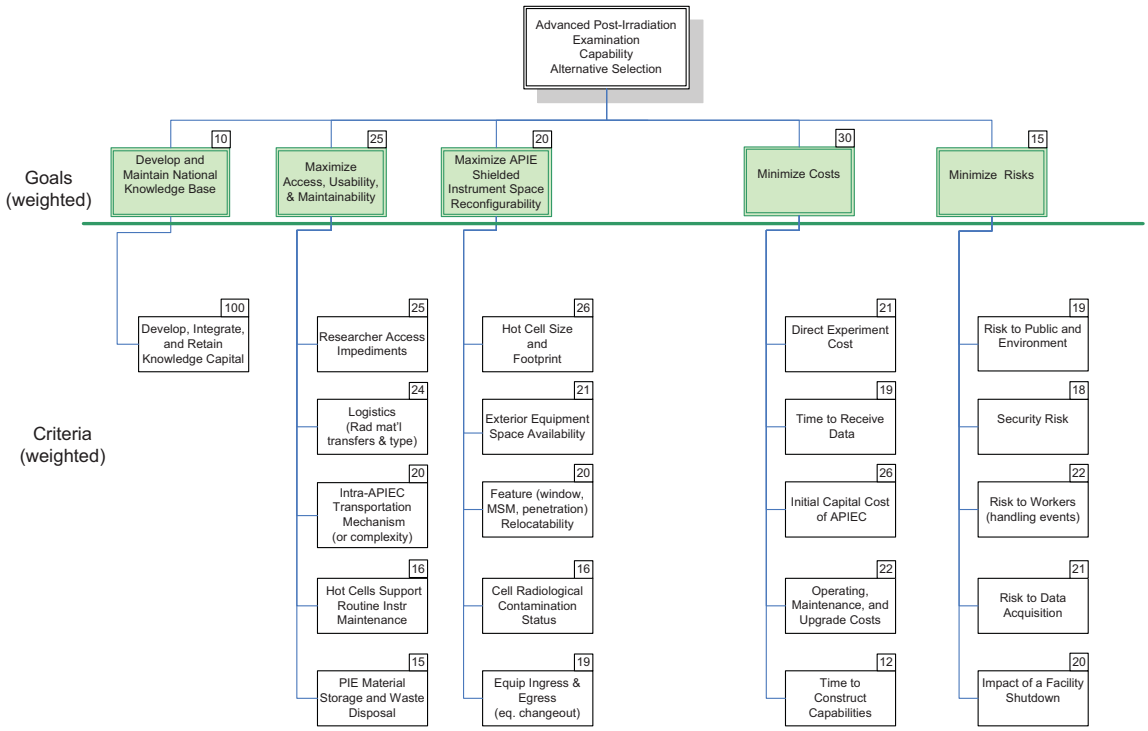


Figure A-2. Weighted goals and evaluation criteria

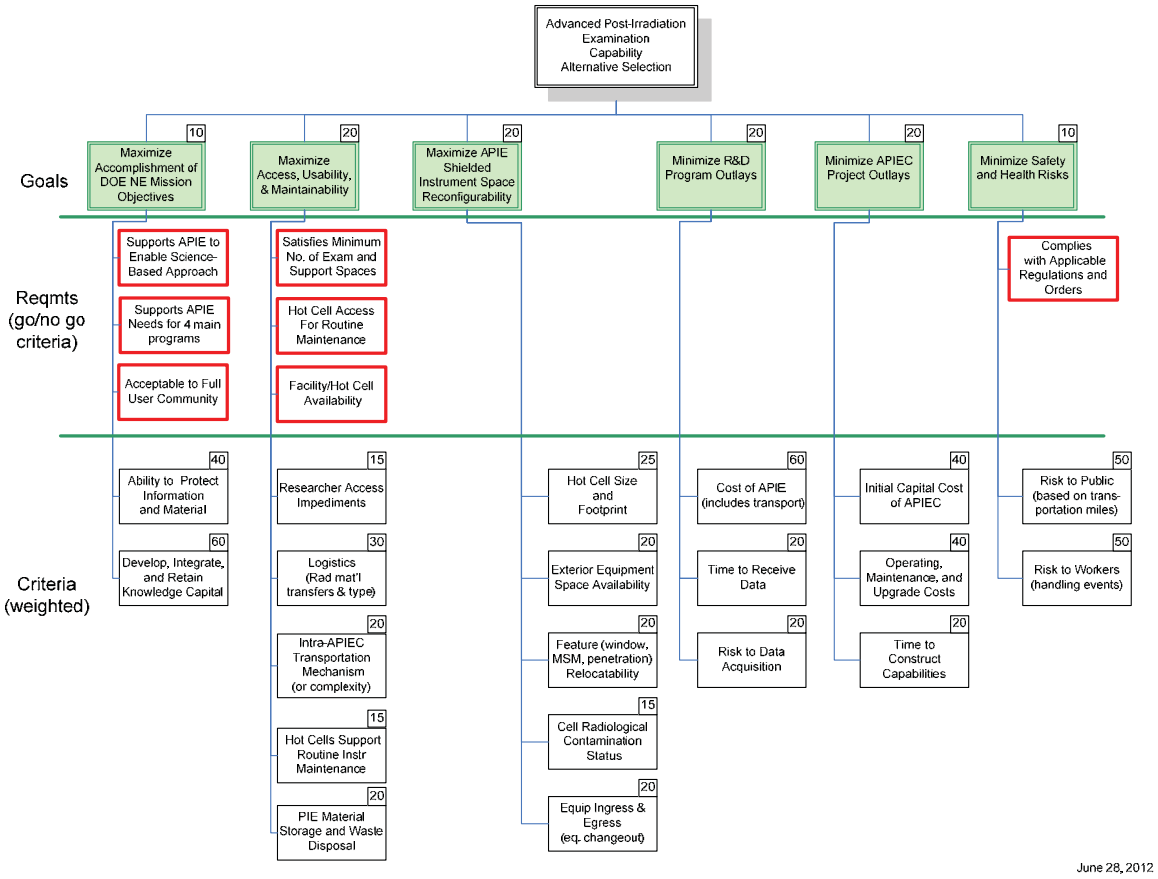


Figure A-3. Original Goals and Criteria (prior to workshop)

Table A-1. Individual SRC Scores

		SRC Member Goal and Criteria Weights						
		Ken G	**Andy G**	**Mike C**	**Steve Z**	**Jeff T**	**Erik M**	**Mitch M**
Goal 1	Develop and Maintain National Knowledge Base	5	15	15	10	10	15	10
	Develop, Integrate, and Retain Knowledge Capital	100	100	100	100	100	100	100
Goal 2	Maximize Access, Usability, and Maintainability	25	20	25	25	26	25	30
	Researcher Access Impediments	28	30	20	20	57	10	15
	Logistics (Rad material transfers and types)	27	20	25	25	8	30	30
	Intra- APIEC Transportation Mechanism	15	20	25	20	8	30	20
	Hot Cells Support, Routine Instrument Maintenance	15	15	15	20	19	15	15
	PIE Material Storage and Waste Disposal	15	15	15	15	8	15	20
Goal 3	Maximize APIEC Shielded Instrument Space Reconfigurability	20	15	25	20	15	20	20
	Hot Cell Size and Footprint	20	25	20	25	46	30	25
	Exterior Equipment Space Availability	20	20	20	20	33	20	20
	Feature (window, MSM, penetration) Relocatability)	20	15	20	20	7	20	20
	Cell Radiological Contamination Status	20	20	20	15	7	10	15
	Equip Ingress and Egress	20	20	20	20	7	20	20
Goal 4	Minimize Costs	30	35	20	30	31	30	25
	Direct Experiment Cost	30	15	20	15	22	25	25
	Time to Receive data	20	15	30	10	23	25	15
	Initial capital cost	20	30	20	35	22	25	25
	Operating Maintenance and Upgrade costs	20	20	10	30	23	20	25
	time to construct capabilities	10	20	20	10	10	5	10
Goal 5	Minimize Risks	20	15	15	15	18	10	15
	Risk to public and environment	5	20	25	25	17	20	30
	security risk	20	20	20	10	17	20	10
	risk to workers	5	25	20	40	17	25	30
	risk to data acquisition	35	20	20	5	22	25	20
	impact of a facility shut down	35	15	15	20	27	10	10

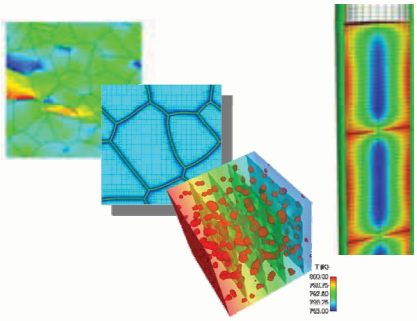
Table A-2. Adjusted Goals and Weights

		Average Goal Weights	Average Individual Computed Criteria	Adjusted Goal Weights	Adjusted Criterion Weights	Adjusted Computed Criteria Weights	Difference (avg-adj) avg
Goal 1	Develop and Maintain National Knowledge Base	11.43		10			-13%
	Develop, Integrate, and Retain Knowledge Capital		11.43		100	10	-13%
Goal 2	Maximize Access, Usability, and Maintainability	25.14		25			-1%
	Researcher Access Impediments		6.43		25	6.25	-3%
	Logistics (Rad material transfers and types)		5.96		24	6	1%
	Intra- APIEC Transportation Mechanism		4.93		20	5	1%
	Hot Cells Support, Routine Instrument Maintenance		4.11		16	4	-3%
	PIE Material Storage and Waste Disposal		3.71		15	3.75	1%
Goal 3	Maximize APIEC Shielded Instrument Space Reconfigurability	19.29		20			4%
	Hot Cell Size and Footprint		5.11		26	5.2	2%
	Exterior Equipment Space Availability		4.14		21	4.2	1%
	Feature (window, MSM, penetration) Relocatability)		3.46		18	3.6	4%
	Cell Radiological Contamination Status		3.00		16	3.2	7%
	Equip Ingress and Egress		3.57		19	3.8	6%
Goal 4	Minimize Costs	28.71		30			4%
	Direct Experiment Cost		6.21		21	6.3	1%
	Time to Receive data		5.50		19	5.7	4%
	Initial capital cost		7.39		26	7.8	6%
	Operating Maintenance and Upgrade costs		6.18		22	6.6	7%
	time to construct capabilities		3.43		12	3.6	5%
Goal 5	Minimize Risks	15.43		15			-3%
	Risk to public and environment		3.00		19	2.85	-5%
	security risk		2.57		18	2.7	5%
	risk to workers		3.39		22	3.3	-3%
	risk to data acquisition		3.32		21	3.15	-5%
	impact of a facility shut down		3.14		20	3	-5%

APIEC Workshop 1 Welcome

Kemal Pasamehmetoglu
Associate Laboratory Director
Nuclear Science & Technology

July 24, 2012

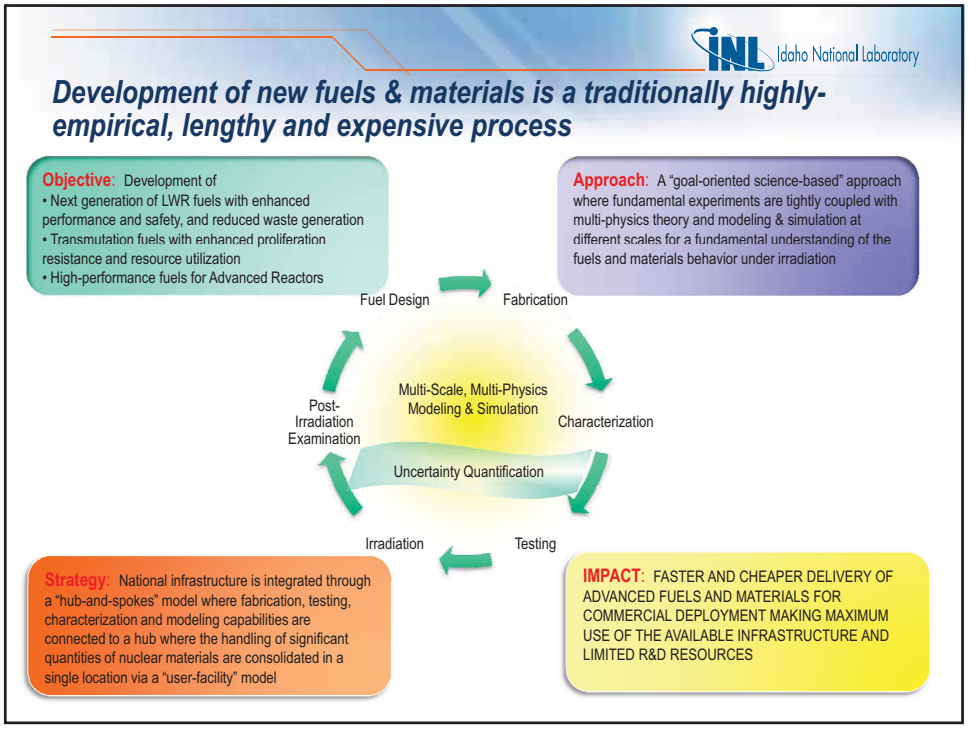


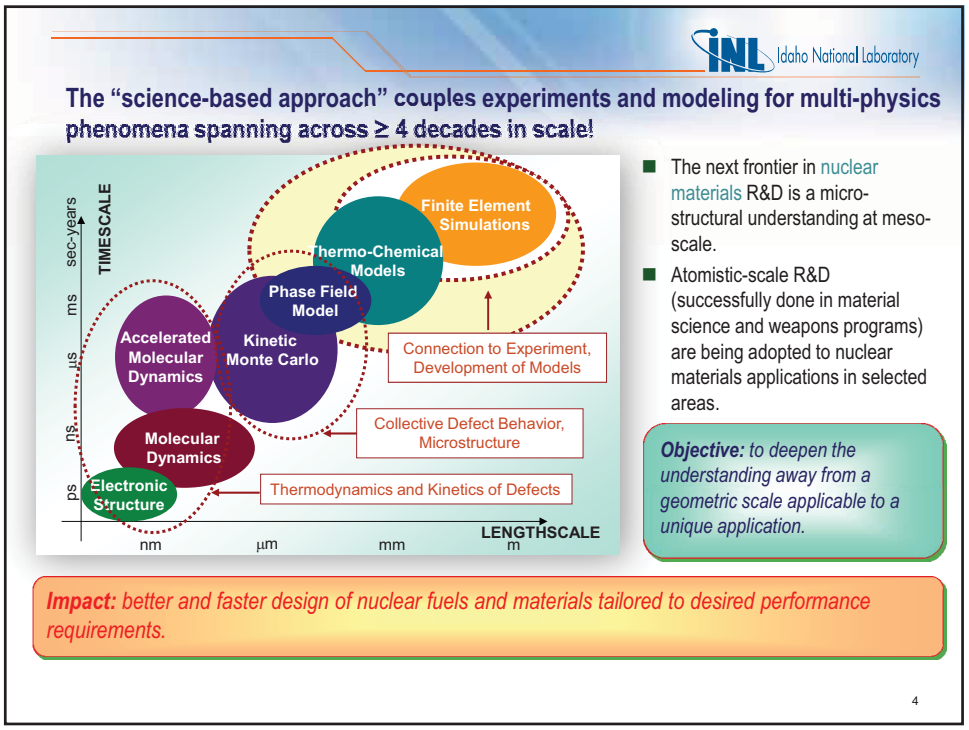
www.inl.gov

Idaho National Laboratory

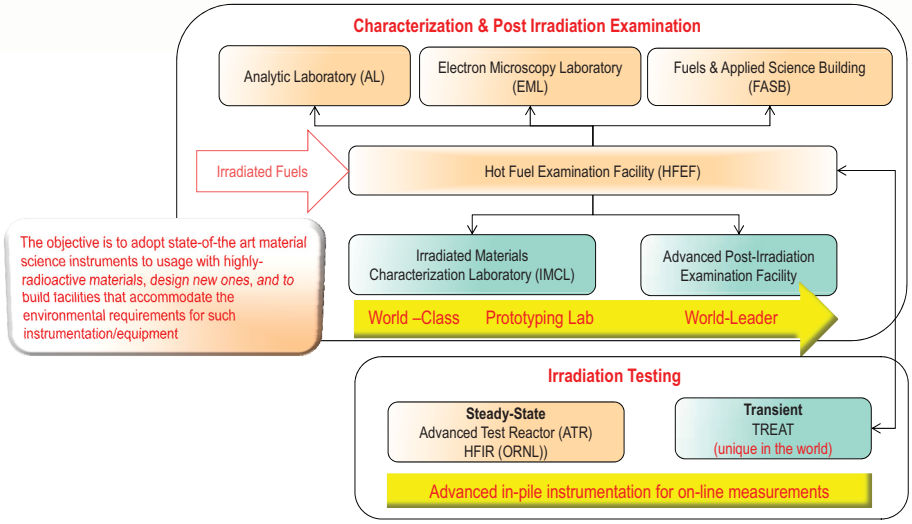
Introductions

Idaho National Laboratory


Idaho National Laboratory
Development of new fuels & materials is a traditionally highly-empirical, lengthy and expensive process
Objective: Development of
• Next generation of LWR fuels with enhanced performance and safety, and reduced waste generation
• Transmutation fuels with enhanced proliferation resistance and resource utilization
• High-performance fuels for Advanced Reactors
Approach: A "goal-oriented science-based" approach where fundamental experiments are tightly coupled with multi-physics theory and modeling & simulation at different scales for a fundamental understanding of the fuels and materials behavior under irradiation
Fuel Design
Fabrication
Characterization
Testing
Irradiation
Post-Irradiation Examination
Multi-Scale, Multi-Physics Modeling & Simulation
Uncertainty Quantification
Strategy: National infrastructure is integrated through a "hub-and-spokes" model where fabrication, testing, characterization and modeling capabilities are connected to a hub where the handling of significant quantities of nuclear materials are consolidated in a single location via a "user-facility" model
IMPACT: FASTER AND CHEAPER DELIVERY OF ADVANCED FUELS AND MATERIALS FOR COMMERCIAL DEPLOYMENT MAKING MAXIMUM USE OF THE AVAILABLE INFRASTRUCTURE AND LIMITED R&D RESOURCES


Idaho National Laboratory
The "science-based approach" couples experiments and modeling for multi-physics phenomena spanning across ≥ 4 decades in scale!
TIMESCALE
sec-years
ms
µs
ns
ps
LENGTHSCALE
nm
µm
mm
m
Finite Element Simulations
Thermo-Chemical Models
Phase Field Model
Accelerated Molecular Dynamics
Kinetic Monte Carlo
Molecular Dynamics
Electronic Structure
Connection to Experiment, Development of Models
Collective Defect Behavior, Microstructure
Thermodynamics and Kinetics of Defects
The next frontier in nuclear materials R&D is a micro-structural understanding at meso-scale.
Atomistic-scale R&D (successfully done in material science and weapons programs) are being adopted to nuclear materials applications in selected areas.
Objective: to deepen the understanding away from a geometric scale applicable to a unique application.
Impact: better and faster design of nuclear fuels and materials tailored to desired performance requirements.
4

To achieve DOE's objectives, INL's strategy is to fill in the capability gap consolidating the handling of significant quantities of nuclear materials, investing into state-of-the art equipment and facilities while making maximum use of existing National assets



Purpose of Workshops

- The purpose of the workshop is to solicit input from the Stakeholder Review Committee (SRC) to ensure goals, requirements, criteria, and weights are going to provide DOE with the necessary information to make an informed decision on how to fulfill the advanced PIE need
- Capability needs to be available to safely and efficiently accomplish DOE's mission for at least the next 40 years
- Capability needs to maximize accomplishment of DOE mission objectives
  - Logistically simple and affordable to use
- Instruments need to be easily maintainable
- Capability needs to be flexible, so that it can house modern instruments as new characterization capabilities evolve
- Capability has to be within DOE-NE budget to implement

6

Stakeholder Review Committee Charter

- SRC provides broad-based review on output products of the process to ensure a quality alternatives analysis is performed that will provide an adequate and definitive basis for preferred alternative identification
- Ensure that the analysis provides an adequate and definitive basis for identification of a preferred alternative
- The input of this SRC is important to provide DOE and congress the assurance that the right decision is being made for the nation's nuclear energy program
- Focus of this first meeting is to:
  - Present and discuss the alternatives for APIEC
  - Comment on APIEC goals and requirements
  - Comment on scoring criteria and weighting

7

Stakeholder Review Committee Charter

- The SRC consists of members from Industry, U.S. Universities and National Laboratories, International Organizations, and the Department of Energy
- International representative has not been filled yet but we expect to obtain involvement

8

Idaho National Laboratory

Questions?

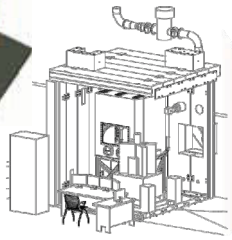
Idaho National Laboratory

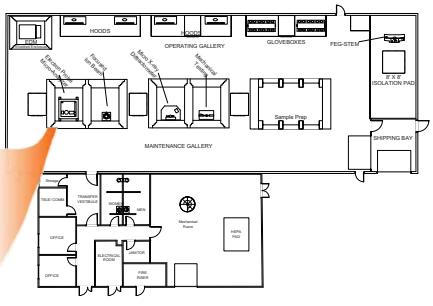
Irradiated Materials Characterization Laboratory (IMCL)

- Hazard category 2 nuclear facility
- Co-location of FIB/EPMA/MXRD/TEM
- Purpose built facility (vibration/temperature/electromagnetic)
- Ability to prototype and gain experience in operation of advanced equipment and techniques in shielded cells
- Radiation/Contamination engineering controls (gloveboxes, shielding, transfer casks)
- Shielding/glovebox configuration allows for routine manned entry to support maintenance on sensitive equipment

Artist's Rendition

Artist's Rendition





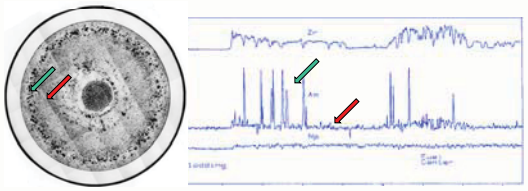
Advanced Post Irradiation Examination Capabilities Alternative Analysis and Project Overview

M.W. "Mike" Patterson
Project Manager
Advanced PIE Capabilities Project

July 24, 2012

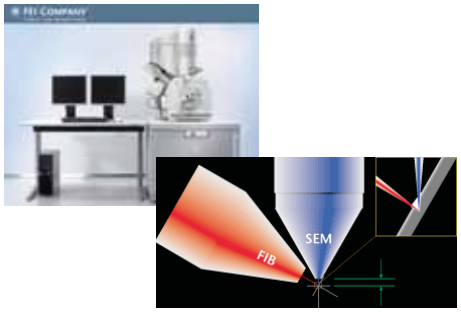
www.inl.gov

Idaho National Laboratory



Objectives:

- National: improve understanding of nuclear fuels and materials in a nuclear environment to develop better fuels and materials
- Project: establish advanced (world-class) post-irradiation exam (PIE) capabilities to enable science-based research
- Alternatives Analysis: select preferred approach, from a range of options, to establish advanced PIE capabilities
- Workshop #1: review option descriptions and get input on the goals, requirements, criteria and weights by which the preferred option is chosen



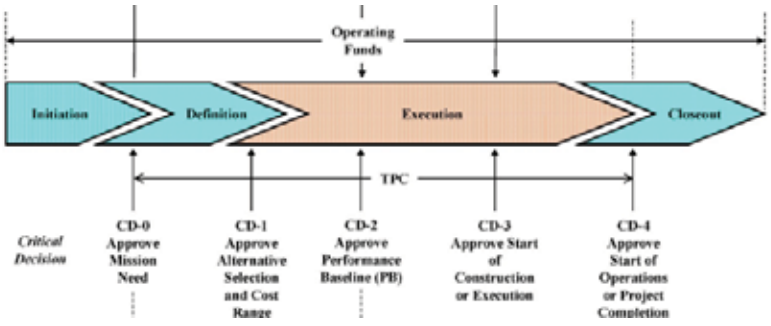
Advanced PIE Capabilities Project - Background

- < 2010: multiple programs identified varied needs for improved characterization capabilities, compiled in various documents
- 2010: mission need statement (MNS) developed and submitted:
  - Six alternatives identified for further evaluation
  - MNS planning is based on pre-conceptual design of single facility
  - Identifies "…advice [from] a body of independent experts to ensure a reasonable range of alternatives are sufficiently considered…" to benefit alternatives analysis
- January 2011: Critical Decision 0 (CD-0) – Approve Mission Need – approved by Assistant Secretary for NE (no funding identified)
- 2011: national and international workshops further define needs
- February 2012: INL authorized to commence activities toward CD-1

3

Advanced PIE Capabilities Project - DOE O 413.3B Capital Asset Project in the Definition Phase:

- Based on size, type and purpose.
- Project Definition consists of:
  - Alternatives Analysis, followed by
  - Conceptual Design of preferred alternative



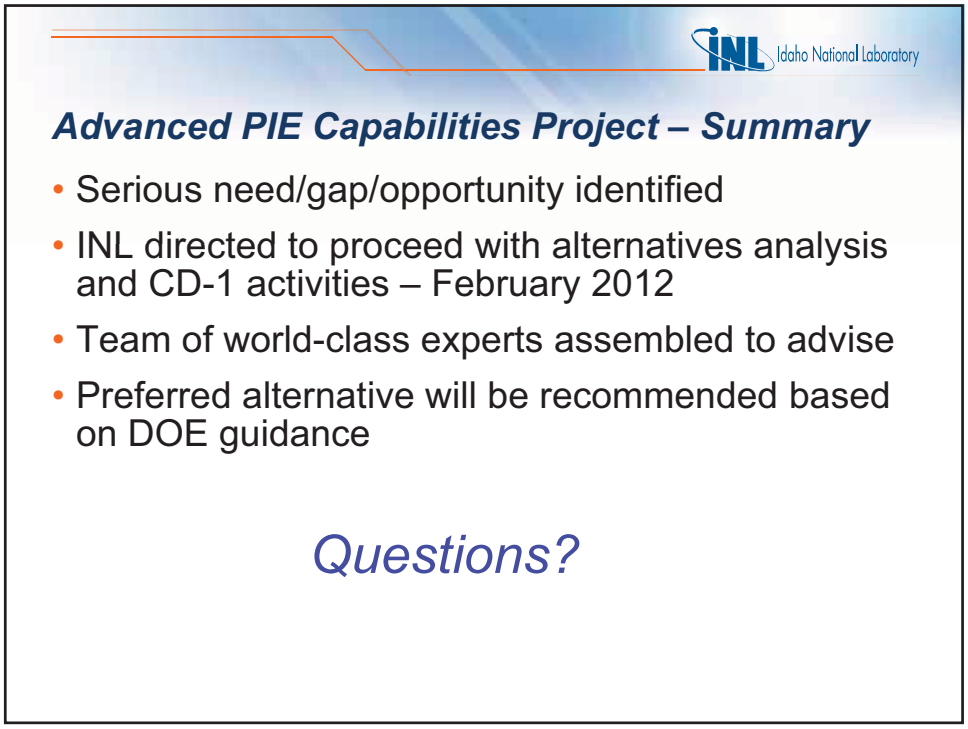
4

Preliminary Functional and Operational Requirements (F&ORs) - Summarized

- Function - provide location(s) for advanced instrumentation with:
  - Flexible and reconfigurable shielded enclosures
  - Stringent vibration, electrical and magnetic field, acoustic isolation
  - Exacting temperature controls
  - Flexible and streamlined workflow
  - Data collection suitable for validating advanced modeling and simulation
  - Interim specimen storage
- Classified as a Hazard Category 2 nuclear facility
- Located to optimize adjacent facilities for initial receipt, sizing, handling and preparation
- Observant of ES&H, Safeguards & Security, relevant codes, etc.
- Provides needed infrastructure to support capability

Path Forward - Short Term

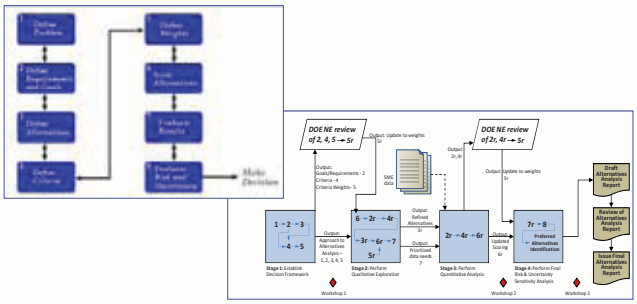
- Recommend preferred alternative based on three workshops:
  - Workshop #1 (this one): review option descriptions, goals, requirements, criteria, weights
  - Workshop #2 (virtual): review scoring
  - Workshop #3 (virtual): review analyses and comment resolution
  - Submit preferred alternative recommendation (best value to the government) - December 2012
- Initiate conceptual design of preferred alternative – FY2013
- Overview of Workshop #1 Agenda:
  - Overview of decision framework
  - Description of alternatives - collect comments
  - Goals and requirements – collect comments
  - Criteria and weights – collect comments


INL Idaho National Laboratory
Advanced PIE Capabilities Project – Summary
• Serious need/gap/opportunity identified
• INL directed to proceed with alternatives analysis and CD-1 activities – February 2012
• Team of world-class experts assembled to advise
• Preferred alternative will be recommended based on DOE guidance
Questions?

APIEC Alternatives Analysis Overview

Jeff Bryan

July 24, 2012



www.inl.gov

Idaho National Laboratory

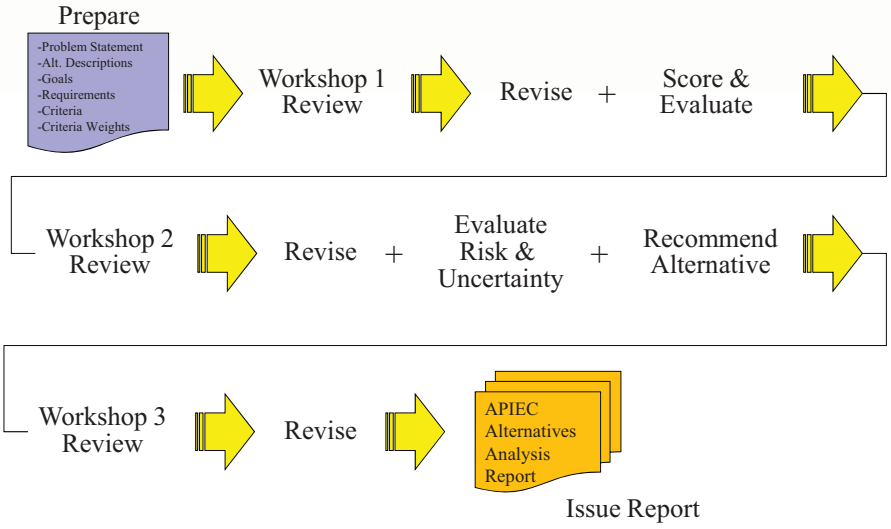
Topics

- Problem Statement
- Overview of APIEC Alternatives Analysis Process
- List of Alternatives
- Expectations for this Workshop

Problem Statement
(paraphrased)

- Current DOE PIE capabilities are located in 30 to 50-year-old hot cell facilities that are not designed for modern-day research tools and instruments.
- These tools and instruments require facility spaces with attributes and flexibility to accommodate their unique set of sensitivities (e.g., vibration isolation, tight temperature control, and maintenance needs).
- Thus, existing PIE capabilities are unable to adequately characterize high dose rate nuclear fuels and materials at the resolution (i.e., nano-scale and finer) necessary to accomplish NE's mission objectives.
- The desired state will be achieved when a suitable nuclear facility environment has been established for advanced PIE that includes:
  - An initial suite of modern tools and instruments
  - Attributes supporting optimal instrument performance
  - Flexibility to accommodate installation and operation of new, cutting-edge PIE instruments for the next 40 years.

Overview of APIEC Alternatives Analysis



List of Alternatives

1. No action
2. Modify existing facilities distributed across the DOE complex
3. Modify existing facilities within the DOE complex, but consolidate capabilities at one or two laboratories
4. Construct a modern research facility to support advanced PIE capabilities
5. Establish partnerships or contractual arrangements with commercial laboratories to establish advanced PIE capabilities
6. Leverage international partnerships to use advanced PIE capabilities located around the world.

Expectations for this Workshop

For APIEC Project Team

- Keep an open mind, listen, and capture all SRC comments / constructive criticism
- Be "honest brokers" focused on making the best recommendation for DOE & Nuclear Industry

For SRC Members

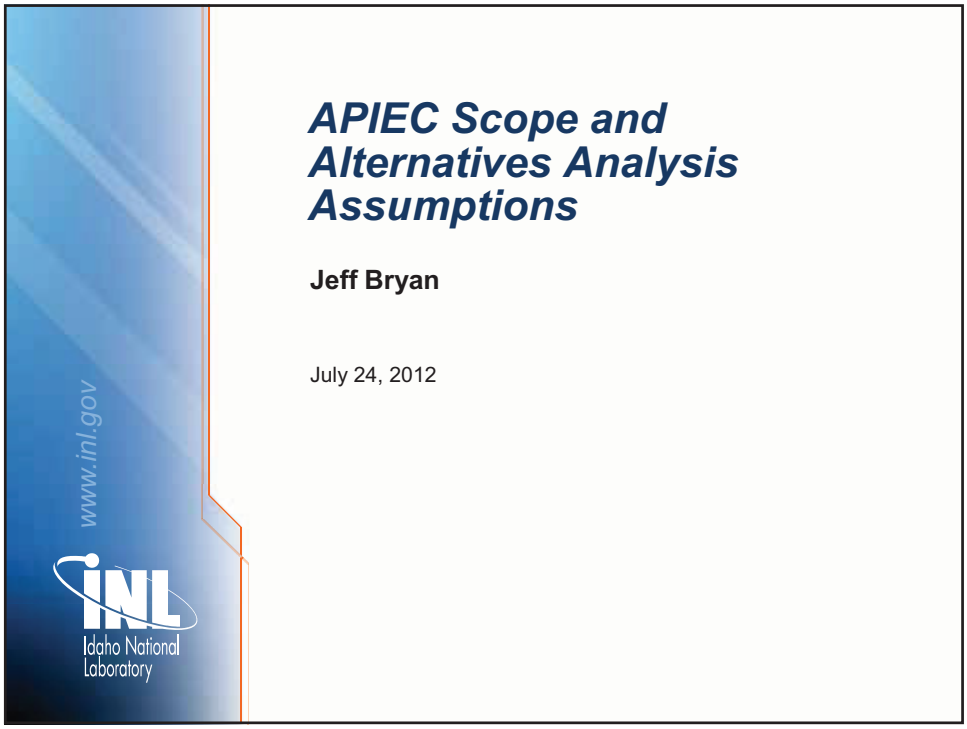
- Represent a typical user from your sector or perspective
- Provide constructive input toward improving the quality of the APIEC decision process

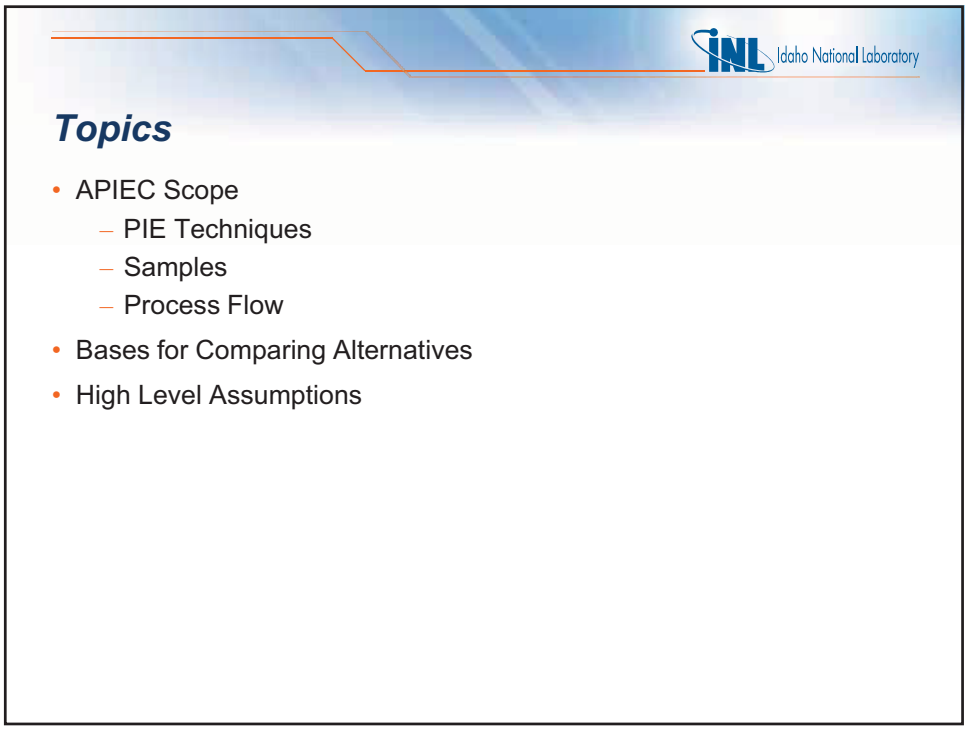
- Preferred Comments:
  - Identify improvements (e.g., better ways to define alternative or better measures for evaluating alternatives' value)
  - Identify inaccuracies/inconsistencies/errors
  - Identify omissions/missed opportunities
  - Identify risks/problems
- Types of comments to avoid
  - Editorial comments on the report
  - Assessment/evaluation of alternatives (we're not there yet)

Expectations for this Workshop – General Flow

- Written Comments
  - Will be accepted at any time during the workshop
  - Please specify to what section of the report (or to which presentation) they are applicable
  - Can be hardcopy or electronic (email to jeffrey.bryan@inl.gov)
- Presentation
  - Informal - so ask questions (caveat - facilitator may need to interrupt discussion to keep overall workshop on track)
  - Facilitators will record comments/remarks as we proceed
- Review Period
  - Ask additional questions
  - Make additional comments/remarks
  - Facilitators will review comments/remarks to ensure accuracy and understanding

Questions?


APIEC Scope and Alternatives Analysis Assumptions
Jeff Bryan
July 24, 2012
www.inl.gov
INL
Idaho National Laboratory


INL Idaho National Laboratory
Topics
• APIEC Scope
– PIE Techniques
– Samples
– Process Flow
• Bases for Comparing Alternatives
• High Level Assumptions

APIEC Scope

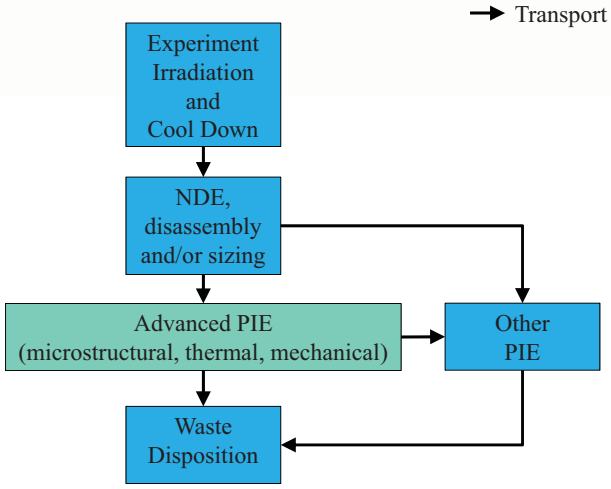
- PIE Functions

Included:	Not Included:
• Micro-/Nano-structure	• NDE
• Thermal Properties	• Chemical/Elemental
• Mechanical Properties (specific)	• Radiological/Isotopic
• Micro-/nano-hardness	• Aqueous
• Nano-indenter	

- Sample Types (size reduced to < 2 ft, as applicable, prior to APIEC receipt)
  - Nuclear Materials
    - Core components (e.g., structural)
    - Cladding materials
  - Nuclear Fuels
    - Fuel only (e.g., TRISO particles, pellets, plate; metals, sodium-bonded, oxides, ceramic, actinide)
    - Clad fuels (e.g., pebbles, pins, rodlets, rods)

APIEC Scope

- Process Flow (simplified)



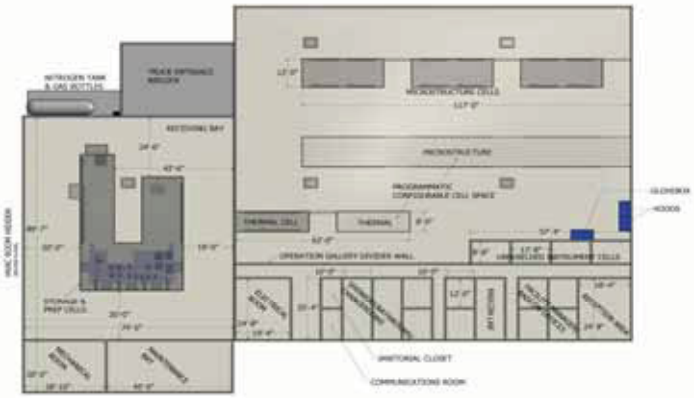
Bases for Comparing Alternatives

- To the extent practical, create a level playing field for comparisons
- PIE instrument generic; Rationale:
  - Expectation of similar performance regardless of installed location (after facility modifications, if allowed)
  - Placeholders for now, actual selection to occur during preliminary design
  - Instruments are continuing to evolve/improve—what is selected 2 – 3 yrs hence could differ
- Alternatives (and constituent facilities) must address all major APIEC functions – other ancillary support functions are assumed available and will not be discriminators
  - Sample receiving (i.e., specific casks, at a minimum)
  - Sample/specimen storage and archive
  - Sample/specimen preparation
  - Waste processing/packaging
  - Shielded exam cells
  - Non-shielded exam spaces

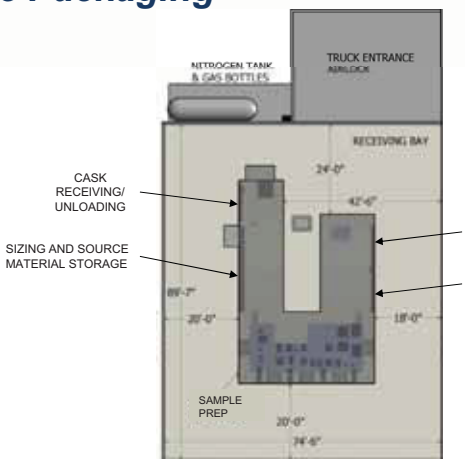
Bases for Comparing Alternatives

- Preconceptual Design of Post Irradiation Examination Line Item Building (PIE LIB) used as a benchmark for defining and comparing alternatives, including:
  - Number of shielded exam cells needed
    - Microstructural/Mechanical – 6
    - Thermal – 1
  - Number of non-shielded exam spaces – 4
  - Space requirements by function

Post Irradiation Examination Line Item Building

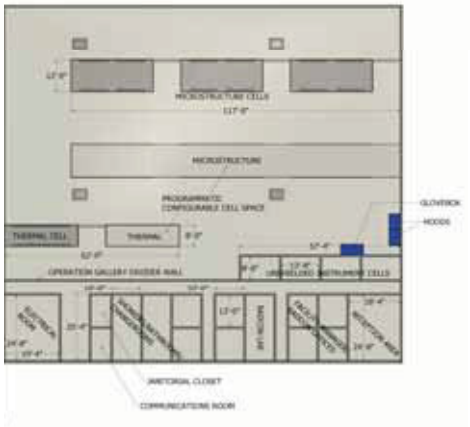


Cask Receiving, Sample Preparation, Storage, Waste Packaging



Cask Receiving/Unloading	80 sq ft
Source Material Storage	80 sq ft
Source Material Sizing and Sample Prep	400 sq ft
Specimen Storage	250 sq ft
Waste Packaging	100 sq ft

Examination Cells



Microstructural	6 cells, 600 sq ft
Thermal	1 cell, 120 sq ft
Non-shielded	4 spaces, 480 sq ft

High Level Assumptions

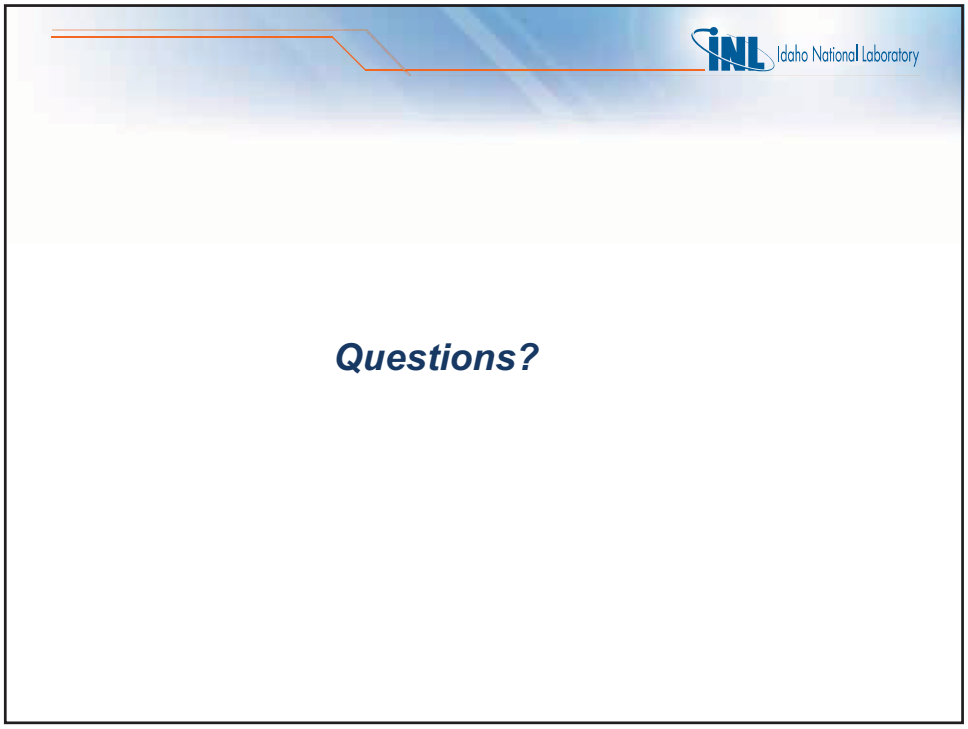
- APIEC needs to build on existing PIE capability
  - Lower rad examination capabilities are still needed (e.g., for pre-irradiation/fresh fuel exams)
  - NDE and other PIE techniques are still needed
  - Advanced PIE work currently cannot be done
- Facilities must be operating HC-2 nuclear facilities, or equivalent
- Advanced PIE shielded cells, as established/modified, require full flexibility relative to:
  - Types of initial and future instruments to be installed (e.g., all must meet vibration, EMI/RFI, & temp/humidity requirements)
  - Types of samples to be examined (materials & fuels – all types)
  - Sample atmosphere (i.e., dry, argon for storage, prep, & exam)
  - Sample dose rates (shielding > 12” steel, or equivalent, for shielded instrument cells and associated shielded support functions)

High Level Assumptions (cont.)

- NDE and size reduction/disassembly, if required, is done prior to APIEC receipt (e.g., at HFEF, IFEL, RPL A-Cell)
  - Examples of largest samples to be received: ≤ 2 ft (section of fuel rod) or 5 fuel pins (~ 6 in. long)
- Concept for advanced PIE includes use of alpha confinement/inert atmosphere confinement box within shielded enclosures to allow man-entries for routine instrument maintenance (e.g., monthly)
- Full-time availability of hot cells (exceptions – Alt. 5 Commercial and Alt. 6 International)
- The alternatives analysis needs to consider transportation of samples/specimens – thus, for purposes of comparison:
  - No duplication of advanced PIE instruments (i.e., each shielded cell houses a unique instrument)
  - Each sample gets the full suite of analyses; portions of every sample will be sent to each instrument (and transported to each involved facility, as applicable)

High Level Assumptions (cont.)

- Advanced PIE instruments will be changed out every 10 years
- Analysis period of 40 years
- Facility resets (life-extensions) add 20 years to a facility's useful life
- Major programs to use APIEC
  - Fuel Cycle Research and Development
  - Light Water Reactor Sustainability
  - Advanced Reactor Concepts
  - DoD and National Homeland Security
- Sources of irradiated experiments for advanced PIE (estimated distribution, based on past 3 years for 4 programs listed above)
  - ATR - 80%
  - HFIR - 10%
  - Other (e.g., international, university, commercial) - 10%


INL Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis

Alternative 4: Construct New Facility

www.inl.gov

Idaho National Laboratory

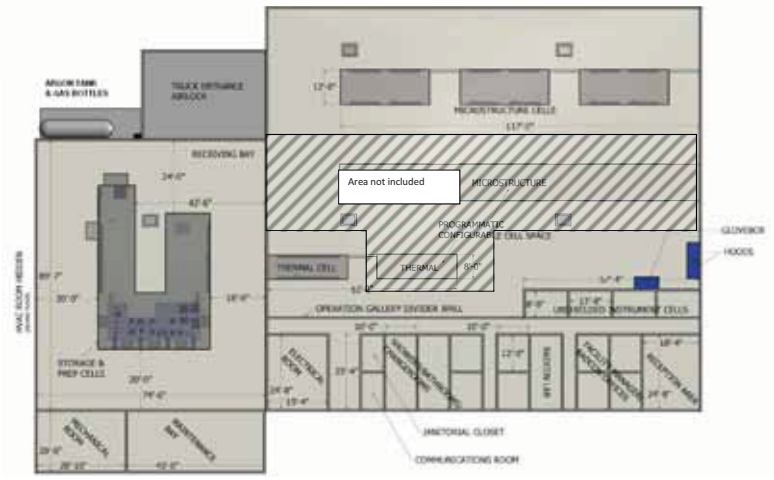
Alternative 4: Construct New Facility
Summary Description

Idaho National Laboratory

- Construct a single new HC-2 facility (designated the Advanced Post Irradiation Examination (APEX) facility for this analysis)
  - Suite of hot cells for receipt, storage, preparation, examination of irradiated samples and associated waste packaging
  - Unshielded instrument spaces, support hoods, glove boxes
  - Advanced temperature control, HEPA-filtered ventilation, EMI/RFI protection, vibration and noise control, and dry, inert environment
  - Space allocation for PIE instrument development, hot/cold equipment maintenance, and personnel support

Alternative 4: Construct New Facility
Assumptions

- APEX facility will be similar to the PIE Line Item Building Preconceptual Design with appropriate adjustments

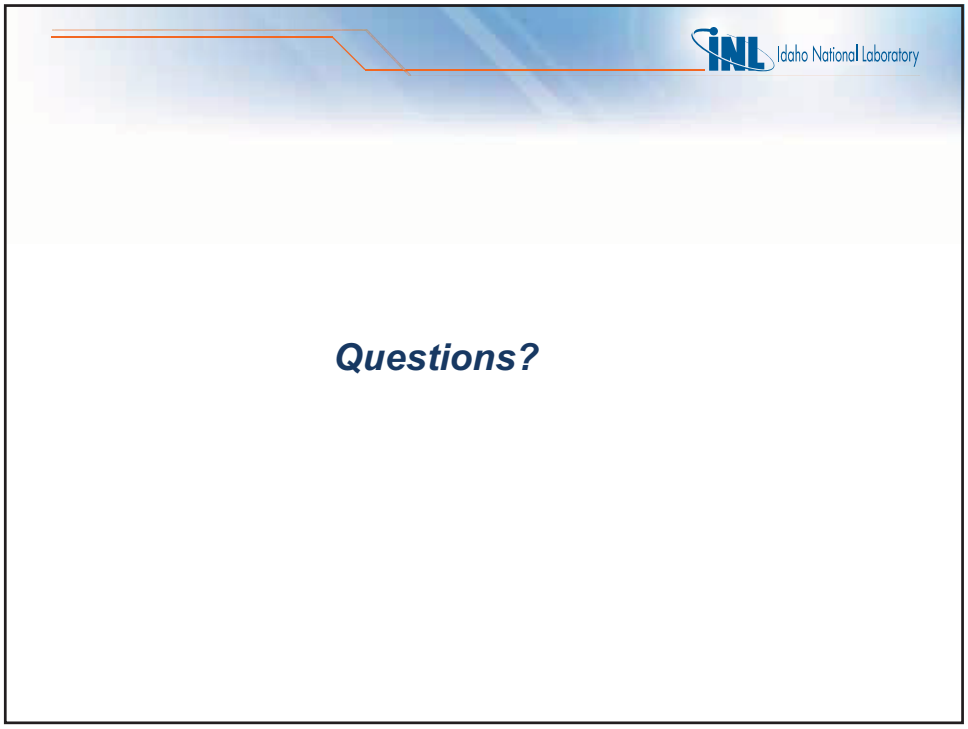


Alternative 4: Construct New Facility
SubAlternatives

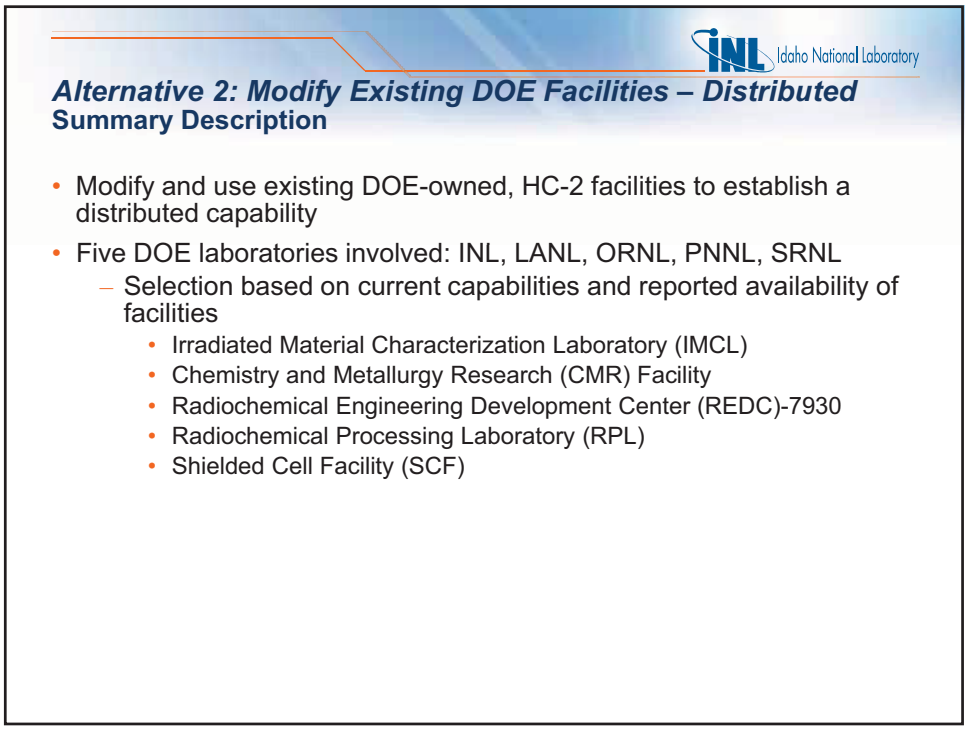
- Three sub-alternatives are included to assess a range of possible locations – two sites with co-located reactor and a site without a co-located reactor
  - Alternative #4a –APEX facility sited at MFC at the INL
  - Alternative #4b – APEX facility sited at ORNL
  - Alternative #4c – APEX facility sited at a DOE laboratory with only pre- and post-irradiation capabilities and no reactor (i.e., LANL, PNNL, or SRNL).
    - Identified sites are considered equivalent with respect to proximity to reactor

Alternative 4: Construct New Facility
Facility and Hot Cells Description

- One HC-2 non-reactor nuclear facility that provides world-leading capabilities to examine irradiated fuel and materials
  - Seven (7) reconfigurable shielded enclosures with 720 ft^2 total
  - Approximately 440 ft^2 of space for ancillary support equipment
  - Four (4) non-shielded instrument spaces of 470 ft^2
  - A shielded cask receiving/unpacking/packing hot cell of 80 ft^2
  - A shielded source material hot cell of 88 ft^2
  - A shielded sample/specimen preparation hot cell of 400 ft^2
  - Hot cell space for storage and archival of specimens of 250 ft^2
  - Hot cell space for waste processing/packaging of 100 ft^2
  - Space allocation for receiving bay, cask transfer corridor, operating galleries, operational support areas, mechanical and electrical rooms, communications rooms, janitorial rooms, HVAC rooms, and a maintenance bay


INL Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Alternative 2: Modify Existing DOE Facilities – Distributed
www.inl.gov
INL
Idaho National Laboratory


INL Idaho National Laboratory
Alternative 2: Modify Existing DOE Facilities – Distributed
Summary Description
• Modify and use existing DOE-owned, HC-2 facilities to establish a distributed capability
• Five DOE laboratories involved: INL, LANL, ORNL, PNNL, SRNL
– Selection based on current capabilities and reported availability of facilities
• Irradiated Material Characterization Laboratory (IMCL)
• Chemistry and Metallurgy Research (CMR) Facility
• Radiochemical Engineering Development Center (REDC)-7930
• Radiochemical Processing Laboratory (RPL)
• Shielded Cell Facility (SCF)

Alternative 2: Distributed
Assumptions

- Facility modifications do not include converting non-HC-2 facilities to HC-2
- Facility modifications do not include wholesale tear-out and replacement of existing fixed hot cells
- Hot cells must be available to support APIEC on a full-time basis
- Each of the advanced PIE instruments will be unique, however, the support functions and equipment will be duplicated at the different laboratories
- Allocation of functions to shielded cells at each facility must first provide sample receiving, storage, preparation and waste packaging before allocation of the first shielded exam cell
- Each shielded cell (i.e., including examination and process support cells) and non-shielded instrument spaces will be modified, as needed, to provide full flexibility as to the types of advanced PIE instruments to be installed and for the range of fuels and materials to be examined

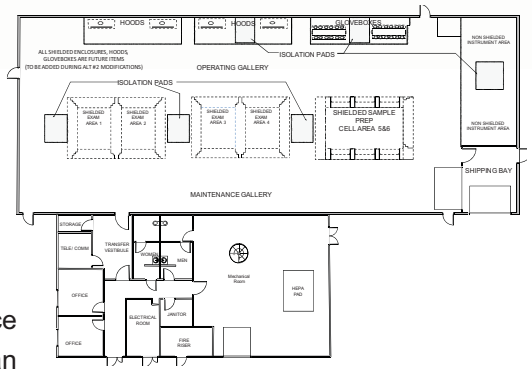
Alternative 2: Distributed
Assumptions (cont.)

- The allocation of shielded instrument cells and non-shielded instrument spaces to the involved labs are as shown below. This assumption is intended to fulfill that the distributed nature of the alternative.
  - IMCL at INL (2 shielded instruments; 1 non-shielded instrument)
  - CMR Wing 9 at LANL (1 shielded instrument)
  - REDC 7930 at ORNL (2 shielded instruments; 1 non-shielded instrument at IFEL)
  - RPL at PNNL (1 shielded instrument; 1 non-shielded instrument)
  - SCF at SRNL (1 shielded instrument; 1 non-shielded instrument)
- Samples require the full suite of advanced PIE characterization and, thus, must be divided and have portions sent to each of the involved DOE sites.

Alternative 2: Distributed
Facility and Hot Cells Description

INL MFC-1729 IMCL

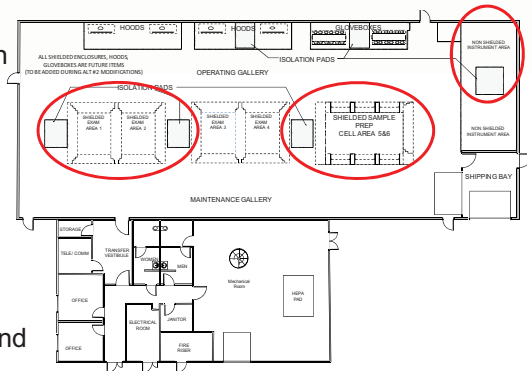
- New HC-2 facility
- Has existing temperature control, EMI protection, vibration isolation, HEPA-filtered exhaust
- Use large hot cell space for sample prep, storage, and waste packaging; 2 hot cell spaces for instruments; and 1 non-shielded instrument space
- Co-located with HFEF that can support large cask/sample receiving, NDE, and large-scale sizing



Alternative 2: Distributed
Facility and Hot Cells Description

INL MFC-1729 IMCL Mods

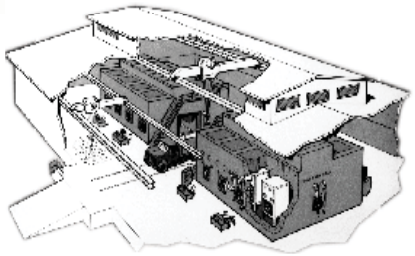
- Add noise protection (partition wall for non-shielded instrument space)
- Add 3 new modular shielded enclosures (MSEs) including manipulators and windows
- Add tie-ins between MSEs and existing HEPA exhaust
- Add storage, supply piping, and maintenance system for inert atmosphere to MSEs
- Add sample prep, storage and waste packaging equipment into MSE



Alternative 2: Distributed
Facility and Hot Cells Description

LANL TA-3-29 CMR

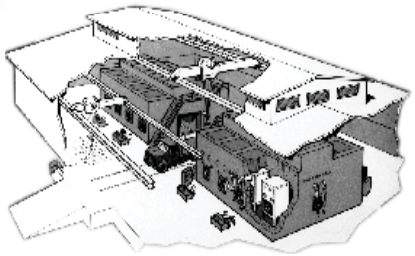
- CMR Wing 9 is existing HC-2 facility (has 16 total 6' x 6' spaces; 12 are reported available)
- Use shielded storage wells (existing) for source mat'l storage
- Use 4 shielded spaces for sample preparation
- Use 2 shielded spaces for one instrument hot cell (6' x 12')
- Use 1 shielded space each for prepared specimen storage and waste packaging



Alternative 2: Distributed
Facility and Hot Cells Description

LANL CMR Wing 9 Mods

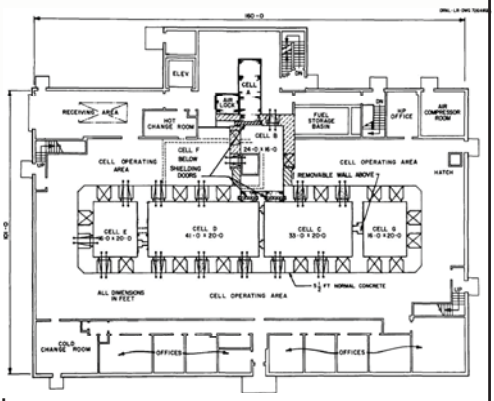
- Add noise, EMI/RFI, and vibration isolation upgrades
- Restart HEPA filtration/alpha confinement exhaust system
- Provide temperature control upgrade
- Perform decontamination (some cells)
- Provide inert atmosphere storage, supply piping, & maintenance system
- Manipulator and penetration upgrades
- Add sample prep, storage and waste packaging equipment
- Replace hot cell corridor cranes
- Wing 9 requires $20M to $50M for seismic and fire code upgrades



Alternative 2: Distributed
Facility and Hot Cells Description

ORNL Bldg. 7930 REDC

- REDC is existing HC-2 facility
- Cells D and E have never been used and are available
- Use Cell B for cask receiving (shared)
- Use Cells D & E to create 2 instrument hot cells and supporting storage, sample prep, and waste packaging cells
- Use IFEL for large cask/sample receiving, NDE, large scale sizing, and non-shielded space

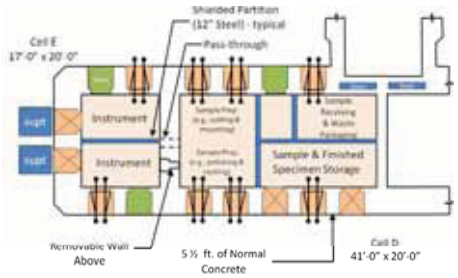


Alternative 2: Distributed
Facility and Hot Cells Description

ORNL Bldg. 7930 REDC Mods

- Cut and install access doors (~ 3)
- Add noise, EMI/RFI, and vibration isolation upgrades
- Provide HEPA filtration/alpha confinement exhaust system
- Provide temperature control upgrade
- Provide inert atmosphere storage, supply piping, & maintenance system
- Add new shielding walls, windows, manipulators, penetrations, and Cell E floor upgrade
- Add sample prep, storage and waste packaging equipment
- Provide fire protection system upgrades
- Add material transfer systems (Cell B to D and from sample prep to instruments)

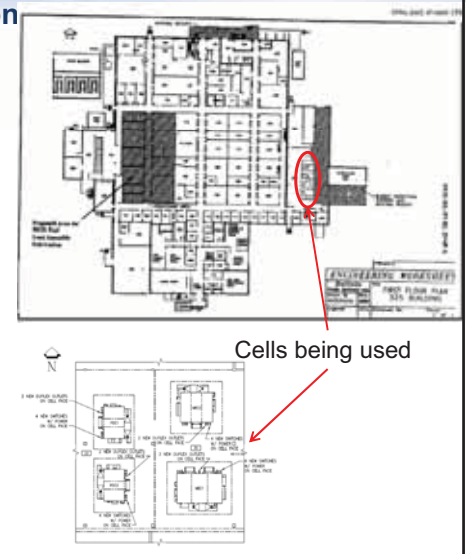
Example Layout



Alternative 2: Distributed
Facility and Hot Cells Description

PNNL Bldg 325 RPL

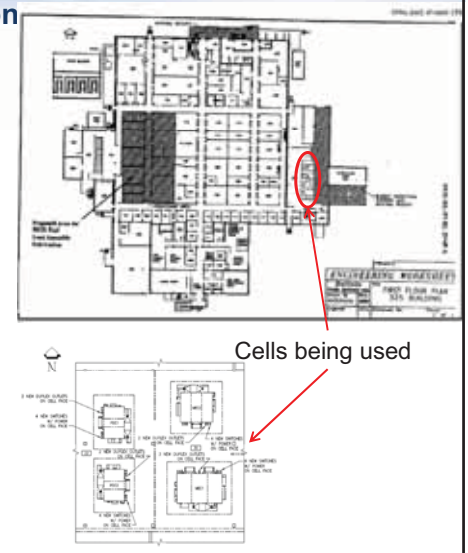
- RPL is existing HC-2 facility, newly refurbished
- Use HLRF A, B, and C Cells for sample receiving (shared), storage, and waste packaging, respectively
- Use PDC1 and MEC2 for sample sizing and prep
- Use MEC1 for shielded instrument cell
- Use PDC2 for prepared specimen storage/archive
- Non-shielded examination space available (TBD room)



Alternative 2: Distributed
Facility and Hot Cells Description

PNNL Bldg. 325 RPL Mods

- Add noise, EMI/RFI, and vibration isolation upgrades
- Decontaminate B Cell
- Provide temperature control upgrade
- Provide inert (argon) atmosphere storage, supply piping, and maintenance system
- Add sample prep, storage and waste packaging equipment



Alternative 2: Distributed
Facility and Hot Cells Description

SRNL Bldg. 773-A SCF

- SCF is existing HC-2 facility
- Use High Bay Area for cask/sample receiving
- Use 6 cells in Block B for APIEC
  - 1 cell for sample and prepared specimen storage
  - Combine 2 cells for sample prep
  - Combine 2 cells for shielded instrument cell
  - Use 1 cell for waste packaging
- Non-shielded examination space available

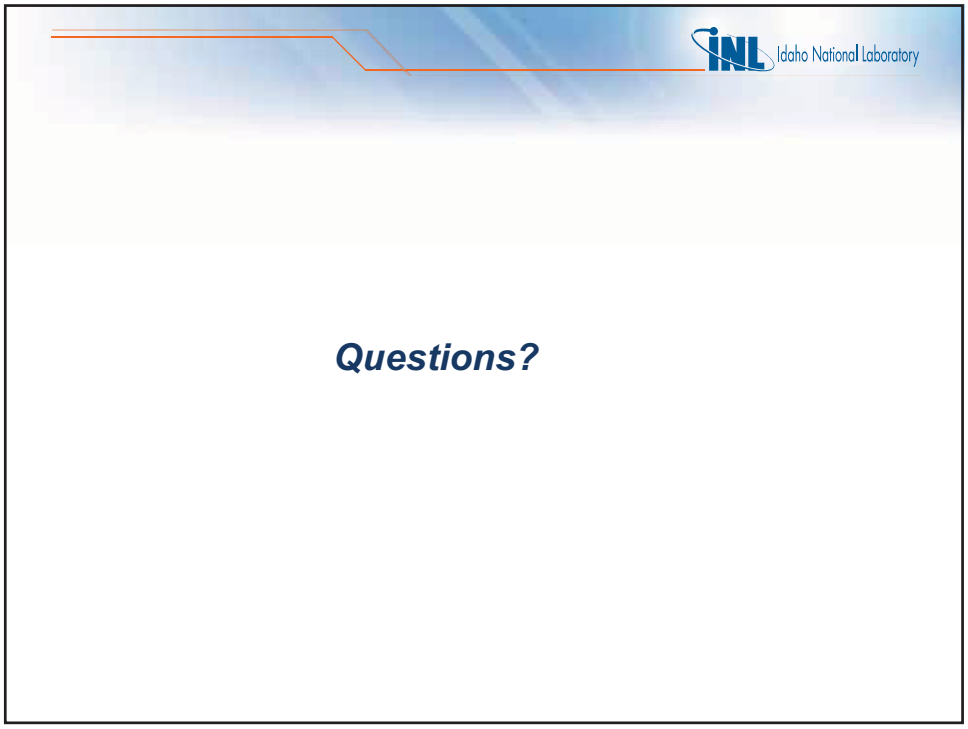
Plan View E-Wing Cell Blocks A & B and Cells' Support Space

Alternative 2: Distributed
Facility and Hot Cells Description

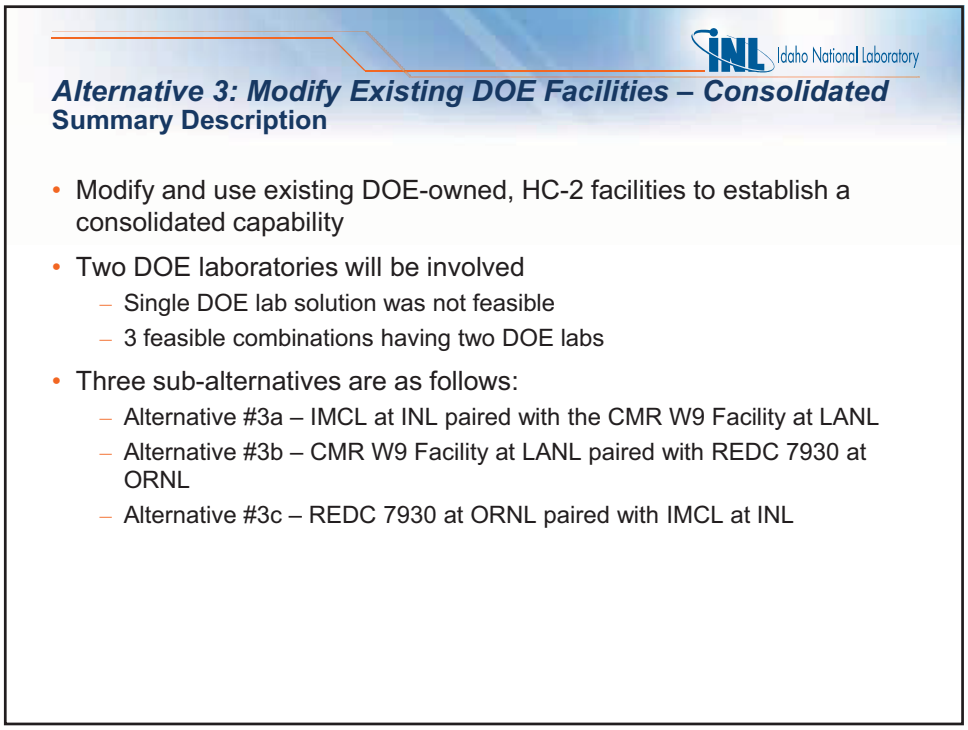
SRNL Bldg. 773-A SCF Mods

- Cut and install access doors
- Add noise, EMI/RFI, and vibration isolation upgrades
- Perform cell decontamination
- Provide tie-ins to HEPA filtration/alpha confinement exhaust system
- Provide temperature control upgrade
- Provide inert atmosphere storage, supply piping, and maintenance systems
- Add new shield walls (partial) and shielded penetrations
- Add sample prep, storage and waste packaging equipment

Plan View E-Wing Cell Blocks A & B and Cells' Support Space


INL Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Alternative 3: Modify Existing DOE Facilities – Consolidated
www.inl.gov
INL
Idaho National Laboratory


INL Idaho National Laboratory
Alternative 3: Modify Existing DOE Facilities – Consolidated
Summary Description
• Modify and use existing DOE-owned, HC-2 facilities to establish a consolidated capability
• Two DOE laboratories will be involved
– Single DOE lab solution was not feasible
– 3 feasible combinations having two DOE labs
• Three sub-alternatives are as follows:
– Alternative #3a – IMCL at INL paired with the CMR W9 Facility at LANL
– Alternative #3b – CMR W9 Facility at LANL paired with REDC 7930 at ORNL
– Alternative #3c – REDC 7930 at ORNL paired with IMCL at INL

Alternative 3: Consolidated
Assumptions

- Facility modifications do not include converting non-HC-2 facilities to HC-2
- Facility modifications do not include wholesale tear-out and replacement of existing fixed hot cells
- Hot cells must be available to support APIEC on a full-time basis
- Each of the advanced PIE instruments will be unique, however, the support functions and equipment will be duplicated at the different laboratories
- Allocation of functions to shielded cells at each facility must first provide sample receiving, storage, preparation and waste packaging before allocation of the first shielded exam cell
- Each shielded cell (i.e., including examination and process support cells) and non-shielded instrument spaces will be modified, as needed, to provide full flexibility as to the types of advanced PIE instruments to be installed and for the range of fuels and materials to be examined

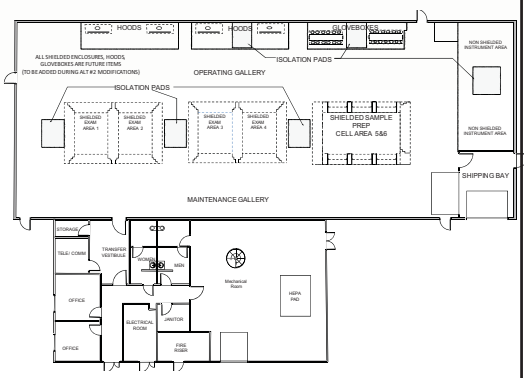
Alternative 3: Consolidated
Assumptions

- The allocation of shielded instrument cells and non-shielded instrument spaces to the involved labs are as shown below. This assumption is intended to fulfill that the consolidated nature of the alternative.
  - IMCL at INL (4 [or 3] shielded instruments; 2 non-shielded instruments)
  - CMR Wing 9 at LANL (3 shielded instruments, 2 non-shielded instruments - TBD)
  - REDC 7930 at ORNL (4 shielded instruments; 2 non-shielded instruments at IFEL)
- Samples require the full suite of advanced PIE characterization and, thus, must be divided and have portions sent to each of the involved DOE sites.

Alternative 3: Consolidated
Facility and Hot Cells Description

INL MFC-1729 IMCL

- New HC-2 facility
- Has existing temperature control, EMI protection, vibration isolation, HEPA-filtered exhaust
- Use large hot cell space for sample prep, storage, and waste packaging; 4 (#3a) or 3 (#3c) hot cell spaces for instruments; and 2 non-shielded instrument spaces
- Co-located with HFEF that can support large cask/sample receiving, NDE, and large-scale sizing



Alternative 3: Consolidated
Facility and Hot Cells Description

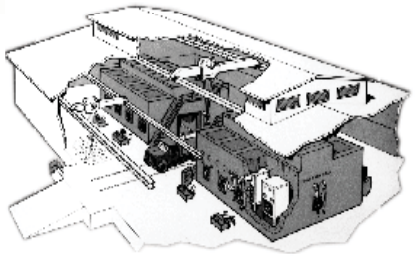
INL MFC-1729 IMCL Mods

- Add noise protection (partition wall for non-shielded instrument spaces)
- Add 5 (#3a) or 4 (#3c) new modular shielded enclosures (MSEs) including manipulators and windows
- Add tie-ins between MSEs and existing HEPA exhaust
- Add storage, supply piping, and maintenance system for inert atmosphere to MSEs
- Add sample prep, storage and waste packaging equipment into MSE

Alternative 3: Consolidated
Facility and Hot Cells Description

LANL TA-3-29 CMR

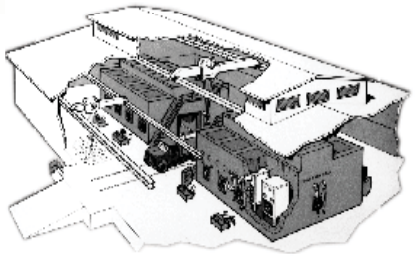
- CMR Wing 9 is existing HC-2 facility (has16 total 6' x 6' spaces; 12 are reported available)
- Use shielded storage wells (existing) for source mat'l storage
- Use 4 shielded spaces for sample preparation
- Use 6 shielded spaces for 3 instrument hot cells (6' x 12')
- Use 1 shielded space each for prepared specimen storage and waste packaging



Alternative 3: Consolidated
Facility and Hot Cells Description

LANL CMR Wing 9 Mods

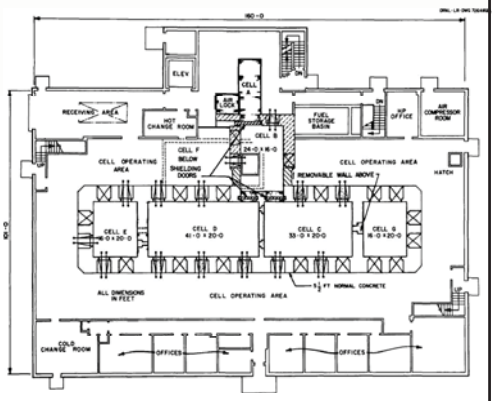
- Add noise, EMI/RFI, and vibration isolation upgrades
- Restart HEPA filtration/alpha confinement exhaust system
- Provide temperature control upgrade
- Perform decontamination (some cells)
- Provide inert atmosphere storage, supply, and maintenance system
- Manipulator and penetration upgrades
- Add sample prep, storage and waste packaging equipment
- Replace hot cell corridor cranes
- Wing 9 requires $20M to $50M for seismic and fire code upgrades



Alternative 3: Consolidated
Facility and Hot Cells Description

ORNL Bldg. 7930 REDC

- REDC is existing HC-2 facility
- Cells D and E have never been used and are available
- Use Cell B for cask receiving, Cell F for sample storage (shared)
- Use Cells D & E to create 4 instrument hot cells and supporting storage, sample prep, and waste packaging cells
- Use IFEL for large cask/sample receiving, NDE, large scale sizing and two non-shielded instrument spaces

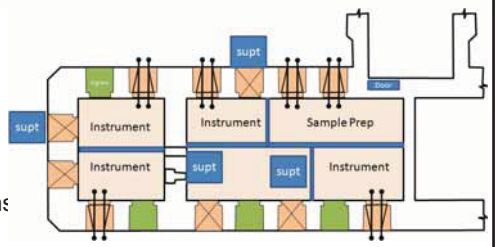


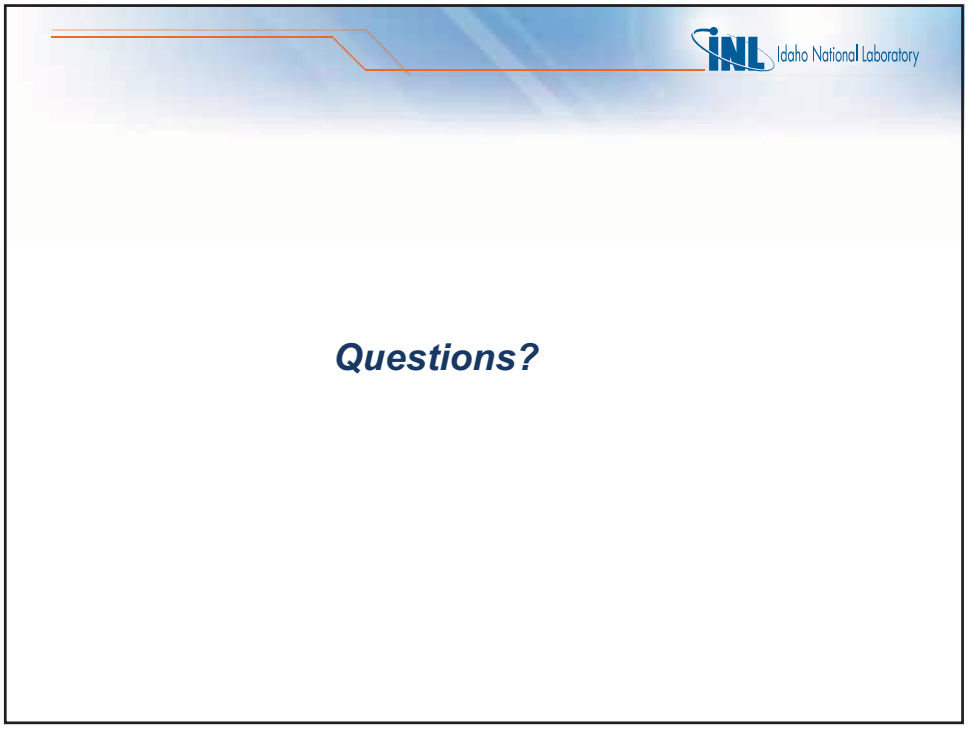
Alternative 3: Consolidated
Facility and Hot Cells Description

ORNL Bldg. 7930 REDC Mods

- Cut and install access doors (~ 4)
- Add noise, EMI/RFI, and vibration isolation upgrades
- Provide HEPA filtration/alpha confinement exhaust system
- Provide temperature control upgrade
- Provide inert atmosphere storage, supply piping, & maintenance systems
- Add new shielding walls, windows, manipulators, penetrations, and Cell E floor upgrade
- Add sample prep, storage and waste packaging equipment
- Provide fire protection system upgrades
- Add material transfer systems (Cell B to D and from sample prep to instruments)

Example Layout




INL Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Alternative 5: Commercial Partnership
www.inl.gov
INL
Idaho National Laboratory

INL Idaho National Laboratory
Alternative 5: Commercial Partnership
Summary Description
• Use only existing U.S. commercially-owned hot cell facilities; more than one will be required to meet APIEC requirements
• Contractual agreements are needed between DOE and commercial entities to address capital expenditures for facility modifications and equipment, facility use, etc.
• Must have shielding equivalent to 12 inches of steel

Alternative 5: Commercial Partnership
Assumptions

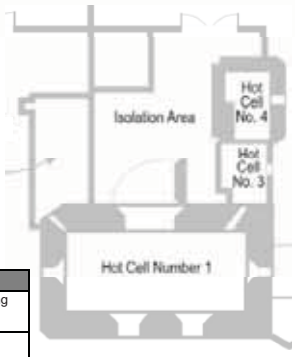
- Commercial hot cells would not be dedicated solely to the APIEC Contractual arrangements for timely access will be required
- Contractual arrangements must include the necessary provisions for control and protection of the physical items and data
- A portion of every sample will go to each facility

Alternative 5: Commercial Partnership
Facility and Hot Cells Description

- **Commercial Facilities**
  - Babcock and Wilcox (B&W) Lynchburg Technology Center (LTC) cells, located in Virginia
  - Global Nuclear Fuels (GNF) Vallecitos Nuclear Center in Vallecitos, CA
  - George Westinghouse Research & Technology Park in Churchill, PA.

Alternative 5: Commercial Partnership
Facility and Hot Cells Description (cont)

- **Babcock and Wilcox (B&W)**
  - 4 independent hot cells that have sufficient shielding for APIEC built in the 1960's
  - All are air cells
  - Manned entry is difficult because all cells are contaminated
  - 25' deep storage pool accessible to cell #1 with 25-ton crane



Cell #	Size(WxLxH)	Shielding material	Shielding Capability	Function
Cell 1	8'x16'x15'	42" of high density concrete	300,000ci of Co-60	Fuel Assembly handling
Cell 2	4.5'x15.5'x9'	13' Lead shot filled calls	6,000ci of Co-60	Metallographic Examinations
Cell 3	4'x9'x9'	10" Lead shot filled calls	600ci of Co-60	Used in the past for fuel decladding and fuel density measurements
Cell 4	6'x6'x9'	10" Lead shot filled calls	600ci of Co-60	Mechanical testing and cladding

Alternative 5: Commercial Partnership
Facility and Hot Cells Description (cont)

- **Global Nuclear Fuels (GNF)**
  - 4 hot cells that have sufficient shielding to support APIEC constructed in the 1950's
  - All are air cells
  - Has NDE capabilities and is equipped to handle a full length LWR fuel
  - Each cell has three workstations with a pair of manipulators at each workstation

Cell #	Size (WxLxH)	Shielding material	Function
Cell 1	6'x16'x7'	3' high density concrete	Supported by 6'x6'x10' interlocks. One of these cells is currently being used for PIE on spent fuel including Metallographic/Ceramic and SEM examinations.
Cell 2	6'x16'x7'	3' high density concrete	
Cell 3	6'x16'x7'	3' high density concrete	
Cell 4	6'x16'x7'	3' high density concrete	
Cell 9	5'x5'x7'	18" high density concrete	Two of these cells, along with one larger cell, are currently being used for PIE on spent fuel including Metallographic/Ceramic and SEM examinations.
Cell 10	5'x5'x7'	18" high density concrete	
Cell 11 (A & B)	5'x5'x7'	18" high density concrete	The shielding on these cells is not sufficient to meet the requirements of the APIEC.

Alternative 5: Commercial Partnership
Facility and Hot Cells Description (cont)

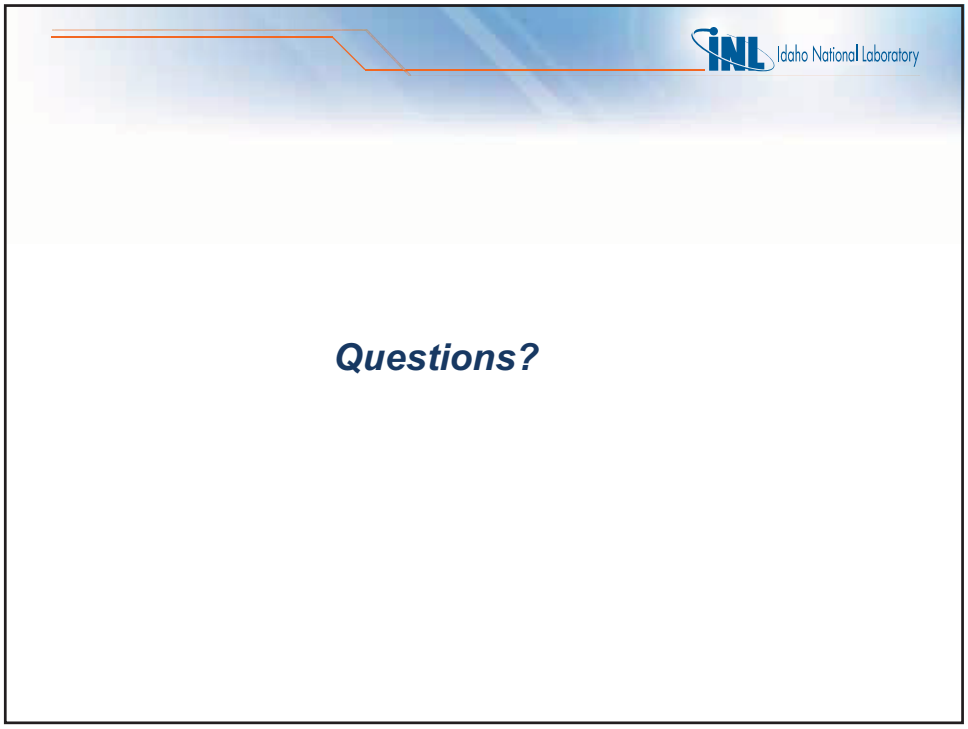
- **Westinghouse**
  - Four cells air cells with 9 remote handling stations
  - All cells are continuously utilized to support both commercial and industry PIE
  - Licensed to handle irradiated materials but currently have no plans to perform PIE on any fuels

Cell Name	Cell Size	Shielding	Function	Comments
High Level Cell (HLC)	24'x5'x12'	27" reinforced high density concrete	Examples include machining, cutting, grinding, milling, photograph, storage, ultrasonic measurements, etc.	Adjacent to LLC with a transfer tubes through call walls to facilitate materials/equipment transfers
Low Level Cell (LLC)	17.5'x6'x10'	12"-24" reinforced high density concrete	Examples include charpy impact testing, immersion density measurements, tensile testing, fracture toughness testing, ultrasonic and eddy current measurements, etc.	
Cell A	6'x6'x11.5'	10" steel	Examples include loading and unloading autoclaves, hydrogen analysis, laser measurements, etc.	Cells A and M are independent cells and not adjacent to each other or the HLC or LLC cells
Cell M	6'x6'x11.5'	10" steel	Examples include metallographic sample preparation (i.e., mounting, grinding, polishing, etching), etc.	

All Westinghouse cells are multi-functional and routinely re-configured to meet the needs of the program / customer

Alternative 5: Commercial Partnership
Mapping of APIEC Functions to Sites

Allocation for Alternative 5 (Commercial)-v1					
Function	APIEC Desired State (in spaces)	(APIEC Desired State n ft2)	B&W	GNF	Westinghouse
Shielded cask receiving/ unpacking/packing	1	80	Use part of Cell 1	Use Interlock access area	HLC
Shielded source material storage	12	80	Use Cell 4 (36 ft2)	Use part of third available cell for source material storage (40 ft2 of 96 ft2)	HLC
Shielded source material sizing/ capsule disassembly	Assume function is included with sample prep	Assume function is included with sample prep	With sample prep	With sample prep	With Sample Prep
Shielded sample/specimen preparation (SPHC)	12	400	A limited prep area could be provided in cell 1 (128 sq ft total)	Use second available cell for sample prep (96 ft2)	HLC / LLC
Shielded sample/ specimen examination cells	7	720 [1,160 with support equipment space]	Cell 2 could provide space for one instrument (70 ft2)	Use first available cell for one instrument (96 ft2)	Cell A and M
Non-shielded sample/specimen examination areas	4	480	Unshielded areas available	Unshielded areas available	Unshielded areas available
Final prepared sample/specimen storage and archive	12	250	Limited temporary storage could be provided in cell 4	Use part of third cell for sample/specimen storage (56 ft2 of 96 ft2)	HLC / LLC
Waste processing/ packaging	12	100	Limited space could be provided in Cell 1	Limited space may be available in second cell	HLC


INL Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Alternative 6: International Partnership
www.inl.gov
INL
Idaho National Laboratory

INL Idaho National Laboratory
Alternative 6: International Partnership
Summary Description
• Use only existing international hot cell facilities
• International Atomic Energy Agency (IAEA) PIE database was used to provide capability details
• Selected four facilities based on the current capabilities/facilities
• DOE/Users will have to develop agreements with International agencies

Alternative 6: International Partnership
Assumptions

- Capabilities in the International Community will continue to be upgraded. These upgrades will support the APIEC needs.
- DOE will not invest any taxpayer money in developing an alternative that is not owned and managed within the United States
- For comparison, only one overseas shipment per experiment will be made. However, because this alternative involves more than one international facility, portions of every sample will go to each facility.

Alternative 6: International Partnership
Facility and Hot Cells Description

- **International Facilities**
  - Joint Research Centre (JRC)-Institute for Transuranium Elements (ITU) in Germany;
  - Commissariat à l'énergie Atomique et aux énergies Alternatives (CEA) facilities in Cadarache, France,
    - Laboratoire d'Examen de Combustibles Actifs (LECA)
    - Station de Traitement Assainissement Reconditionnement (STAR)
  - Studsvik site in Nykoping Sweden.

Alternative 6: International Partnership
Facility and Hot Cells Description (cont)

- **JRC Institute for Transuranium Elements**
  - JRC-ITU's prime objectives are to serve as a reference center for basic actinide research
  - ITU has 24 shielded hot cells with up to 1x10^6 Ci shielding along with two decontamination cells
  - ITU has a containment box that allows for equipment change out as well as manned entry
  - ITU has EPMA in cell and this cell meets the thermal, EMI, and shielding requirements set forth by manufacturer

Technique	Destructive /Non-Destructive
Visual Examination	Non-Destructive
Eddy Current Testing	Non-Destructive
Oxide Thickness	Non-Destructive
Rod Puncture	Non-Destructive
Visual Examination	Non-Destructive
Rod Length measurement	Non-Destructive
Gamma Scanning	Non-Destructive
Length and Diameter	Non-Destructive
Density	Destructive
EPMA	Destructive
Open Porosity	Destructive
Retained gas measurement	Destructive
Optical Microscopy	Destructive
SEM	Destructive
Burnup	Destructive
Micro Gamma Scanning	Destructive
X-ray Diffraction	Destructive
Clad Creep Testing	Destructive

Alternative 6: International Partnership
Facility and Hot Cells Description (cont)

- **CEA Facilities LECA and STAR**
  - CEA is a French government funded organization with LECA and STAR being the nuclear facilities in Cadarache
  - STAR facility is primarily a NDE facility while LECA has both NDE and DE capabilities
  - LECA has 10 concrete cells with 100KCi shielding capability and 7 lead cells with about 1000Ci shielding capability; these air cells can accept a fuel rod up to 2.5m in length
  - The TN-106 cask is currently licensed in France but requires Department of Transportation (DOT) review and significant documentation to use the TN-106 cask in the United States.

Technique	Site	Destructive /Non-Destructive
Length and Diameter	STAR	Non-Destructive
Oxide Thickness	STAR	Non-Destructive
Gamma Scanning	STAR	Non-Destructive
Visual Examination	STAR	Non-Destructive
Eddy Current Testing	STAR	Non-Destructive
X-Radiography	STAR	Non-Destructive
Rod Puncture	STAR	Non-Destructive
Length and Diameter	LECA	Non-Destructive
Eddy Current Testing	LECA	Non-Destructive
Oxide Thickness	LECA	Non-Destructive
Gamma Scanning	LECA	Non-Destructive
Visual Examination	LECA	Non-Destructive
Optical Microscopy	LECA	Destructive
SEM	LECA	Destructive
Image Analysis	LECA	Destructive
EPMA	LECA	Destructive
Heat treatments with on-line gas analysis	LECA	Destructive
X-ray Diffraction	LECA	Destructive
Density	LECA	Destructive
Micro-coring	LECA	Destructive
Burnup	LECA	Destructive
SIMS	LECA	Destructive
Retained gas measurement	LECA	Destructive
Numerical Macroscope	LECA	Destructive
Oxidation Furnace	LECA	Destructive

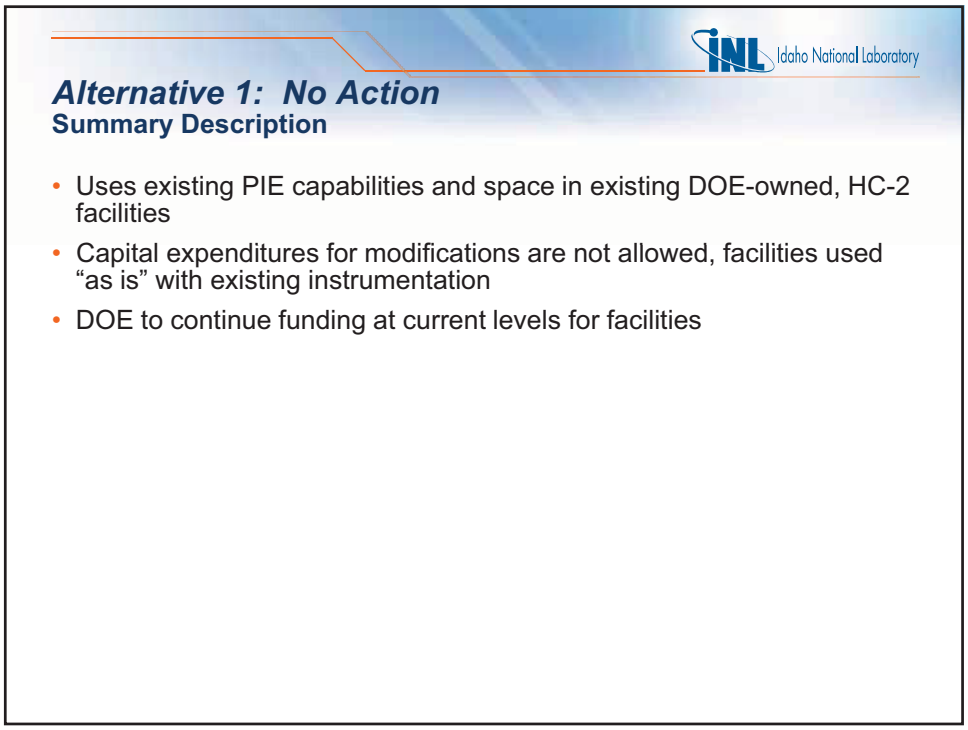
Alternative 6: International Partnership
Facility and Hot Cells Description (cont)

- **Studsvik**
  - Studsvik is focused on the international nuclear power industry and offers advanced services in waste treatment and decommissioning
  - Studsvik has 7 concrete cells with about 13.5KCi shielding and 10 lead cells
  - Studsvik can receive a fuel rod up to 4.5m in length using a horizontal cask
  - Studsvik has the ability to receive fuel rods and then dispose of them within Sweden

Technique	Destructive /Non-Destructive
Optical Microscopy	Destructive
SEM	Destructive
Image Analysis	Destructive
EPMA	Destructive
X-ray Diffraction	Destructive
Density	Destructive
Burnup	Destructive
O to M Ratio	Destructive
Hydrogen Analysis	Destructive
Clad Creep Testing	Destructive
Clad Fatigue Testing	Destructive
Other Mechanical Testing	Destructive
Length and Diameter	Non-Destructive
Gamma Scanning	Non-Destructive
Eddy Current Testing	Non-Destructive
Oxide Thickness	Non-Destructive
Neutron Radiography	Non-Destructive
Clad-fuel Gap	Non-Destructive
Non-destructive Gas Release	Non-Destructive
Rod Puncture	Non-Destructive
Tube Burst Testing	Destructive
Leak Testing	Destructive

Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Alternative 1: No Action
www.inl.gov
INL
Idaho National Laboratory


INL Idaho National Laboratory
Alternative 1: No Action
Summary Description
• Uses existing PIE capabilities and space in existing DOE-owned, HC-2 facilities
• Capital expenditures for modifications are not allowed, facilities used "as is" with existing instrumentation
• DOE to continue funding at current levels for facilities

Alternative 1: No Action
Assumptions

- Facilities must be DOE-owned
- No modifications for the purpose of supporting advanced PIE after 12/31/2012
- Replacement of PIE instrumentation will be like-for-like at end of useful life
- Facilities used to support APIEC will be “reset” at the end of their expected facility life
- Existing capability for PIE to support other PIE will still be needed

Alternative 1: No Action
Facility and Hot Cells Description

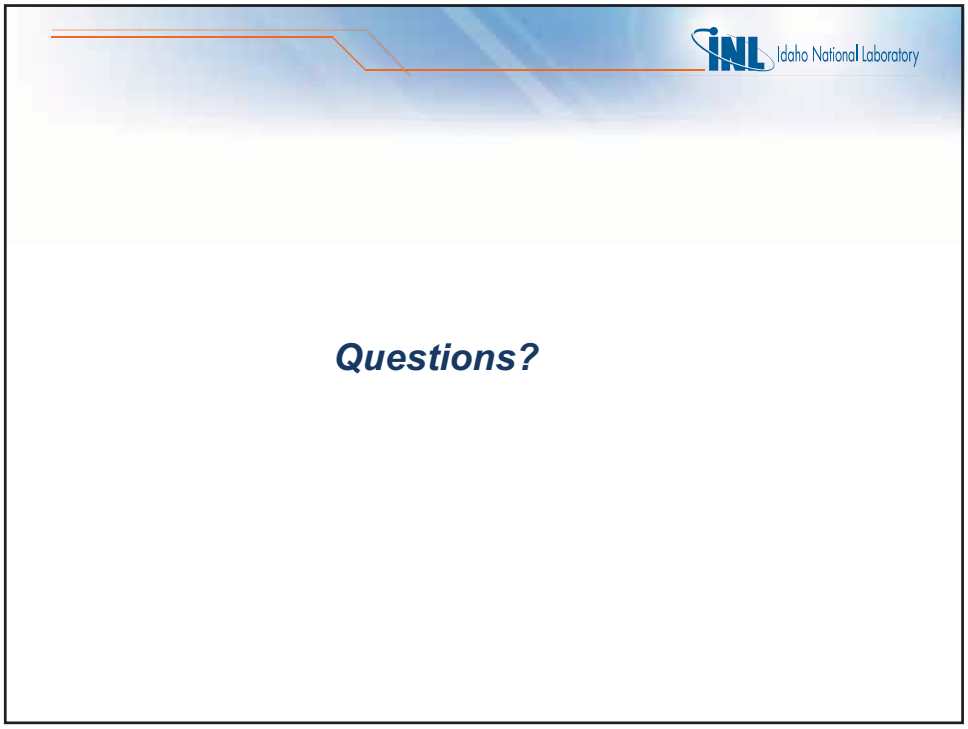
- HC-2 Facilities that could be considered in this alternative:
  - INL – MFC-785, Hot Fuels Examination Facility (HFEF)
  - Los Alamos National Laboratory (LANL) – Chemical and Metallurgical Research (CMR) Facility – Wing 9 Hot Cells
  - ORNL – Building 3525, Irradiated Fuels Examination Laboratory (IFEL)
  - Pacific Northwest National Laboratory (PNNL) – Building 325, Radiochemical Processing Laboratory (RPL)
  - Savannah River National Laboratory (SRNL) – Shielded Cell Facility—High-Level Cell

Alternative 1: No Action
Facility and Hot Cells Description

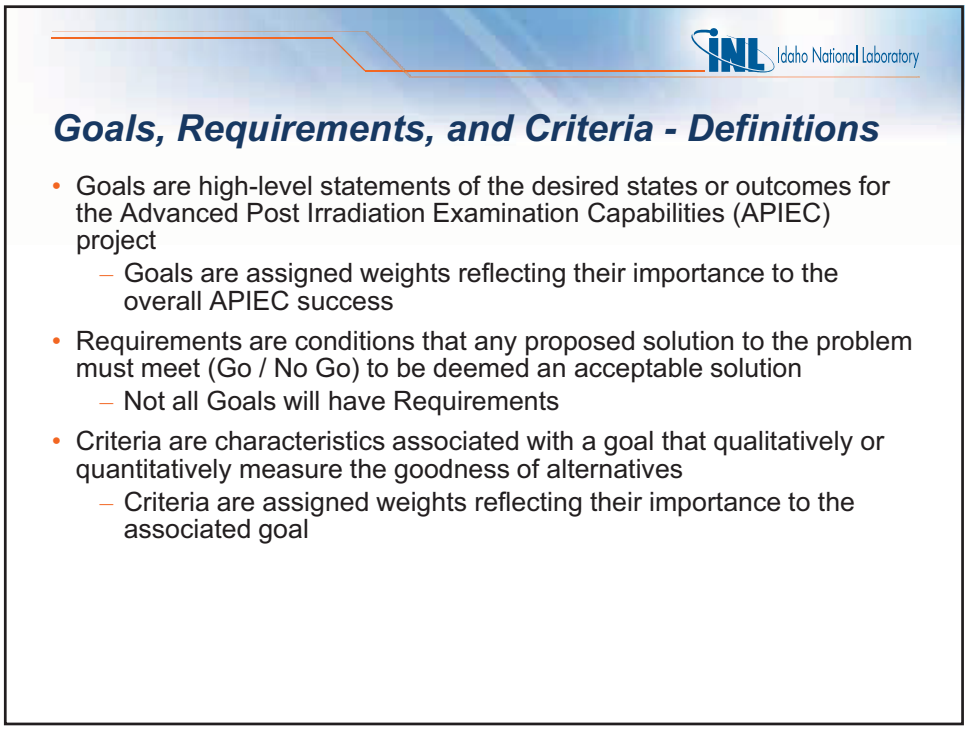
- HC-3 Facilities that might be considered but typically do not have adequate shielding:
  - INL – MFC-752, Analytical Laboratory (AL)
  - INL – MFC-787, Fuels and Applied Sciences Building (FASB)
  - INL – MFC-774, Electron Microscopy Laboratory (EML)
  - ORNL – Building 3025E, Irradiated Materials Examination and Testing (IMET).

Alternative 1: No Action
Mapping of APIEC Functions to Sites

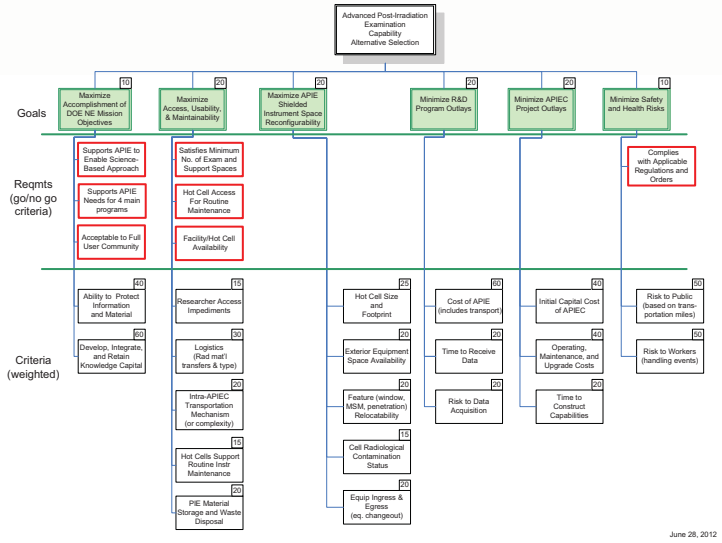
Functions (Advanced PIE)	Current HC-2 PIE Capabilities at DOE Sites				
	INL	LANL	ORNL	PNNL	SRNL
Shielded cask receiving/ unpacking/packing (*assuming inerted convenience container)	HFEF	CMR Wing 9*	IFEL*	RPL (HLRF A-Cell)*	SCF*
Shielded source material storage (*assuming inerted convenience container)	HFEF	CMR Wing 9 (wells)*	IFEL*	RPL (HLRF B-Cell)*	SCF*
Shielded source material sizing/ capsule disassembly (full capability requires dry, inert cell environment)	HFEF	–	–	–	–
Shielded sample/specimen preparation (SPHC) (full capability requires dry, inert cell environment and shielded focused ion beam milling)	–	–	–	–	–
Shielded sample/ specimen examination cells	–	–	–	–	–
Non-shielded sample/specimen examination areas (may be mapped to HC-3 or LTHC3 facility)	–	–	–	–	–
Final prepared sample/specimen storage and archive (*assuming inerted convenience container)	HFEF	CMR Wing 9 (wells)*	IFEL*	RPL (Modular Shielded Storage Unit, In-cell shielded storage boxes in MEC1/2)*	SCF*
Waste processing/ packaging (*assuming inerted convenience container)	HFEF	CMR Wing 9*	IFEL*	RPL (HLRF Cells, SAL hot cells, New Modular Hot Cells)*	SCF*


INL Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Overview of Goals, Requirements, and Criteria
www.inl.gov
INL
Idaho National Laboratory

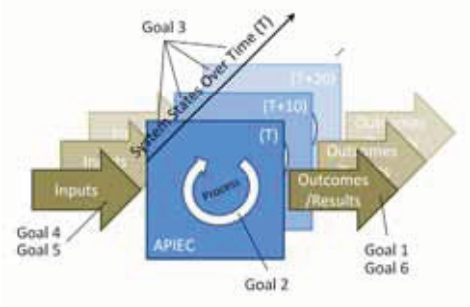

INL Idaho National Laboratory
Goals, Requirements, and Criteria - Definitions
• Goals are high-level statements of the desired states or outcomes for the Advanced Post Irradiation Examination Capabilities (APIEC) project
– Goals are assigned weights reflecting their importance to the overall APIEC success
• Requirements are conditions that any proposed solution to the problem must meet (Go / No Go) to be deemed an acceptable solution
– Not all Goals will have Requirements
• Criteria are characteristics associated with a goal that qualitatively or quantitatively measure the goodness of alternatives
– Criteria are assigned weights reflecting their importance to the associated goal

Hierarchy of Goals, Requirements, and Criteria



Goals/Reqmts Derivation and Context

- Goals and requirements were developed from:
  - Mission Need Statement and associated functional and operational requirements
  - DOE G 413.3-13 Acquisition Strategy Guide
  - PIE Strategy Documents
  - Subject matter experts
- Goals and requirements were reviewed with subject matter experts and DOE-ID
- Context



Advanced Post Irradiation Examination Capabilities Alternative Analysis
Goals and Requirements
www.inl.gov
INL
Idaho National Laboratory

INL Idaho National Laboratory
APIEC Goals
• Goal 1: Maximize Accomplishment of DOE-NE Mission Objectives
• Goal 2: Maximize Access, Usability, and Maintainability
• Goal 3: Maximize APIEC Shielded Instrument Space Reconfigurability
• Goal 4: Minimize R&D Program Outlays
• Goal 5: Minimize APIEC Outlays
• Goal 6: Minimize Safety and Health Risks

Goal 1: Maximize Accomplishment of DOE-NE Mission Objectives

- Evaluates the ability of the alternative to provide the advanced PIE capabilities that will be needed for a science-based approach to developing new nuclear fuels and materials and to support a variety of programs

Requirements

1. Supports advanced PIE to enable science-based approach
2. Supports advanced PIE needs for the four main programs
3. Acceptable to the full user community

Goal 2: Maximize Access, Usability, and Maintainability

- Evaluates selected features of the various alternatives that can impact overall APIEC operations, in other words, that might avoid known "headaches" relative to moving through the advanced PIE process

Requirements

1. Satisfies minimum number of examination and support spaces
2. Hot cell access for routine maintenance
3. Facility and hot cell availability

Goal 3: Maximize APIEC Shielded Instrument Space Reconfigurability

- Rates the flexibility of the various alternatives to be initially configured and, later, reconfigured for installation of new instruments
  - The APIEC is expected to operate for 40 years with an "instrument update" period of about 10 years

Requirements

1. None

Goal 4: Minimize R&D Program Outlays

- Evaluates the costs, in money, time, and risk, to the R&D programs that need the APIEC
- Encompasses the work performed from the time that an experiment is shipped from the irradiator, or some other intermediate facility, to the APIEC until the time that the specimen has been examined and is placed in archival storage or is disposed of as waste

Requirements

1. None

Goal 5: Minimize APIEC Outlays

- Evaluates the costs, in money and time to implement the APIEC
- Addresses the costs, schedule, and risks associated with implementing the capability

Requirements

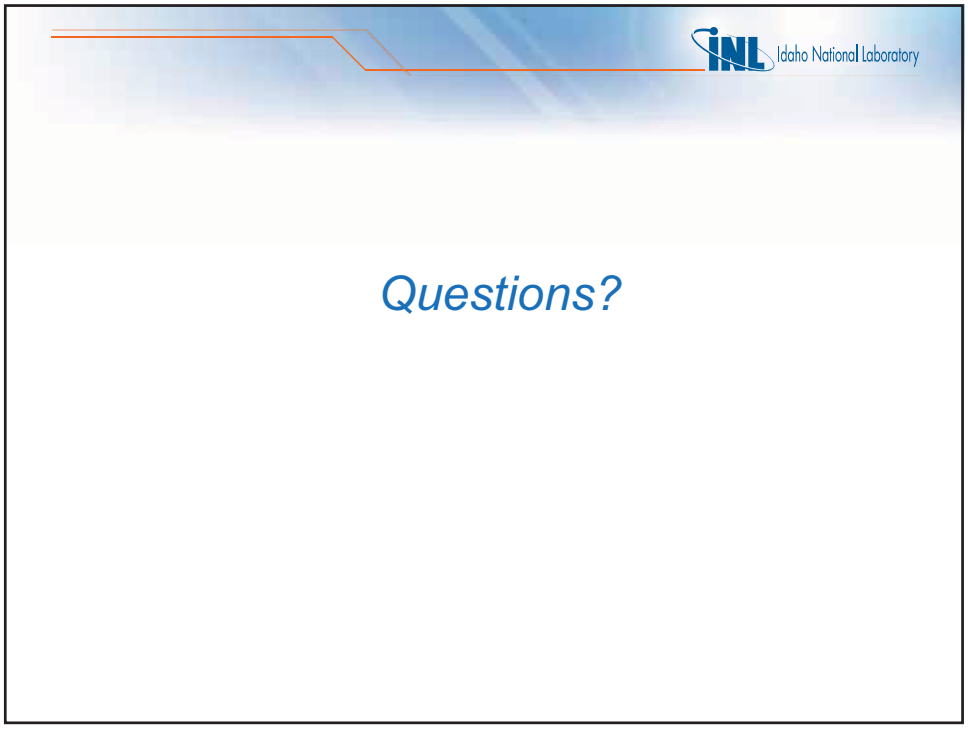
1. None

Goal 6: Minimize Safety and Health Risks

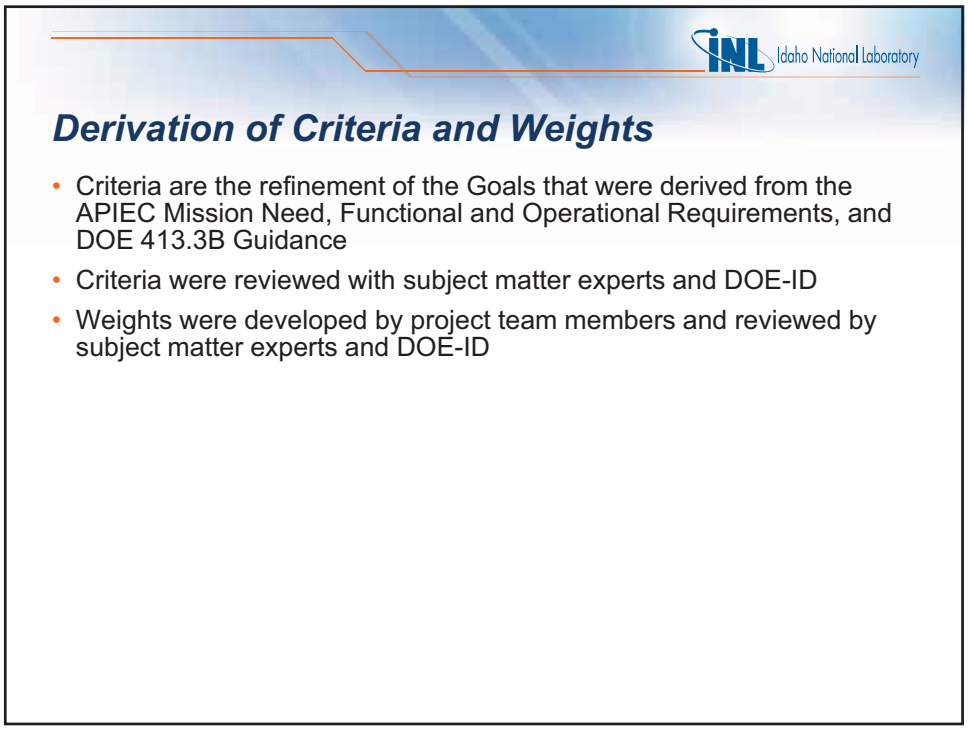
- Addresses the safety and health risks associated with the APIEC on a comparative basis
- All alternatives must comply with the minimum standards for worker, public, and environmental protection and care

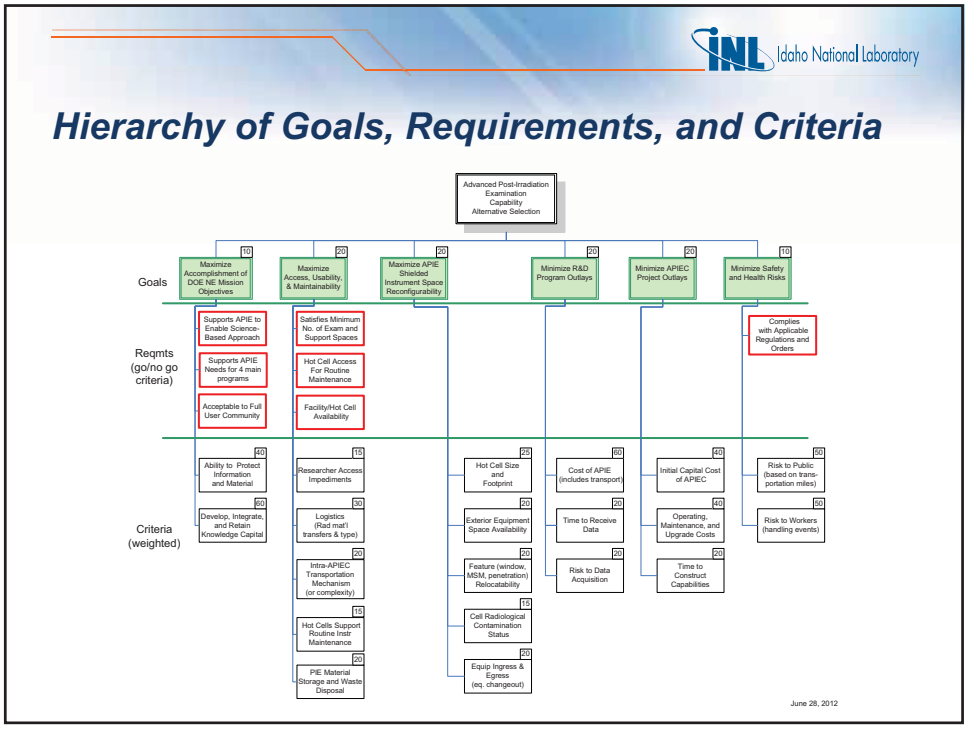
Requirements

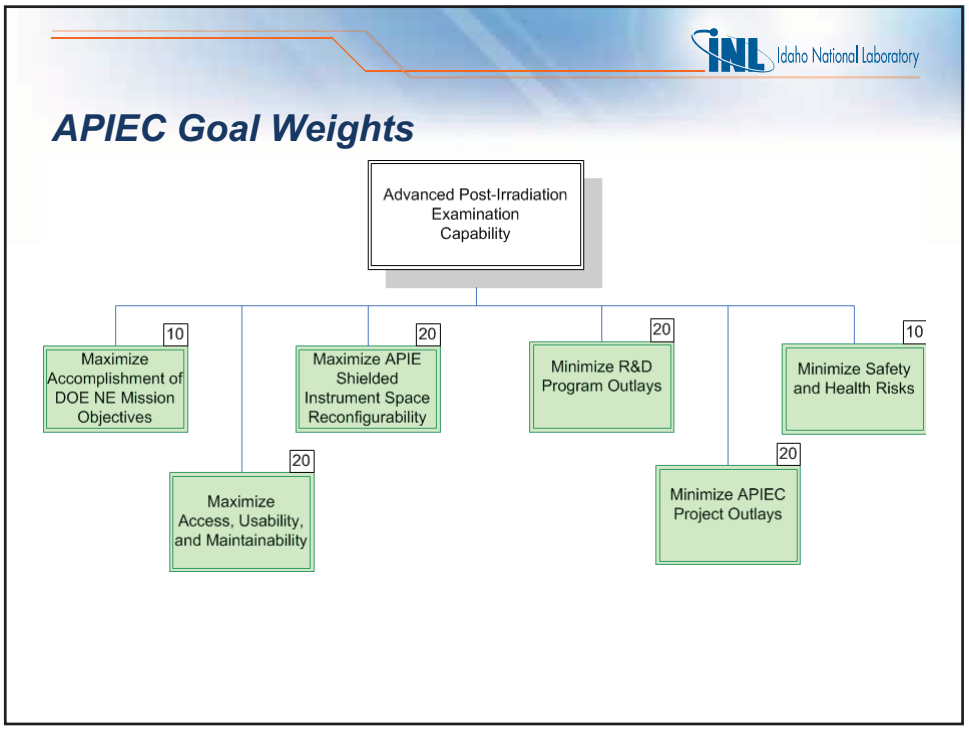
1. Complies with all applicable regulations and orders


Idaho National Laboratory
Questions?

Advanced Post Irradiation Examination Capabilities Alternative Analysis
Criteria and Weights
www.inl.gov
INL
Idaho National Laboratory


INL Idaho National Laboratory
Derivation of Criteria and Weights
• Criteria are the refinement of the Goals that were derived from the APIEC Mission Need, Functional and Operational Requirements, and DOE 413.3B Guidance
• Criteria were reviewed with subject matter experts and DOE-ID
• Weights were developed by project team members and reviewed by subject matter experts and DOE-ID


Idaho National Laboratory
Hierarchy of Goals, Requirements, and Criteria
Advanced Post-Irradiation Examination Capability Alternative Selection
Goals
Reqmts (go/no go criteria)
Criteria (weighted)
10 Maximize Accomplishment of DOE NE Mission Objectives
20 Maximize Access, Usability, & Maintainability
20 Maximize APIE Shielded Instrument Space Reconfigurability
20 Minimize R&D Program Outlays
20 Minimize APIEC Project Outlays
10 Minimize Safety and Health Risks
Supports APIE to Enable Science-Based Approach
Supports APIE Needs for 4 main programs
Acceptable to Full User Community
Satisfies Minimum No. of Exam and Support Spaces
Hot Cell Access For Routine Maintenance
Facility/Hot Cell Availability
Complies with Applicable Regulations and Orders
40 Ability to Protect Information and Material
60 Develop, Integrate, and Retain Knowledge Capital
15 Researcher Access Impediments
30 Logistics (Rad mat'l transfers & type)
20 Intra-APIEC Transportation Mechanism (or complexity)
15 Hot Cells Support Routine Instr Maintenance
20 PIE Material Storage and Waste Disposal
25 Hot Cell Size and Footprint
20 Exterior Equipment Space Availability
20 Feature (window, MSM, penetration) Relocatability
15 Cell Radiological Contamination Status
20 Equip Ingress & Egress (eq. changeout)
60 Cost of APIE (includes transport)
20 Time to Receive Data
20 Risk to Data Acquisition
40 Initial Capital Cost of APIEC
40 Operating, Maintenance, and Upgrade Costs
20 Time to Construct Capabilities
50 Risk to Public (based on trans-portation miles)
50 Risk to Workers (handling events)
June 28, 2012


Idaho National Laboratory
APIEC Goal Weights
Advanced Post-Irradiation Examination Capability
10 Maximize Accomplishment of DOE NE Mission Objectives
20 Maximize Access, Usability, and Maintainability
20 Maximize APIE Shielded Instrument Space Reconfigurability
20 Minimize R&D Program Outlays
20 Minimize APIEC Project Outlays
10 Minimize Safety and Health Risks

Criteria for Goal 1: Maximize Accomplishment of DOE NE Mission Objectives

10% of Overall Weight

1. Ability to protect information and material
   - Evaluates the ability of an alternative to protect a user's sensitive, classified, and/or proprietary information or material public disclosure and from other APIEC users
   - **40**% of Goal 1; **4**% of overall weight (9th)

2. Develop, integrate, and retain knowledge capital
   - Evaluates the alternatives' ability to develop and retain the advanced PIE skills and derived information within the United States. It also addresses the ease by which the derived information is collected and integrated with other related PIE results (e.g., NDE, chemical, isotopic, radiological) to support DOE missions.
   - **60**% of Goal 1; **6**% of overall weight (4th)

Criteria for Goal 2: Maximize Access, Usability, & Maintainability

20% of Overall Weight

1. Researcher access impediments
   - Evaluates the impact of the alternative on the effort needed from a researcher to establish agreements with the parties providing the APIE capabilities and gain access to the facility(ies). Considers the complexity of agreements to perform work, the access controls associated with each facility (e.g., clearances), and the amount of training needed to access each facility. It is expected that more facilities implies more impediments.
   - **15**% of Goal 2; **3**% of overall weight(18th)

Criteria for Goal 2: Maximize Access, Usability, & Maintainability
(cont'd)

2. Logistics (type and complexity of initial radioactive material transfers)
   - Evaluates the logistics associated with getting the irradiated fuel or material from the irradiator site to the APIEC. Covers shipment from the irradiation facility; receipt at an NDE/sizing facility; subsequent transfer from the NDE/sizing facility to the APIEC facility. Alternatives that necessitate fewer sample transfers or perform irradiation, NDE/sizing, and APIEC at the same site would rate higher.
   - **30**% of Goal 2; **6**% of overall weight (5th)

Criteria for Goal 2: Maximize Access, Usability, & Maintainability
(cont'd)

3. Intra-APIEC transportation mechanism (or complexity)
   - Evaluates the transportation needs between buildings or facilities associated with getting the samples examined after they have been received at the APIEC. Addresses transportation activities that occur after the sample has been prepared at the APIEC sample preparation area. Some options may have sample preparation located in the same building as the examination cells, while others may require transportation of the prepared sample from one building to another (it is assumed that specimen preparation and subsequent examinations are carried out on the same DOE site). Options that have sample preparation and all the examination cells in the same building would score higher than those that require shipments to other buildings, even if they are still within the facility boundary.
   - **20**% of Goal 2; **4**% of overall weight (10th)

Criteria for Goal 2: Maximize Access, Usability, & Maintainability
(cont'd)

4. Hot cells support routine instrument maintenance
   - evaluates the ease with which the maintenance activities can be performed. Cells that have a door that is readily accessible and easy to open would rate higher than cells that require a crane or fork truck to remove a wall plug for access. Cells that can implement additional pass-throughs, pneumatic transport unloading stations, and other enhancements would rate higher than cells that only have a door. Finally, this criterion also considers the amount of cell space available in which to perform the maintenance.
   - **15**% of Goal 2; **3**% of overall weight (19th)

Criteria for Goal 2: Maximize Access, Usability, & Maintainability
(concluded)

5. PIE material storage and waste disposition
   - evaluates the involved facilities' ability to store specimens after examination as well as temporary storage and disposition of the unused sample portions and resultant waste after destructive examination. This includes consideration of fuels and materials that may be accepted for examination as well as the source of the sample (e.g., government, commercial, international).
   - **20**% of Goal 2; **4**% of overall weight (11th)

Criteria for Goal 3: Maximize Shielded Instr Space Reconfigurability

20% of Overall Weight

1. Hot cell size and footprint
   - Evaluates the size (area and height) and shape (aspect ratio) of the hot cells with respect to installation of an instrument (and future instruments) in the cell. The size of a hot cell is a measure of how likely examination instruments are to fit in the hot cell. An area of 100 sq ft is considered optimal. Cell height should be at least 10 ft.
   - **25**% of Goal 3; **5**% of overall weight (6th)
2. Exterior equipment space availability
   - Evaluates the ability to locate the radiation-sensitive parts of the instrument and supporting systems outside the shielding wall but adjacent to the instrument. External equipment should be located within the parameters of the instrument requirements but in protected areas away from routine traffic patterns outside the cell.
   - **20**% of Goal 3; **4**% of overall weight (12th)

Criteria for Goal 3: Maximize Shielded Instr Space Reconfigurability

(cont'd)

3. Feature relocatability
   - Evaluates the ability to relocate features of the cell, such as windows, manipulators, and pass-throughs, to accommodate installation of a new instrument that may require certain actions. It also evaluates the ability to modify the shape of the cell (add length, width, or height).
   - **20**% of Goal 3; **4**% of overall weight (13th)
4. Cell radiological contamination status
   - Evaluates the levels of radioactive contamination in the cell, which will affect the maintenance activities or reconfiguration of the cell from both cost and personnel exposure perspectives.
   - **15**% of Goal 3; **3**% of overall weight (20th)

Criteria for Goal 3: Maximize Shielded Instr Space Reconfigurability
(concluded)

5. Equipment ingress and egress (equipment change-out)
   - evaluates the ease with which personnel and equipment can access a hot cell to replace an instrument and its associated confinement enclosure. Cells that have a way to allow access to large components (e.g., removable walls) would rate higher than cells with traditional personnel access doors only
   - **20**% of Goal 3; **4**% of overall weight (14th)

Criteria for Goal 4: Minimize R&D Program Outlays
20% of Overall Weight

1. Cost of Advanced PIE
   - evaluates the cost to the Programs incurred during the advanced PIE process. While the process includes packaging and transportation, sample preparation, examination, and reporting, the key discriminator is expected to be the transportation costs.
   - **60**% of Goal 4; **12**% of overall weight (1st)
2. Time to receive data
   - considers the time it will take to obtain the data from the advanced PIE. It spans the duration from the start of shipment from the irradiator to completion of the examination data report. Again, the number of handling events and transportation time is judged to be the key discriminator for this criterion.
   - **20**% of Goal 4; **4**% of overall weight (15th)

Criteria for Goal 4: Minimize R&D Program Outlays
(concluded)

3. Risk to data acquisition
   - evaluates the potential for data to be unavailable due to damage to or loss of the experiment, sample, or specimen. This potential for data unavailability is assumed to be related to the number of handling events and less importantly, the miles traveled in transporting the material or fuel.
   - **20**% of Goal 4; **4**% of overall weight (16th)

Criteria for Goal 5: Minimize APIEC Project Outlays
20% of Overall Weight

1. Initial capital cost of providing the APIEC
   - Evaluates capital cost including the engineering, procurement, and construction of modifications and upgrades to existing facilities or a new facility to a level that meets the requirements for deploying the APIEC, sample preparation and other handling equipment and casks.
   - Does not include costs of equipment and confinement enclosures
   - **40**% of Goal 5; **8**% of overall weight (2nd)
2. Operating, maintenance, and refurbishment costs
   - Evaluates the ongoing costs associated with maintaining the APEIC. These costs would include any costs associated with facility labor, facility utilities, facility maintenance, and periodic upgrades to the facility structure (e.g., new roof) that will be required over the 40 year life of the capability.
   - **40**% of Goal 5; **8**% of overall weight (3rd)

Criteria for Goal 5: Minimize APIEC Project Outlays
(concluded)

3. Time to Construct capabilities
   - Evaluates the time it will take to implement the APIEC
   - **20**% of Goal 5; **4**% of overall weight (17th)

Criteria for Goal 6: Minimize Safety and Health Risks
10% of Overall Weight

1. Risk to Public
   - Evaluates the real and perceived risk to the public due to the samples being shipped over the road.
   - **50**% of Goal 6; **5**% of overall weight (7th)
2. Risk to Workers
   - Evaluates the risk to facility workers. For this analysis, the risk to workers is assumed to depend on the number of handling operations.
   - **50**% of Goal 6; **5**% of overall weight (8th)

Weighting Summary

Rank	Goal No	Goal Weight	Criteria No	Criteria Weight	Description	Goal Wt*Criteria Wt*100
1	4	0.2	1	0.60	Cost of APIE	12
2	5	0.2	1	0.40	Initial Capital Cost of APIEC	8
3	5	0.2	2	0.40	Operating, Maintenance, and Upgrade Costs	8
4	1	0.1	2	0.60	Knowledge Capital Development & Integration	6
5	2	0.2	2	0.30	Logistics	6
6	3	0.2	1	0.25	Hot Cell Size and Footprint	5
7	6	0.1	1	0.50	Risk to Public	5
8	6	0.1	2	0.50	Risk to Workers	5
9	1	0.1	1	0.40	Information & Material Protection/Security	4
10	2	0.2	3	0.20	Intra-APIEC Transportation Mechanism (or complexity)	4
11	2	0.2	5	0.20	PIE Fuel and Material Storage and Waste Disposition	4
12	3	0.2	2	0.20	Exterior Equipment Space Availability	4
13	3	0.2	3	0.20	Feature Relocatability	4
14	3	0.2	5	0.20	Equipment Ingress & Egress (equipment changeout)	4
15	4	0.2	2	0.20	Time to Receive Data	4
16	4	0.2	3	0.20	Risk of Loss of Data	4
17	5	0.2	3	0.20	Time to Construct Capabilities	4
18	2	0.2	1	0.15	Researcher Access Impediments	3
19	2	0.2	4	0.15	Hot Cells Support Routine Maintenance	3
20	3	0.2	4	0.15	Cell Radiological Contamination Status	3

Questions?

Appendix B

Workshop 2 – SRC Review and Comments

Appendix B
Workshop 2 – SRC Review and Comments

Advanced PIE Capabilities Alternatives Analysis
Workshop 2 Meeting Minutes and Resolutions

September 19, 2012

Overview

Idaho National Laboratory (INL) is currently identifying and evaluating alternatives for providing Advanced Post-Irradiation Examination Capabilities (APIEC) for the Department of Energy's Office of Nuclear Energy (DOE-NE) in accordance with DOE Order DOE-O-413.3B, "Program and Project Management for the Acquisition of Capital Assets". As part of the alternatives analysis effort, a Stakeholder Review Committee (SCR) has been assembled to review and comment on the analysis as it proceeds. A series of workshops are planned during which the SRC members' comments will be obtained. These meeting minutes document the comments gathered during Workshop 2.

Attendees

The attendees at the workshop are listed below.

Name	Organization	Role
Jeffrey Bryan	INL Systems Engineering	Systems Engineer
Michael Cappiello	Consultant	SRC member
Kenneth Geelhood	Pacific Northwest National Laboratory	SRC member
Steven Hayes	INL Nuclear Fuels and Materials	Subject Matter Expert
Jody Henley	INL Systems Engineering	Meeting Facilitator
Porter Hill	INL Systems Engineering	Systems Engineer
Collin Knight	INL Nuclear Science and Technology	Scientific Coordinator
William Landman	INL Facilities Engineering	APIEC Project Engineer
Michael W. Patterson	INL Project Management	INL APIEC Project Manager
Dr. Jeff Terry	Illinois Institute of Technology	SRC member
Workshop 2 materials were presented to the SRC members listed below during individual conferences.		
Andrew Griffith	DOE-NE	SRC member
Erik Mader	Electric Power Research Institute	SRC member
Kemal Pasamehmetoglu (introduction/conclusion)	INL Nuclear Science and Technology	SRC chair
Steven Zinkle	Oak Ridge National Laboratory	SRC member

Workshop Objective

The objective of Workshop 2 was to review the progress since Workshop 1, review the Go / No Go analysis results, review and score the qualitative criteria, review the quantitative analysis and results. The SRC members scored the qualitative criteria using ThinkTank® during the workshop.

Workshop Products

The products to be produced during Workshop 2 include:

- SRC comments on criteria
- SRC comments on criteria and scoring
- Refined criteria descriptions based on SRC member input.

Workshop Presentations

The following presentations were delivered during Workshop 2 and appear at the end of this appendix:

- APIEC Introduction and Overview – Mike Patterson
- APIEC Go / No Go Analysis – Bill Landman
  - Alternative 1: No Action – Alternative will not be scored
  - Alternative 2: Modify Existing DOE Facilities – Distributed
  - Alternative 3: Modify Existing DOE Facilities – Consolidated
  - Alternative 4: Construct New Facility
  - Alternative 5: Commercial Partnerships – Alternative will not be scored
  - Alternative 6: International Partnerships – Alternative will not be scored
- APIEC Qualitative Scoring – Porter Hill / Doug Hamelin
- APIEC Quantitative Analysis and Results – Jeff Bryan

Actions

Document workshop 2 (Jody Henley)

Action completed with the submittal of Appendix B to Jeff Bryan

Comments on APIEC analysis[aa]

APIEC Go / No Go Analysis Comments

- What are the 5 main programs again? Could not find in the document. (Ken Geelhood)

  The 5 major programs are FCRD, LWRS, ATR, NR, NSUF

- The "No Go" on Alternative 5 relative to "Acceptable to full user community" is weak and likely would not warrant a NO GO. Not a strong NO / GO because it is just based on "concerns." (Ken Geelhood)
- Recognizes that the alternative fails on other requirements. (Ken Geelhood)

[aa] Comments captured in the overall workshop documentation include written comments received by SRC members

- [Go/No Go analysis] seems reasonable here. (Jeff Terry)

APIEC Qualitative Analysis Comments

- How was it decided which criteria would be qualitative and which criteria would be quantitative. For instance, exterior equipment space availability seems like that one could be scored quantitatively. (Mike Cappiello)

  Additional information added to the presentation which should help resolve the concern.

  INL completed the initial categorization of criteria as qualitative or quantitative based on what the APIEC project team believed could be adequately measured quantitatively using appropriate metrics. SRC can comment based on the individual criterion.

- Similar concern about the contamination status of the hot cells. Don't have enough information to do the qualitative scoring. Also, because decontamination costs are included in the estimate, is the contamination status really being scored twice? (Mike Cappiello)

  Discussion deferred to the Cell Radiological Status criterion section.

- For the Qualitative criteria scoring, should the alternatives be scored relative to each other where the worst gets a 6 and the best gets a 1 and the others fall somewhere in between? Or, should the alternatives be scored relative to some other standard/scale (based on scorer's judgment of "High" "Low" etc.) (Ken Geelhood)

  SRC/APIEC team concluded to score the alternatives independently relative to the scorer's judgment of "High" to "Very Low"

- Do you have a feel for the number/percentage of experiments that would be coming from ATR versus other originators(Mike Cappiello)

  80% ATR

  10% HFIR

  10% other (MURR, MITR, commercial NPPs, international]

- Sounds reasonable. (Mike Cappiello)

Develop, Integrate, and Retain Knowledge Capital

Alternative 2 - DOE Facilities (Distributed)

- Existing Infrastructure may limit flow and retention of knowledge (Andrew Griffith)
- There are advantages to having a core group of experts at multiple facilities. (Jeff Terry)
- More experts distributed across the complex will keep knowledge from being lost when one expert retires (Ken Geelhood)

Alternative 3a - IMCL (INL) and CMR (LANL)

- Existing Infrastructure may limit flow and retention of knowledge. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- Existing Infrastructure may limit flow and retention of knowledge. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- Existing Infrastructure may limit flow and retention of knowledge. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

Alternative 4b - New Facility at ORNL

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

General Comments

- Distributed alternative has advantages over the consolidated alternatives. This is because it would involve more experts (e.g., more people would get trained up to do the sample prep and PIE work… less damaging if a particular individual retires) and because there is a better chance at keeping a core group of experts for one particular technique together. (Ken Geelhood. and Jeff Terry)

Researcher Access Impediments

Alternative 2 - DOE Facilities (Distributed)

- While more researchers may have access, interaction may be limited. May be different levels of training available. (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- Distribution will allow more researchers access, interaction may be limited. May be different levels of training available(Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- Distribution will allow more researchers access, interaction may be limited. May be different levels of training available. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- Distribution will allow more researchers access, interaction may be limited. May be different levels of training available. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

- Consolidation may limit researchers' access, interaction will likely be optimized. Standard levels of training would be available. (Andrew Griffith)
- Travel to facilities is not that big of an issue. Training and Badging is not too difficult. There is not much difference. A new facility could be engineered to allow access to control rooms and not to nuclear material. (Jeff Terry)

Alternative 4b - New Facility at ORNL

- Consolidation may limit researchers' access, interaction will likely be optimized. Standard levels of training would be available (Andrew Griffith)

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

- Consolidation may limit researchers' access, interaction will likely be optimized. Standard levels of training would be available(Andrew Griffith)

Hot Cells Support Routine Equipment Maintenance

- INL might be more qualified to score the Exterior Equipment Space Availability criterion quantitatively. (Ken. Geelhood)
- I've seen most of these cells and would not have a problem scoring this [Exterior Equipment Space Availability]. (Jeff Terry)

- Is accessing the LANL cells through the hydraulically actuated back wall an involved process? (Jeff Bryan)
- No, not a big deal and it's done routinely. Means of access not a big discriminator across the alternatives. (Jeff Terry. and Mike Cappiello)
- Relative to specimen removal, does the mechanism used (e.g., rabbit vs. pig) affect time to receive data? (Mike Cappiello)

Ease of PIE Material Storage and Waste Disposition

Alternative 2 - DOE Facilities (Distributed)

- Some sites have limited capability. (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- INL has most favorable capabilities, LANL is limited. . (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- ORNL and LANL are limited when combined. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- INL and ORNL are most capable, 2 site alt. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

- Clearly, INL's ability to accept and store fuel specimens gives it a tremendous advantage. (Jeff Terry)

Alternative 4b - New Facility at ORNL

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

General Comments

- Is it still the case that experiments sent to PNNL the waste must be returned to the source after examination? (Mike Cappiello)
- Isn't that the case everywhere? (Ken. Geelhood)
- Waste typically must be sent back to the source. (Jeff Terry)

  INL has an agreement with the State of Idaho that it can receive both DOE and commercial fuels in limited quantities for research purposes and the resultant waste can be stored on-site pending identification of a final repository.

  Other sites would require the waste to be returned to the source

Exterior Equipment Space Availability

Alternative 2 - DOE Facilities (Distributed)

- Existing facilities have limited space availability, even with some facility upgrades. . (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- Existing facilities have limited space availability, even with some facility upgrades. . (Andrew Griffith)

- LANL Wing 9
  http://www.lanl.gov/history/people/DV_Docs/LASL%20News,%20December%2013,%201962.pdf (Jeff Terry)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- Existing facilities have limited space availability, even with some facility upgrades. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- Existing facilities have limited space availability, even with some facility upgrades. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

Alternative 4b - New Facility at ORNL

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

General Comments:

- Hard to differentiate between the alternatives which should be the worst alternatives. New facilities should always be better than using existing. (Jeff Terry)

Feature Relocatability

Alternative 2 - DOE Facilities (Distributed)

Alternative 3a - IMCL (INL) and CMR (LANL)

- IMCL is most capable existing facility on which to base 2-site alt. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- IMCL and 7930 are most capable existing facilities on which to base 2-site alt .(Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

Alternative 4a - New Facility at INL MFC

Alternative 4b - New Facility at ORNL

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

General Comments

Cell Radiological Status

Alternative 2 - DOE Facilities (Distributed)

- Variety of contaminated hot cells in this alt. (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- CMR is contaminated. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- CMR is contaminated. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

Alternative 4a - New Facility at INL MFC

Alternative 4b - New Facility at ORNL

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

General Comments

- We need some kind of information that tells us to what level the cells are contaminated (Mike Cappiello)

  The level of fixed contamination remaining after decontamination cannot be determined a priori. As a result this criterion will primarily evaluate the number of hot cell spaces requiring decontamination for each APIEC alternative. It is assumed that while loose contamination has been removed and the radiation fields associated with any fixed contamination is satisfactory for APIEC activities, residual contamination would remain and could resurface during reconfigurations and equipment change-out and cause additional cost and schedule delays. The estimated number of contaminated cells involved by alternative is listed:

  - *Alternative 2 (4 out of 8 at LANL, 3 out of 7 at PNNL, and 6 out of 6 at SRNL; none at INL and ORNL): 13 total*
  - *Alternative 3a (6 out of 12 at LANL; none at INL): 6 total*
  - *Alternative 3b (6 out of 12 at LANL; none at ORNL): 6 total*
  - *Alternative 3c (none at INL and ORNL): 0 total*
  - *Alternative 4 a, b, and c (none at any new facility): 0 total*

Ease of Equipment Ingress and Egress (for equipment change-out)

Alternative 2 - DOE Facilities (Distributed)

Alternative 3a - IMCL (INL) and CMR (LANL)

- IMCL and CMR have large access doors. . (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

Alternative 3c - REDC (ORNL) and IMCL (INL)

Alternative 4a - New Facility at INL MFC

- New facility designed for variety of large equipment. . (Andrew Griffith)

Alternative 4b - New Facility at ORNL

- New facility designed for variety of large equipment. . (Andrew Griffith)

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

- New facility designed for variety of large equipment. . (Andrew Griffith)

General Comments

Time to Construct Capabilities

Alternative 2 - DOE Facilities (Distributed)

- Would have to accommodate existing contamination and infrastructure. (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- CMR seismic issues would require design/construction effort to accommodate. Contamination is also a factor. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- 3.1.CMR seismic issues would require design/construction effort to accommodate. Contamination is also a factor (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- Would have to accommodate existing infrastructure (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

- Greenfield construction would require site prep, utility connections, etc. (Andrew Griffith)

Alternative 4b - New Facility at ORNL

- Greenfield construction would require site prep, utility connections, etc. (Andrew Griffith)

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

- Greenfield construction would require site prep, utility connections, etc. (Andrew Griffith)

General Comments:

- Do you have any sites in mind that have collocated operations that might cause a conflict? (Ken Geelhood)

  ORNL has Californium isotope production taking place within the same building (REDC 7930),

  LANL has cladding PIE work going on in 4 of the 16 cells,

  Alt 2 IMCL at INL would be shared with the instrument development activity (closely related) but a possible source of interference.

  Unsure whether SRNL has other work ongoing in the SCF (they were not willing to allocate more than six cells to APIEC so INL has assumed that other work is occurring there or will be occurring there during the 40 year period).

- The only work going on in CMR Wing 9 is for NE so construction of the APIEC would likely be accommodated so there is not much of a discriminator there (Mike Cappiello)

  On a sketch provided by Stuart Maloy (LANL), there is a machine shop shown in Room 9120 and another activity shown in Room 9141. Both of these rooms are adjacent to the room containing the cell blocks.

Security Risk

Alternative 2 - DOE Facilities (Distributed)

- Existing distributed facilities would pose greatest risk - most were not designed for this specific purpose (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- Limited, but manageable risk with distributed capabilities at these sites. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- Limited, but manageable risk with distributed capabilities at these sites. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- Limited, but manageable risk with distributed capabilities at these sites. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

- New, centralized facility would be most secure. (Andrew Griffith)

Alternative 4b - New Facility at ORNL

- New, centralized facility would be most secure(Andrew Griffith)

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

- New, centralized facility would be most secure. (Andrew Griffith)

General Comments

Risk to Data Acquisition

Alternative 2 - DOE Facilities (Distributed)

- More steps, more risk. (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- More steps, more risk. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- More steps, more risk. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- More steps, more risk. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

- More steps within facility, less risk. (Andrew Griffith)
- Having shipped samples around the DOE complex for over 20 years. We have only lost one. Low risk. (Jeff Terry)

Alternative 4b - New Facility at ORNL

- More steps within facility, less risk. . (Andrew Griffith)

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

- More steps within facility, less risk. . (Andrew Griffith)
- This is a really low risk. Shipped a lot of material over the years and have only lost a sample once. Not a significant issue (Jeff Terry)
- For some material shipped between INL and PNNL there was some corrosion that occurred. In alternatives where everything is being shipped, the probability for this would be greater (e.g., 4c). However, agree that there is not a huge risk here (Ken Geelhood)

Impacts of a Facility Shutdown

Alternative 2 - DOE Facilities (Distributed)

- Distributed system would ease impact. (Andrew Griffith)

Alternative 3a - IMCL (INL) and CMR (LANL)

- Distributed system would ease impact. (Andrew Griffith)

Alternative 3b - CMR (LANL) and REDC (ORNL)

- Distributed system would ease impact. (Andrew Griffith)

Alternative 3c - REDC (ORNL) and IMCL (INL)

- Distributed system would ease impact. (Andrew Griffith)

Alternative 4a - New Facility at INL MFC

Alternative 4b - New Facility at ORNL

Alternative 4c - New Facility at Other DOE Lab (No irradiation)

General Comments

- Everything looks pretty reasonable (Jeff Terry)

APIEC Quantitative Assumptions Comments

Logistics Criteria

- Since most of the irradiations would occur at the INL, the scores seem reasonable (Jeff Terry).
- It would have been preferred to have had the range of values for the utility curve set before the alternatives were scored based on expectations of what would be very good for DOE (300) and what DOE couldn't handle (1200). Others had nice justification for the low and high values
- (Ken Geelhood)
- I guess I agree, I would not have scored Alternative 2 a zero (Jeff Terry)
- A score of zero seems better applied to one of the NO GO alternatives (Mike Cappiello)

  Alternative 6 (which did not pass the GO/NO GO requirement analysis) likely represents the worst case in terms of logistics because all samples would be required to be sent overseas for analysis. This alternative could be used to set the upper range for the utility curve (i.e., the zero utility point).

- If changed, what difficulty factor should be used when comparing an international shipment to an off-site transfer? (Jeff Bryan)
- The international should be at least 3 times more difficult than a domestic off-site shipment (Jeff Terry)
- I would agree with that at least 3 or 4 (Mike Cappiello)
- I could see 16 as being an appropriate overall factor. It's definitely not trivial. (Jeff Terry)
- Consider using the worst NO GO alternative relative to a given criteria for setting the low performance boundary. (Jeff Terry)
- That may not work for every criterion (Bill Landman).

Intra-APIEC Transport

- On this criterion there is a natural minimum and maximum value that can be calculated from the columns (i.e., corresponding to 1 and 0 utility values, respectively) (Jeff Terry)
- That's a good idea (Ken Geelhood).
- Determine the minimum (best possible score) by looking across transfer activities independent of alternatives. Then find the maximum (worst possible score) across transfer activities also independent of the alternative. The report should include a justification for these values (i.e., how calculated), otherwise it would be pretty vague [Ken G., Jeff T.].

This works out to 22 (1, full utility) and 40 (0, no utility). However, the full utility value will be rounded to the nearest 10 (i.e., to 20) for reporting purposes.

Hot Cell Size and Footprint

- Most equipment will not have a perfectly square footprint. (Jeff Terry)
- Slight variation from square might not be a bad thing. Slight improvement over a "zero" aspect ratio likewise will be of little value. Suggest that values from 0 to .2 receive no utility (0) and values from .8 to 1 receive full utility (1) (Jeff Terry)
- APIEC project team will consider the suggestion as a possible change. (Jeff Bryan)

Direct Experiment Cost

- Why isn't the number of skilled technicians the same across all alternatives? (Jeff Terry)

  The skilled techs include staffing for cask shipping and receiving, sample prep, and waste handling in addition to the PIE instrument operators. The number of PIE instrument operators was the same in each option (that is, to staff the 11 instrument spaces/cells – basically one per each). The number of personnel staffing the other functions increased due to the distributed (i.e., repeated) nature of those functions and reverse economies of scale. Some job sharing was also assumed where skill sets were similar.

Time to Receive Data

- The times estimated for the different alternatives are so close to one another so spreading these between 0 and 1 does not seem appropriate. The curve should flatten out and not drop below .5 for the worst alternative.(Mike Cappiello)
- The actual uncertainty on the activities is large (~20 days) so a 40 day spread overall is hardly a basis for discriminating between them. The difference is overwhelmed by the uncertainty. (Ken Geelhood)
- Time to receive data durations seem too low. 180 days is almost a miracle. A year is not unexpected (Jeff Terry).

  These times did not include any delays.

Initial Capital Cost

- Consider having these cost estimates reviewed by the facility POCs at the individual labs to get buy-in in order to avoid potential criticism due to a perceived bias (Mike Cappiello)
- Are the costs for each alternative of comparable fidelity? (Mike Cappiello)
- Report text states that the utility curve would go from $150M to $400M, but the utility curve used shows $190M to $380M. Also the reference to Appendix F is incorrect (Ken Geelhood).
- Similar comment to before regarding these alternatives running from 0 to 1. Should use the worst case for all alternatives including any NO GO alternatives.(Mike Cappiello)

  $395M is the upper end of the cost range given in the MNS. INL will use the $150M to $400M values for the full and no utility points, respectively. It is believed that the project would not go forward if the cost exceeds the $395M upper limit and therefore, at such values, the DOE and Nuclear Research community would receive no value.

- That information/justification needs to be documented in the report (Jeff Terry)

Operating, Maintenance, Facility Refurbishment, Equipment Change-out, and D&D Costs

- In the 3b and 3c alternatives, it appears that ORNL is cheaper to use, why is that? (Ken Geelhood)

  It's believed to be that that facility is being used on a shared basis. So the APIEC costs are based on the square footage of only the cells used plus some allowance for operating area around the cells. In other alternatives APIEC is picking up the costs for the full facility (e.g., IMCL). After the 40 year period, we assumed that only what we installed into REDC 7930 would be removed and that the building would be left standing which is different situation for the IMCL or APEX alternatives.

Risk to Public and Environment

- Spreading the alternatives from 0 to 1 (setting the utility curve range based on the minimum to maximum values for the alternatives) seems to be overly weighting the relatively small difference in number of miles, particularly in light of the number of miles driven for WIPP shipments. The actual risk is fairly minimal (Jeff Terry)

Risk to Workers

- Same comment as for Risk to Public and Environment (Jeff Terry, Ken Geelhood)
- Suggest adding in the non-discriminator activities (similar to cell size and footprint where many of the cells were of similar size). Would help to show that the risk to workers isn't particularly high for any of these, in part, because of the many non-discriminator activities (Ken Geelhood)

Path Forward

Timing for Workshop 3 discussed.

Additional Comments

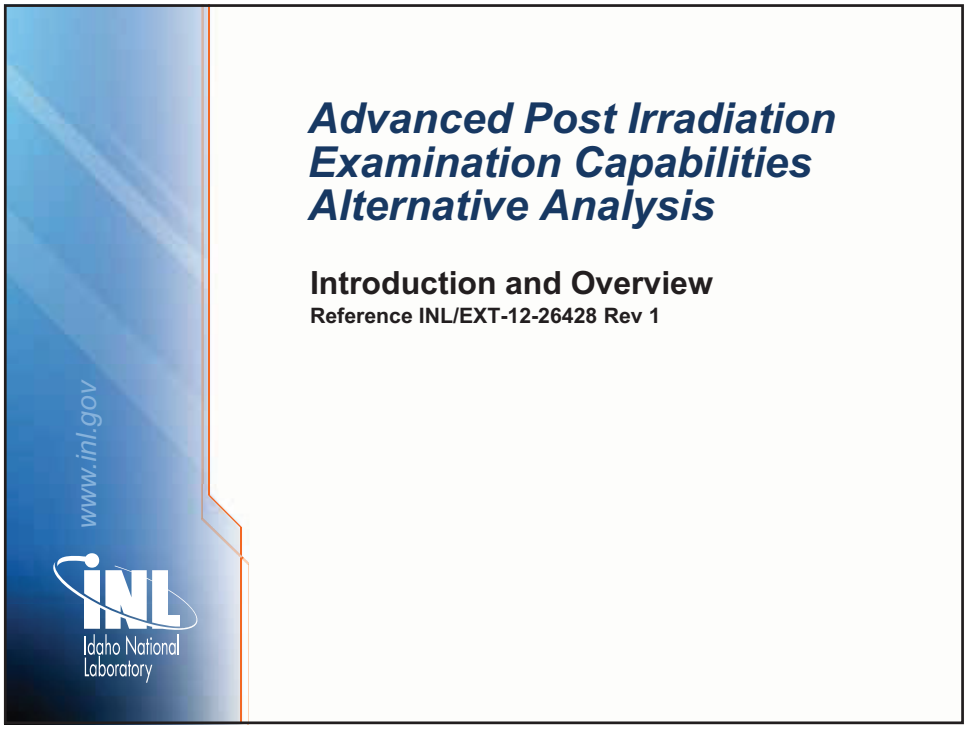
The SRC raw scoring summary for the qualitative criteria is included in Table B-1 and Table B-2.

Table B-1. Summary for SRC raw scores (with standard deviation) for qualitative criteria

	Alt 2 - DOE Facilities (Distributed)		Alt 3a - IMCL (INL) & CMR (LANL)		Alt 3b - CMR (LANL) & REDC (ORNL)		Alt 3c - REDC (ORNL) & IMCL (INL)		Alt 4a - New Facility at INL MFC		Alt 4b - New Facility at ORNL		Atl 4c - New Facility at Other DOE Lab (No irradiation)	
Criteria:	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Develop, Integrate and Retain Knowledge Capital	3.43	1.72	2.86	0.90	3.29	0.95	3.00	0.82	1.29	0.49	1.71	0.76	2.00	0.82
Researcher Access Impediments	3.71	1.11	2.71	0.76	2.71	0.76	2.43	0.53	1.43	0.53	1.57	0.53	1.71	0.49
Hot Cell Support Routine Instrument Maintenance	4.29	1.11	3.57	0.53	3.29	0.49	2.86	0.90	1.29	0.76	1.29	0.76	1.29	0.76
Ease of PIE Material Storage & Waste Disp.	4.43	0.53	3.43	0.98	4.57	1.13	2.86	0.90	1.00	0.00	3.86	1.57	3.86	1.46
Exterior Equipment Space Avail.	4.00	1.29	3.14	0.38	3.71	0.76	3.00	0.58	1.29	0.49	1.29	0.49	1.29	0.49
Feature Relocatability	3.86	1.21	2.57	0.79	3.71	1.25	2.43	0.79	1.00	0.00	1.00	0.00	1.00	0.00
Cell Radiation Contamination Status	4.57	0.98	3.14	1.07	3.29	0.95	1.57	0.53	1.00	0.00	1.00	0.00	1.00	0.00
Ease of Equip. Ingress/Egress	4.00	1.15	2.14	0.90	3.14	0.90	3.14	0.69	1.00	0.00	1.00	0.00	1.00	0.00
Time to Construct Capabilities	4.60	1.14	3.20	0.45	4.00	0.71	3.00	0.71	1.60	0.89	1.60	0.89	1.60	0.89
Security Risk	3.71	2.06	2.57	1.27	2.57	1.27	2.43	1.13	1.86	1.21	1.86	1.21	1.86	1.21
Risk to Workers	3.60	1.67	2.60	0.55	3.00	1.00	2.60	0.55	1.60	0.55	1.80	0.84	1.80	0.84
Risk to Data Acquisition	3.86	1.07	2.86	1.07	3.29	1.11	2.71	0.95	1.29	0.49	1.86	1.07	2.00	1.29
Impact of Facility Shutdown	2.43	0.98	2.86	0.69	2.86	0.69	2.86	0.69	3.71	1.38	3.71	1.38	3.86	1.07

Table B-2. Summary for SRC raw scores (with low/high range) for qualitative criteria

	Alt 2 - DOE Facilities (Distributed)		Alt 3a - IMCL (INL) & CMR (LANL)		Alt 3b - CMR (LANL) & REDC (ORNL)		Alt 3c - REDC (ORNL) & IMCL (INL)		Alt 4a - New Facility at INL MFC		Alt 4b - New Facility at ORNL		Atl 4c - New Facility at Other DOE Lab (No irradiation)	
Criteria:	**Average**	**Low/High**	**Average**	**Low/High**	**Average**	**Low/High**	**Average**	**Low/High**	**Average**	**Low/High**	**Average**	**Low/High**	**Average**	**Low/High**
Develop, Integrate and Retain Knowledge Capital	3.43	1 5	2.86	2 4	3.29	2 4	3.00	2 4	1.29	1 2	1.71	1 3	2.00	1 3
Researcher Access Impediments	3.71	2 5	2.71	2 4	2.71	2 4	2.43	2 3	1.43	1 2	1.57	1 2	1.71	1 2
Hot Cell Support Routine Instrument Maintenance	4.29	2 5	3.57	3 4	3.29	3 4	2.86	2 4	1.29	1 3	1.29	1 3	1.29	1 3
Ease of PIE Material Storage & Waste Disp.	4.43	4 5	3.43	2 5	4.57	3 6	2.86	2 4	1.00	1 1	3.86	2 6	3.86	2 6
Exterior Equipment Space Avail.	4.00	2 6	3.14	3 4	3.71	3 5	3.00	2 4	1.29	1 2	1.29	1 2	1.29	1 2
Feature Relocatability	3.86	2 5	2.57	2 4	3.71	2 6	2.43	2 4	1.00	1 1	1.00	1 1	1.00	1 1
Cell Radiation Contamination Status	4.57	3 6	3.14	2 5	3.29	2 4	1.57	1 2	1.00	1 1	1.00	1 1	1.00	1 1
Ease of Equip. Ingress/Egress	4.00	2 5	2.14	1 4	3.14	2 4	3.14	2 4	1.00	1 1	1.00	1 1	1.00	1 1
Time to Construct Capabilities	4.60	3 6	3.20	3 4	4.00	3 5	3.00	2 4	1.60	1 3	1.60	1 3	1.60	1 3
Security Risk	3.71	1 6	2.57	1 4	2.57	1 4	2.43	1 4	1.86	1 4	1.86	1 4	1.86	1 4
Risk to Workers	3.60	2 6	2.60	2 3	3.00	2 4	2.60	2 3	1.60	1 2	1.80	1 3	1.80	1 3
Risk to Data Acquisition	3.86	2 5	2.86	1 4	3.29	1 4	2.71	1 4	1.29	1 2	1.86	1 3	2.00	1 4
Impact of Facility Shutdown	2.43	1 4	2.86	2 4	2.86	2 4	2.86	2 4	3.71	1 5	3.71	1 5	3.86	2 5


Advanced Post Irradiation Examination Capabilities Alternative Analysis
Introduction and Overview
Reference INL/EXT-12-26428 Rev 1
www.inl.gov
INL
Idaho National Laboratory

INL Idaho National Laboratory
Agenda
• Meeting administration
• Progress Since Workshop 1
• Go / No Go Analysis Results (Bill Landman)
• Qualitative Scoring (Porter Hill/Doug Hamelin)
– Process Overview
– ThinkTank Orientation
– Qualitative score collection
• Quantitative Analysis and Results (Jeff Bryan)
• Adjourn

Administration

- We have the ability to record all or parts of this session. **Are there any objections to recording this workshop?**
- All comments on the report are welcome during or after the meeting - Please send them to Bill Landman (bill.landman@inl.gov / 208-526-7170) or Jeff Bryan (jeffrey.bryan@inl.gov / 208-526-1899)

Progress Since Workshop 1

- Workshop 1 comment response / incorporation into Rev. 1 of APIEC Alternatives Analysis Report (INL/EXT-12-26428)
- Meeting minutes for Workshop 1 are in Appendix A of report
- Go / No Go analysis
- Qualitative criteria refinement for scoring during Workshop 2
- Quantitative analysis for estimating metrics, developing utility curves

Advanced Post Irradiation Examination Capabilities Alternative Analysis

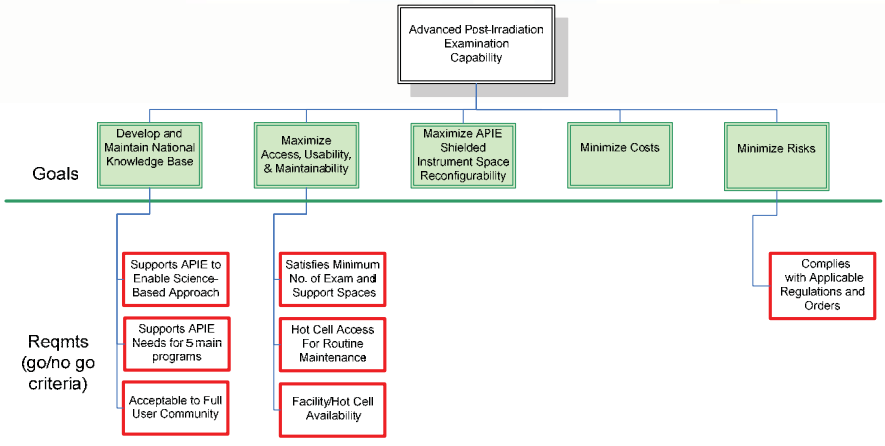
Go / No Go Criteria Review

Reference INL/EXT-12-26428 Rev 1

www.inl.gov

Idaho National Laboratory

Go / No Go Criteria



Alternative 1: No Action

Requirements	Go / No Go	Comments
Supports APIEC Science Based Approach	GO	This alternative provides minimal support of advanced PIE using instrumentation that is or could be made available at IMCL, LANL, PNNL, SRNL and ORNL, but likely not on an equivalent production basis or for the full suite of anticipated characterization analyses. The IMCL's instrument development shielded cell capabilities are only expected to support small quantities of specimens which would limit throughput.
Supports APIEC Needs for 5 main Programs	NO GO	Among other things, this alternative does not allow the necessary modifications to support installation of inert systems into existing facilities and therefore does not support the Fuel Cycle R&D (FCRD) program, which is expected to include pyrophoric fuel materials and sodium-bearing fuels that will require inert atmospheres for sample preparation and examination
Acceptable to full User Community	NO GO	Given that modifications cannot be made to provide the inert gas systems support the FCRD program, this alternative does not satisfy this requirement.
Satisfies Minimum No. of Exam and Support Spaces	NO GO	None of these facilities provide the necessary number of shielded examination cells and support spaces, either individually or collectively.
Hot Cell Access For Routine Maintenance	GO	Most facilities considered in this alternative have access of some sort into the cells for routine maintenance, although the access may not be ideal (e.g., roof hatches).
Facility / Hot Cell Availability	GO	It is assumed that the facilities identified in the alternative are available.
Complies with Applicable Regulations and Orders	GO	This alternative meets this requirement.

Alternative will **NOT** be scored because it does not pass all the GO/NO GO requirements

Alternative 2: Modify Existing DOE Facilities – Distributed

Requirements	Go / No Go	Comments
Supports APIEC Science Based Approach	GO	This alternative supports advanced PIE to enable the science-based approach through necessary facility modifications and new instrument installation.
Supports APIEC Needs for 5 main Programs	GO	This alternative includes modifications to existing facilities (e.g., inert atmosphere capabilities and hot cell enhancements) that will support the needs of the DOE programs identified in the Mission Need document.
Acceptable to full User Community	GO	This alternative is expected to be acceptable to the full user community.
Satisfies Minimum No. of Exam and Support Spaces	GO	The minimum number of examination and support spaces have been identified for this alternative.
Hot Cell Access For Routine Maintenance	GO	All hot cells identified for use in this alternative have or will be modified to have access for routine maintenance.
Facility / Hot Cell Availability	GO	All the facilities identified in the alternative are reported to be available.
Complies with Applicable Regulations and Orders	GO	This alternative has been defined in a manner such that it will include necessary modifications or other attributes to meet this requirement.

Alternative will be scored because it satisfies all the GO/NO GO requirements

Alternative 3: Modify Existing DOE Facilities – Consolidated

Requirements	Go / No Go	Comments
Supports APIEC Science Based Approach	GO	This alternative supports advanced PIE to enable the science-based approach through necessary facility modifications and new instrument installation.
Supports APIEC Needs for 5 main Programs	GO	This alternative includes modifications to existing facilities (e.g., inert atmosphere capabilities and hot cell enhancements) that will support the needs of the DOE programs identified in the Mission Need document.
Acceptable to full User Community	GO	This alternative is expected to be acceptable to the full user community.
Satisfies Minimum No. of Exam and Support Spaces	GO	This alternative is expected to be acceptable to the full user community. The minimum number of examination and support spaces have been identified for this alternative.
Hot Cell Access For Routine Maintenance	GO	All hot cells identified for use in this alternative have or will be modified to have access for routine maintenance.
Facility / Hot Cell Availability	GO	All the facilities identified in the alternative are reported to be available.
Complies with Applicable Regulations and Orders	GO	This alternative has been defined in a manner such that it will include necessary modifications or other attributes to meet this requirement.

Alternative will be scored because it satisfies all the GO/NO GO requirements

Alternative 4: Construct New Facility

Requirements	Go / No Go	Comments
Supports APIEC Science Based Approach	GO	This alternative supports advanced PIE to enable the science-based approach through construction of a state-of-the-art hot cell laboratory and installation of advance PIE instruments.
Supports APIEC Needs for 5 main Programs	GO	The new facility will be designed and constructed to specifically support the needs of the programs identified in the Mission Need document.
Acceptable to full User Community	GO	This alternative is expected to be acceptable to the full user community.
Satisfies Minimum No. of Exam and Support Spaces	GO	The new facility will be designed with the minimum number of examination and support spaces and may also provide additional space for expansion.
Hot Cell Access For Routine Maintenance	GO	The hot cells in the new facility will be designed for routine maintenance as well as change-out of the inert confinement enclosures.
Facility / Hot Cell Availability	GO	The new facility will be dedicated to the performance of advanced PIE.
Complies with Applicable Regulations and Orders	GO	This alternative has been defined in a manner such that it will include necessary features and attributes to meet this requirement.

Alternative will be scored because it satisfies all the GO/NO GO requirements

Alternative 5: Commercial Partnerships

Requirements	Go / No Go	Comments
Supports APIEC Science Based Approach	GO	This alternative is assumed to support advanced PIE to enable science-based approach. The existing commercial facilities do not currently support advanced PIE but it is assumed that contractual agreements between the suppliers and DOE can be achieved to allow the commercial suppliers to modify their facilities to meet the advanced PIE requirements.
Supports APIEC Needs for 5 main Programs	NO GO	The commercial suppliers do not currently handle irradiated nuclear fuels. Therefore, they cannot support the Fuel Cycle R&D program.
Acceptable to full User Community	NO GO	This alternative is not expected to be acceptable to the full user community. There is a concern that some commercial entities will not use a competitor's facilities due to potential for loss of business sensitive information.
Satisfies Minimum No. of Exam and Support Spaces	NO GO	The cells currently available from domestic commercial suppliers are not sufficient, on their own, to meet the minimum required number of cells.
Hot Cell Access For Routine Maintenance	GO	The hot cells in the commercial suppliers' facilities have access that can be used for routine maintenance.
Facility / Hot Cell Availability	GO	It is likely that the commercial suppliers will prefer to use their facilities to support both DOE and their own development programs. It is assumed that contractual agreements between the suppliers and DOE can be achieved to allow the DOE access to the hot cells in a timely manner.
Complies with Applicable Regulations and Orders	GO	It is expected that the commercial entities identified would fully comply with applicable federal, state, and DOE orders and directives such that this alternative would meet this requirement.

Alternative will **NOT** be scored because it does not pass all the GO/NO GO requirements

Alternative 6: International Partnerships

Requirements	Go / No Go	Comments
Supports APIEC Science Based Approach	GO	This alternative is assumed to support advanced PIE to enable science-based approach. There are existing international facilities that support advanced PIE.
Supports APIEC Needs for 5 main Programs	NO GO	From a technical perspective, the international facilities can likely support the five main programs identified in the Mission Need document. However, due to the expense associated with international transportation of samples, from a financial perspective, the University Programs likely could not afford to use this alternative to achieve their research goals. Most of the international capabilities are located in air cells so there is an issue as to whether the full suite of characterization capabilities would be modified and made available for samples requiring inert atmosphere processing.
Acceptable to full User Community	NO GO	This alternative is not expected to be acceptable to the full user community. The Naval Nuclear Propulsion Program will not be able to use foreign facilities.
Satisfies Minimum No. of Exam and Support Spaces	GO	A combination of cells from various international facilities can provide the minimum number of examination and support spaces.
Hot Cell Access For Routine Maintenance	GO	The hot cells in the international facilities have access that can be used for routine maintenance
Facility / Hot Cell Availability	GO	It is likely that the international facilities will use their facilities to support both DOE and their own development programs. It is assumed that agreements between the operators of the international facilities and DOE can be achieved to allow the DOE access to the hot cells in a timely manner.
Complies with Applicable Regulations and Orders	GO	This alternative meets this requirement.

Alternative will **NOT** be scored because it does not pass all the GO/NO GO requirements

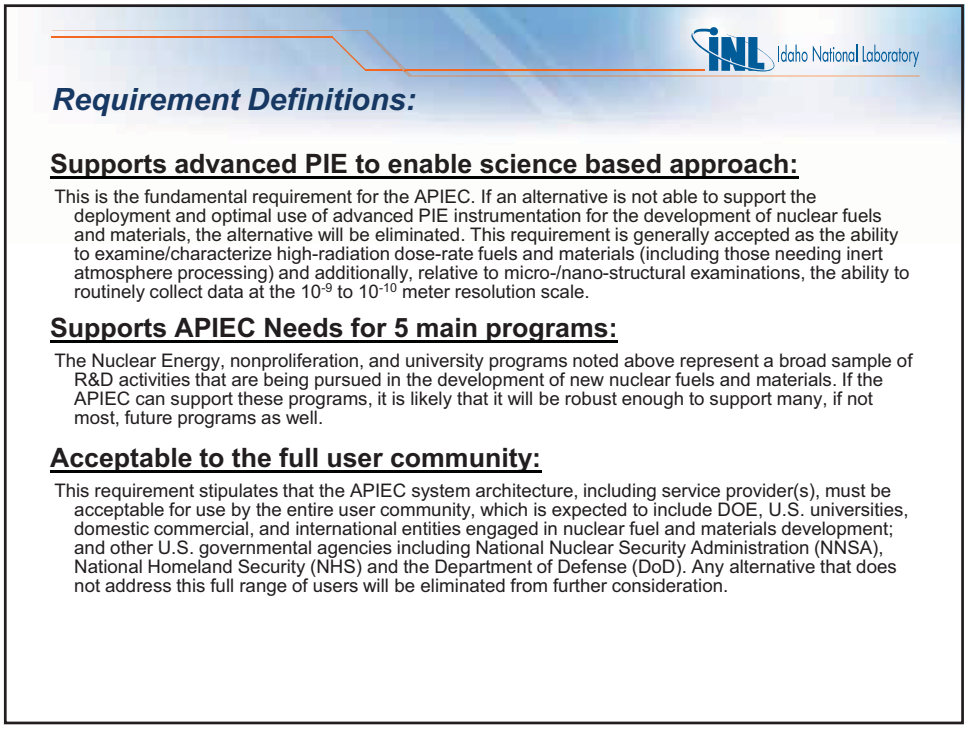
Go / No Go Criteria summary

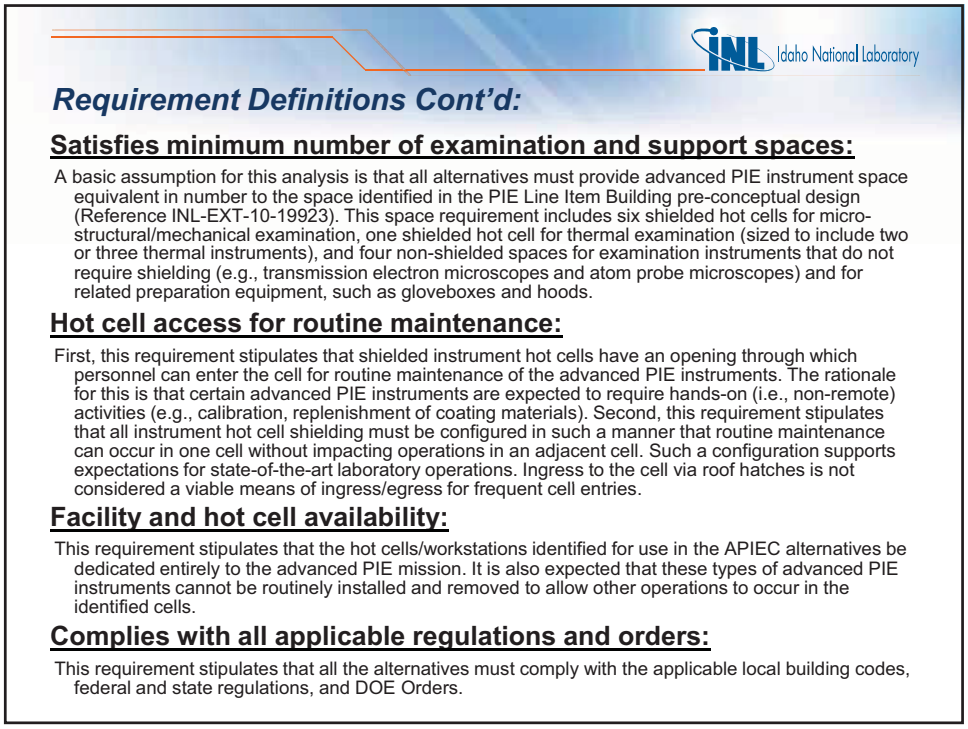
Alternative	Supports Science based approach	Supports 5 main programs	accepts full user community	has minimum number of exam spaces	Hot cell access for maintenance	Facility availability	Complies with Regulations
1	GO	NO GO	NO GO	NO GO	GO	GO	GO
2	GO	GO	GO	GO	GO	GO	GO
3	GO	GO	GO	GO	GO	GO	GO
4	GO	GO	GO	GO	GO	GO	GO
5	GO	NO GO	NO GO	NO GO	GO	GO	GO
6	GO	NO GO	NO GO	GO	GO	GO	GO

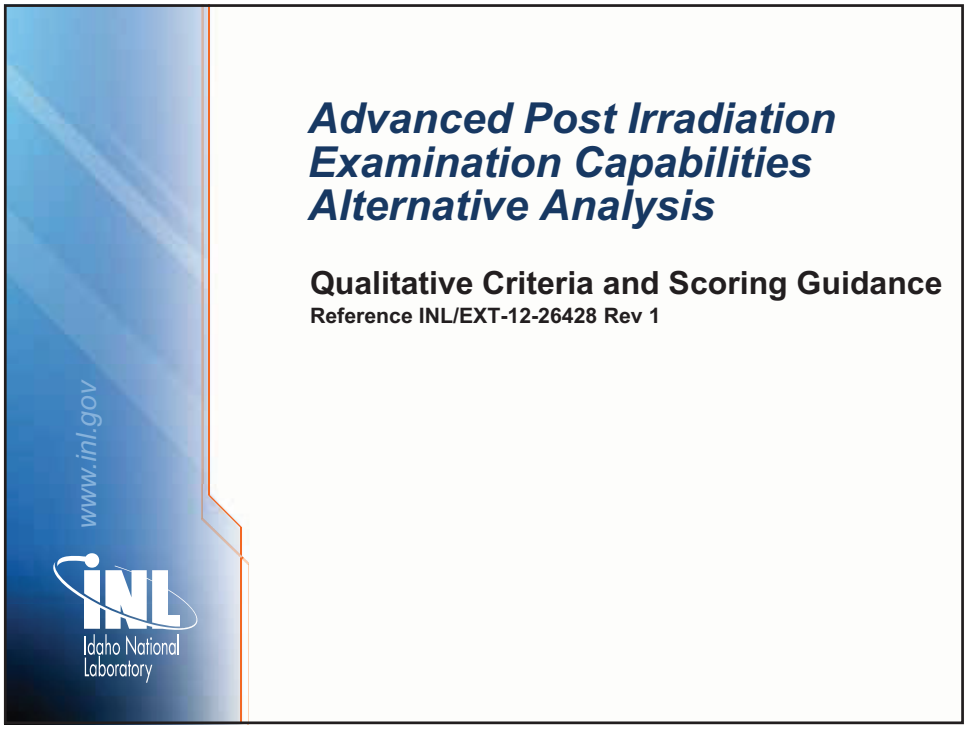
Alternatives 2, 3a,3b, 3c, 4a, 4b, 4c will be the only alternatives scored.

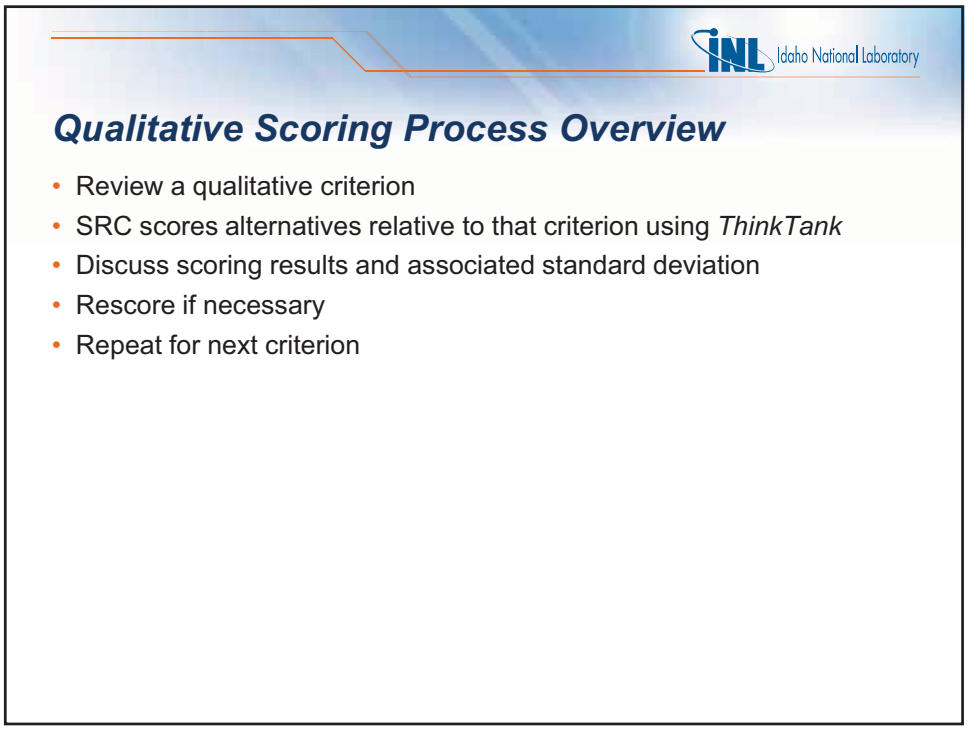
Questions?

INL Idaho National Laboratory
BACK UP SLIDES


INL Idaho National Laboratory
Requirement Definitions:
Supports advanced PIE to enable science based approach:
This is the fundamental requirement for the APIEC. If an alternative is not able to support the deployment and optimal use of advanced PIE instrumentation for the development of nuclear fuels and materials, the alternative will be eliminated. This requirement is generally accepted as the ability to examine/characterize high-radiation dose-rate fuels and materials (including those needing inert atmosphere processing) and additionally, relative to micro-/nano-structural examinations, the ability to routinely collect data at the 10-9 to 10-10 meter resolution scale.
Supports APIEC Needs for 5 main programs:
The Nuclear Energy, nonproliferation, and university programs noted above represent a broad sample of R&D activities that are being pursued in the development of new nuclear fuels and materials. If the APIEC can support these programs, it is likely that it will be robust enough to support many, if not most, future programs as well.
Acceptable to the full user community:
This requirement stipulates that the APIEC system architecture, including service provider(s), must be acceptable for use by the entire user community, which is expected to include DOE, U.S. universities, domestic commercial, and international entities engaged in nuclear fuel and materials development; and other U.S. governmental agencies including National Nuclear Security Administration (NNSA), National Homeland Security (NHS) and the Department of Defense (DoD). Any alternative that does not address this full range of users will be eliminated from further consideration.


Idaho National Laboratory
Requirement Definitions Cont'd:
Satisfies minimum number of examination and support spaces:
A basic assumption for this analysis is that all alternatives must provide advanced PIE instrument space equivalent in number to the space identified in the PIE Line Item Building pre-conceptual design (Reference INL-EXT-10-19923). This space requirement includes six shielded hot cells for micro-structural/mechanical examination, one shielded hot cell for thermal examination (sized to include two or three thermal instruments), and four non-shielded spaces for examination instruments that do not require shielding (e.g., transmission electron microscopes and atom probe microscopes) and for related preparation equipment, such as gloveboxes and hoods.
Hot cell access for routine maintenance:
First, this requirement stipulates that shielded instrument hot cells have an opening through which personnel can enter the cell for routine maintenance of the advanced PIE instruments. The rationale for this is that certain advanced PIE instruments are expected to require hands-on (i.e., non-remote) activities (e.g., calibration, replenishment of coating materials). Second, this requirement stipulates that all instrument hot cell shielding must be configured in such a manner that routine maintenance can occur in one cell without impacting operations in an adjacent cell. Such a configuration supports expectations for state-of-the-art laboratory operations. Ingress to the cell via roof hatches is not considered a viable means of ingress/egress for frequent cell entries.
Facility and hot cell availability:
This requirement stipulates that the hot cells/workstations identified for use in the APIEC alternatives be dedicated entirely to the advanced PIE mission. It is also expected that these types of advanced PIE instruments cannot be routinely installed and removed to allow other operations to occur in the identified cells.
Complies with all applicable regulations and orders:
This requirement stipulates that all the alternatives must comply with the applicable local building codes, federal and state regulations, and DOE Orders.


Advanced Post Irradiation Examination Capabilities Alternative Analysis
Qualitative Criteria and Scoring Guidance
Reference INL/EXT-12-26428 Rev 1
www.inl.gov
INL
Idaho National Laboratory


INL Idaho National Laboratory
Qualitative Scoring Process Overview
• Review a qualitative criterion
• SRC scores alternatives relative to that criterion using ThinkTank
• Discuss scoring results and associated standard deviation
• Rescore if necessary
• Repeat for next criterion

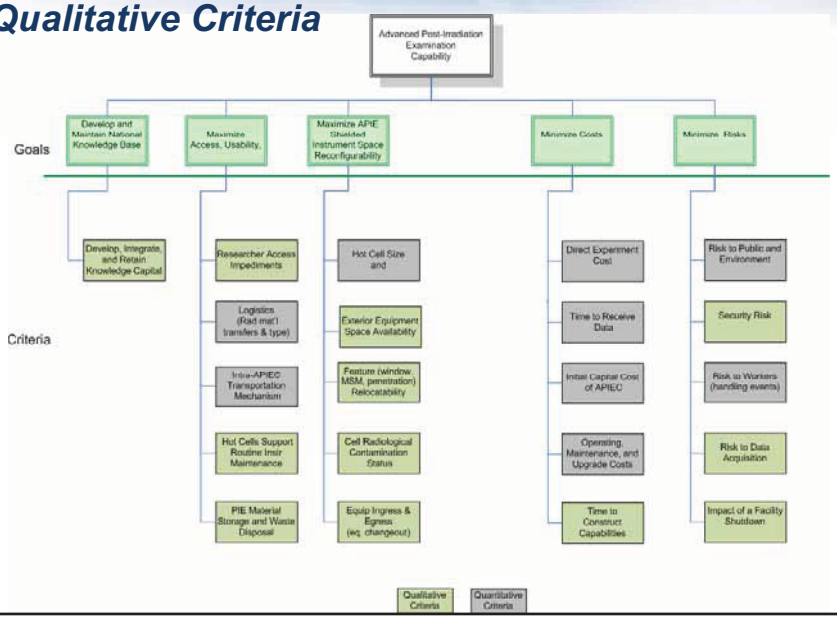
ThinkTank Orientation

- Use *ThinkTank* decision support software to record scores
  - 12 scoring (voting) activities – one for each Qualitative criterion
  - Use qualitative scale (1 to 6) to score each alternative against each criterion
    - 1 is always best performance
    - 6 is always worst performance
  - Opportunity to comment or document basis for scores given for each alternative
  - *ThinkTank* returns average of scores and standard deviation
  - *ThinkTank* environment login and familiarization

https://thinktank.inl.gov

Meeting ID: **22**
Passkey: **APIEC**
GUEST
Email and **Screen Name**

Qualitative Criteria



Criterion: Develop, Integrate, and Retain Knowledge Capital

Criterion Definition:

This criterion addresses the ability to:

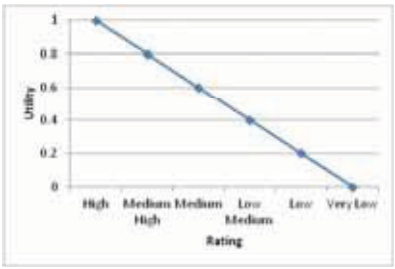
Develop and retain in the U.S., experience in deploying the advanced PIE instrumentation; the technical expertise to prepare specimens for examination; and the technical expertise to operate and maintain these advanced instruments remotely in high radiation environments.

Obtain and retain the data from the advanced examinations and integrate that information with other programs.

Facilitate communications across all phases of the experiment program, from design of the experiment to its irradiation and subsequent examination, for the purpose of identifying and incorporating process improvement.

Considerations for Scoring

- The number of locations where the PIE work will be performed
- Access to personnel engaged in other nuclear development programs
- Researcher access to experiment designers, safety analysts, and other PIE team members.
- Alternatives that allow more of the APIEC functions to be performed domestically by U.S. researchers and technicians or that promote better communication across the PIE life-cycle will score higher.



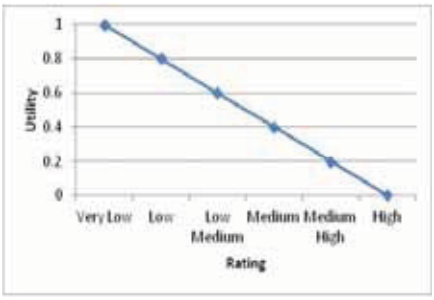
Criterion: Researcher Access Impediments

Criterion Definition:

This criterion evaluates the impact of the alternatives on the researcher in using the APIEC, and the complexities that of gaining access to the facilities.

Considerations for Scoring

- The number of facilities that researchers are required to access to perform work
- Access controls associated with each facility
- Amount of training to access each facility
- Note: Low impediments score higher (1)



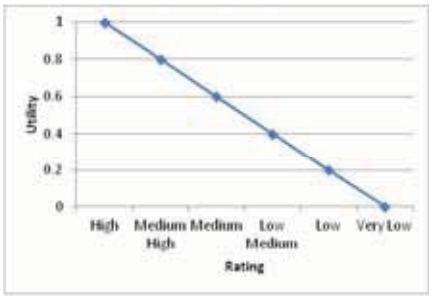
Criterion: Hot Cells Support Routine Instrument Maintenance

Criterion Definition:

This criterion is used to evaluate the alternatives on the ease with which the maintenance activities can be performed.

Considerations for Scoring

- Person operated doors are more favorable than a crane operated door
- In cell storage or rabbit system is more favorable than cask removal of sample prior to entry
- In cell space is critical for operators and maintenance workers.
- A cell that has sufficient space is more favorable than one that is tight fitting with equipment
- Note: A high level of support receives a high score (1)



Add'l Considerations for Hot Cells Support Routine Instrument Maintenance

Alt	Site	Facility	# of cells	Means of Routine Ingress	Specimen removal	Cell Size (W x L x H, ft)
2	INL	IMCL	2	Personnel door in MSE	Shielded Pig	9.75 x 9.75 x 11.75
	LANL	CMR W9	1	Hydr actuated back wall	Shielded Pig	6 x 12 x 11
	ORNL	7930	2	Door in concrete wall	Rabbit	16 x 9.5 x 21
	PNNL	RPL	1	Personnel door in MSE	Shielded Pig	12 x 6 x 8.5
	SRNL	SCF	1	Door in concrete wall	Shielded Pig	12 x 6 x 15
3A	INL	IMCL	4	Personnel door in MSE	Shielded Pig	9.75 x 9.75 x 11.75
	LANL	CMR W9	3	Hydr actuated back wall	Shielded Pig	6 x 12 x 11
3B	LANL	CMR W9	3	Hydr actuated back wall	Shielded Pig	6 x 12 x 11
	ORNL	7930	2 2	Door in concrete wall	Rabbit	16 x 9.5 x 21 15 x 9.5 x 13
3C	INL	IMCL	3	Personnel door in MSE	Shielded Pig	9.75 x 9.75 x 11.75
	ORNL	7930	2 2	Door in concrete wall	Rabbit	16 x 9.5 x 21 15 x 9.5 x 13
4	various	APEX	7	Personnel door in MSE	Rabbit	10 x 10 x 12

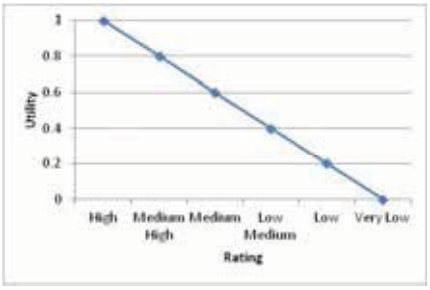
Criterion: PIE Material storage and disposition

Criterion Definition:

This criterion evaluates the involved facilities' ability to store specimens after examination as well as temporary storage and disposition of the unused sample portions and resultant waste after destructive examination.

Considerations for Scoring

- Ability to provide interim storage for fuel
- Means of non-fuel waste disposal



Additional Considerations for PIE Material storage and disposition

Facility	Fuel Receipt	Interim Fuel Storage	Other Waste
INL	Existing agreement with state of Idaho to receive quantities of DOE and commercial fuel	Currently storing	Developing RH LLW disposal on-site. Can also ship to commercial LLW disposal sites
LANL	Case by case basis to receive	Not storing	Can ship to commercial LLW disposal sites
ORNL	Case by case basis to receive	Not storing	Limited on-site disposal. Can ship to commercial LLW disposal sites
PNNL	Case by case basis to receive	Currently storing, limited additional	On-site. Can also ship to commercial LLW disposal sites
SRNL	Case by case basis to receive	Currently storing	On-site. Can also ship to commercial LLW disposal sites

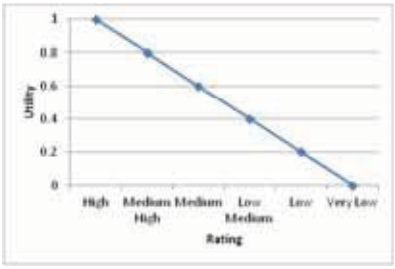
Criterion: Exterior Equipment Space Availability

Criterion Definition:

This criterion evaluates the ability to locate the instrument support system and radiation-sensitive components outside of the shielding wall but adjacent to the instrument. Ideally, this external equipment should be located within the parameters of the instrument requirements but in protected areas away from instrument operators and routine traffic patterns outside the cell.

Considerations for Scoring

- The size, proximity, and location of available space for installing the instrument support system and radiation-sensitive components
- Installations that allow the external equipment to be located within the parameters of the instrument requirements and in protected areas away from instrument operators and routine traffic patterns outside the cell will rate higher.



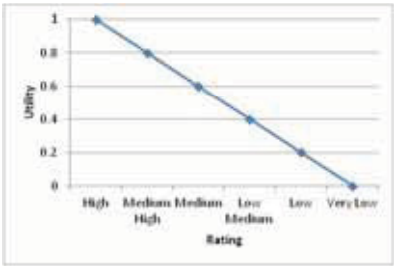
Criterion: Feature Relocatability

Criterion Definition:

This criterion evaluates the ability to relocate features of the cell, such as windows, manipulators, and pass-throughs, to accommodate installation of a new instrument that may require certain actions (e.g., placing the specimen in the machine). It should also evaluate the ability to modify the shape, or footprint, of the cell (e.g., add length, width, or height).

Considerations for Scoring

- Cells that can easily accommodate relocation of pass-throughs or telemanipulators will rate higher.
- Cells with the ability to change their footprint to accommodate deploying a new instrument will rate higher.
- INL, PNNL and new facilities would have modular cells and would score higher and all other facilities have fixed cells.



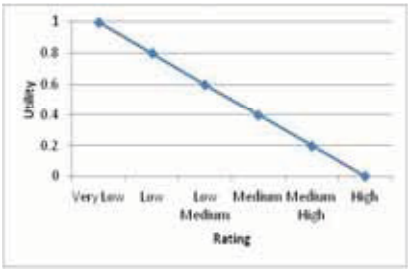
Criterion: Cell Radiological Contamination Status

Criterion Definition:

This criterion evaluates the levels of radioactive contamination in the cell, which will affect the maintenance activities or reconfiguration of the cell from both cost and personnel exposure perspectives. For this analysis, it is assumed that all existing cells that are proposed will be used to house APIEC instruments and will be decontaminated to levels that are as low as reasonably achievable.

Considerations for Scoring

- Cells that have minimal or no contamination will rate higher than contaminated steel-lined cells, which will rate higher than cells with concrete surfaces
- INL, ORNL and new facility hot cells currently have no contamination



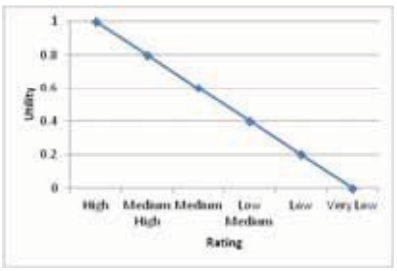
Criterion: Equipment Ingress and Egress (Equip.Change-out)

Criterion Definition:

This criterion evaluates the ease with which personnel and equipment can access a hot cell to replace an instrument and its associated confinement enclosure.

Considerations for Scoring

- Cells that allow large components to be easily removed/installed (e.g., full-width removable walls) will rate higher than cells with only personnel access doors.
- INL, LANL, PNNL, and new facility have large area ingress / egress doors



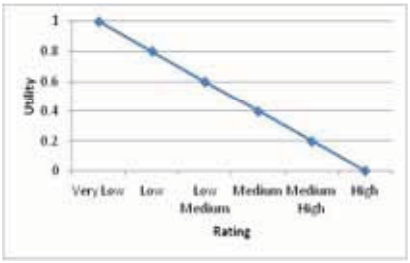
Criterion: Time to Construct Capabilities

Criterion Definition:

This criterion evaluates the time it will take to implement the APIEC.

Considerations for Scoring

- New construction versus modification of existing facilities
- Levels of radiological contamination expected to be encountered
- Possible interference with collocated operations
- New facilities typically require less time in design, field verification, and construction as compared to the retrofitting of existing facilities.



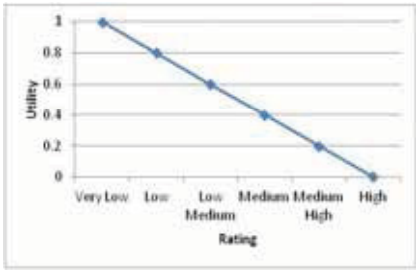
Criterion: Security Risk

Criterion Definition:

This criterion evaluates the security risk associated with unauthorized access to material or data.

Considerations for Scoring

- Physical security measures at each of the facilities
- A facility that offers higher level of protection would result in lower risk
- Alternatives that involve more sites, less stringent physical security measures, or that require samples to spend more time in transit will rate higher for risk.



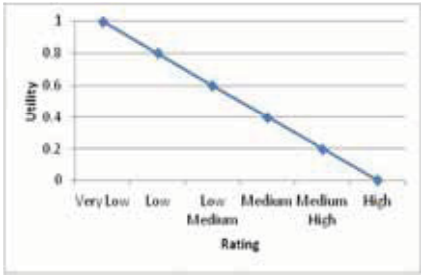
Criterion: Risk to Data Acquisition

Criterion Definition:

This criterion evaluates the potential for data to be unavailable due to damage to or loss of the experiment or prepared specimen

Considerations for Scoring

- Number of handling events or number of shipments would increase the potential for sample damage
- The type of shipment (i.e., inter-site or intra-site)
- The modes of transportation (e.g., rabbit, carry/cart, cask, vehicle etc.)



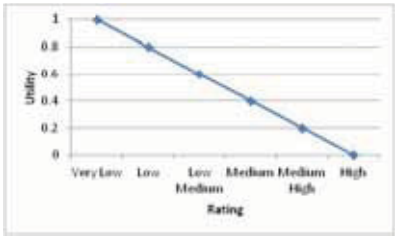
Criterion: Impacts of facility shutdown

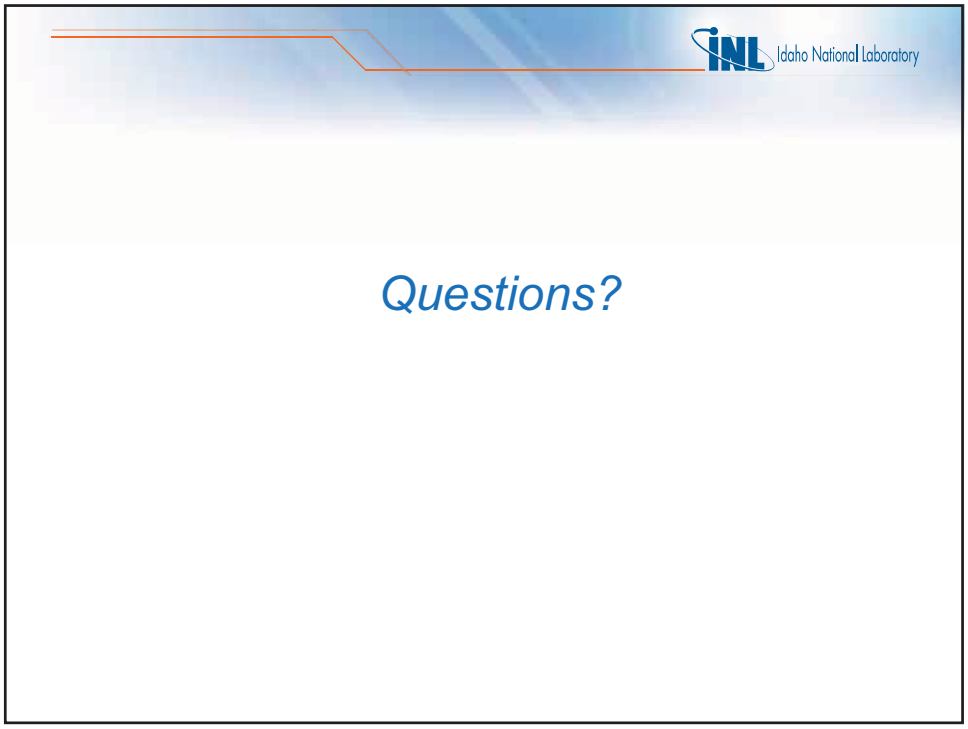
Criterion Definition:

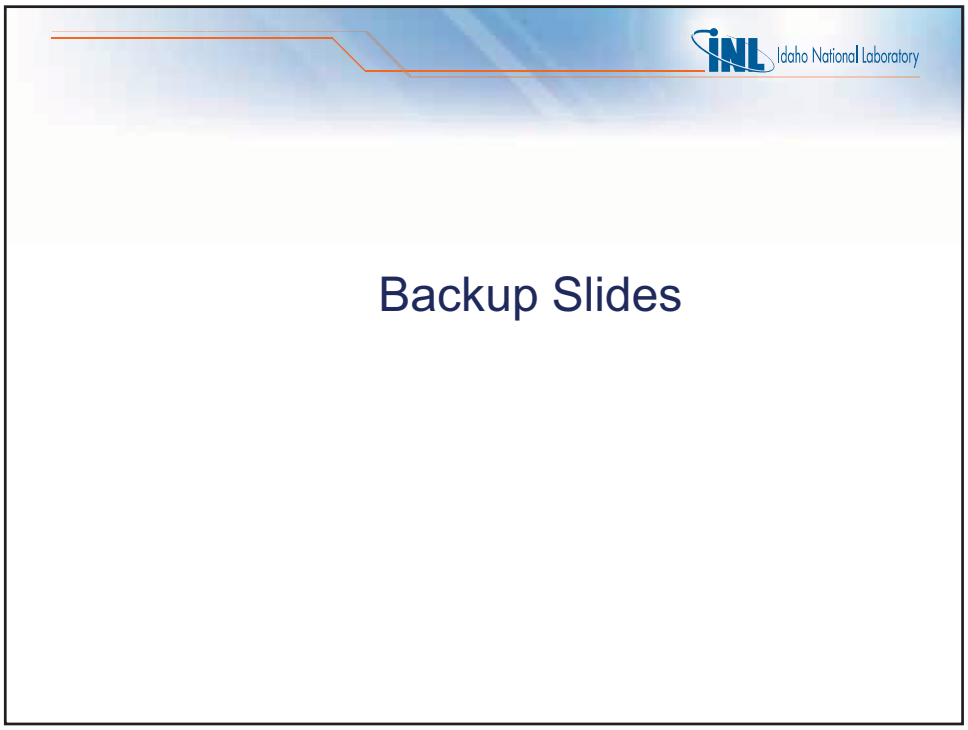
This criterion evaluates the impact of a facility shutdown, if one occurs, on the APIEC mission and the need to obtain the PIE data.

Considerations for Scoring

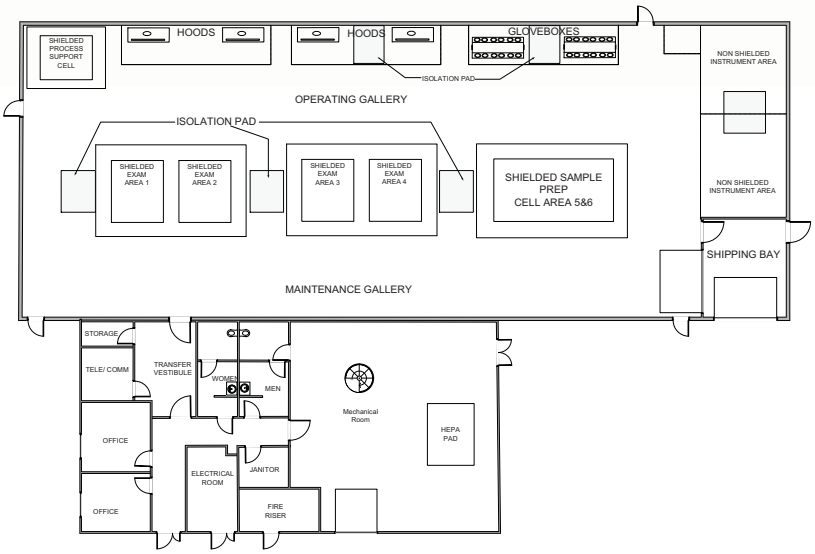
- The number of facilities that make up the APIEC would impact this criterion the larger number of facilities would result in less impact
- It is assumed that all facilities have the same probability of an incident



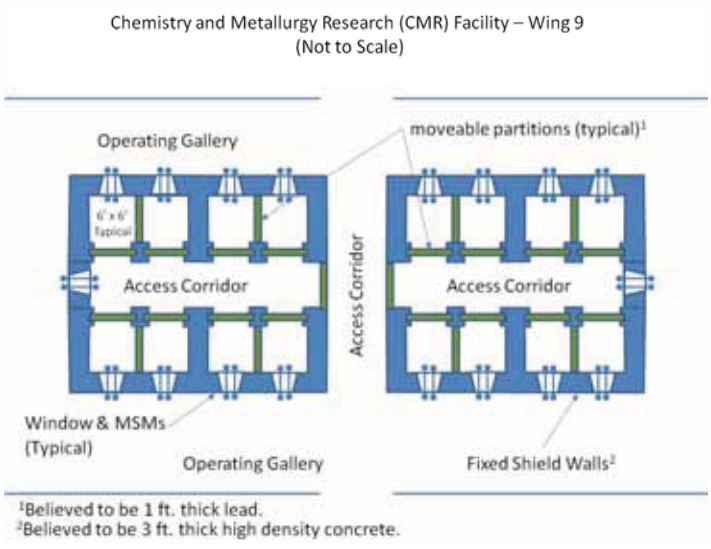

Idaho National Laboratory
Questions?


Idaho National Laboratory
Backup Slides

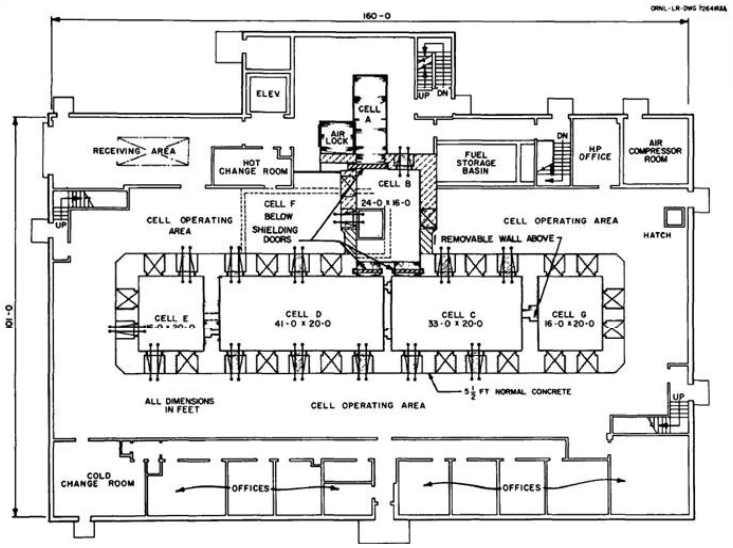
IMCL Facility Floor Plan



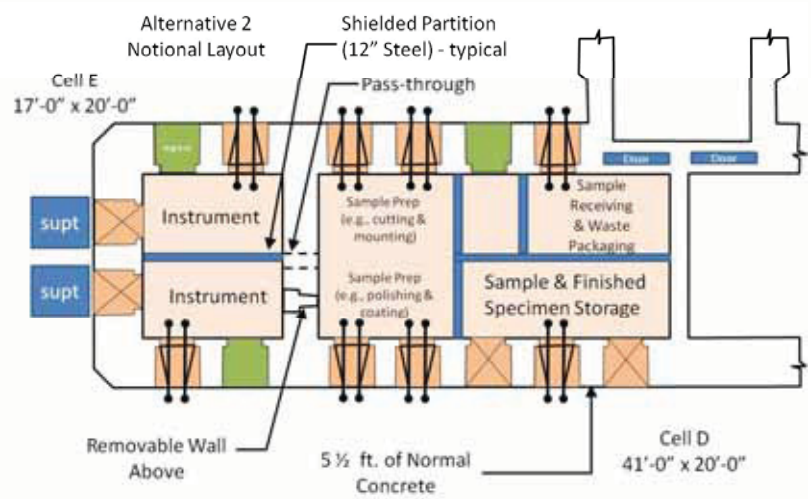
CMR Wing 9 Facility Floor Plan Sketch



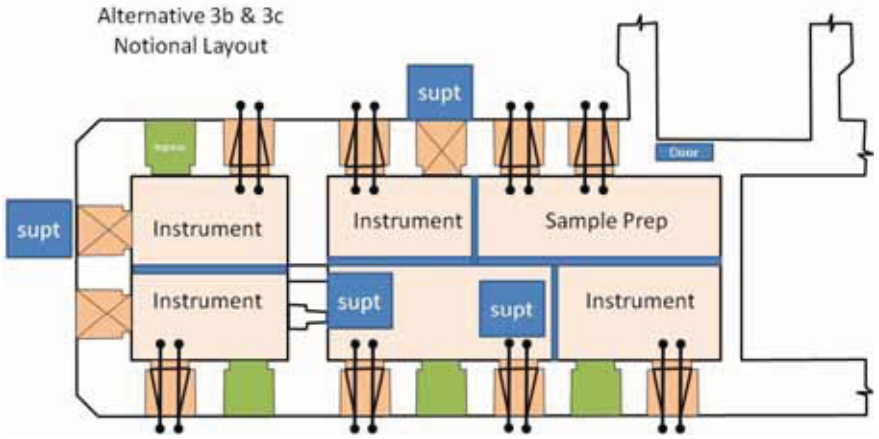
ORNL REDC 7930 Facility Floor Plan



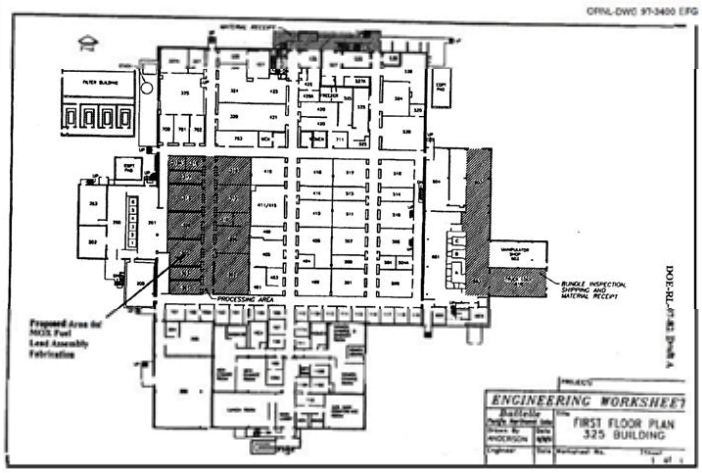
ORNL REDC 7930 – Cells D and E Plan



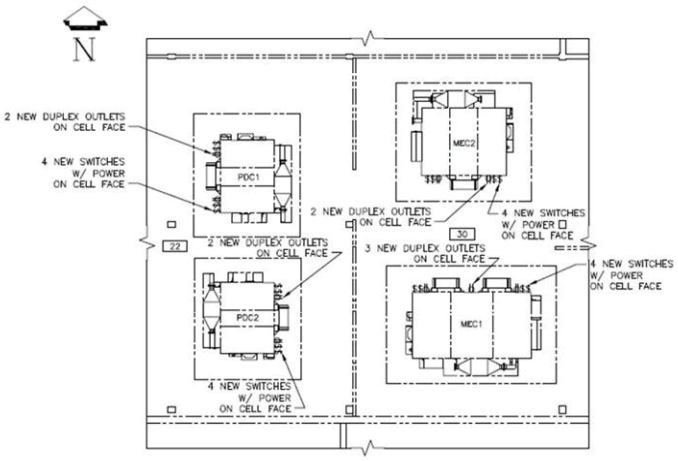
ORNL REDC 7930 – Cells D and E Plan



RPL at PNNL Facility Floor Plan



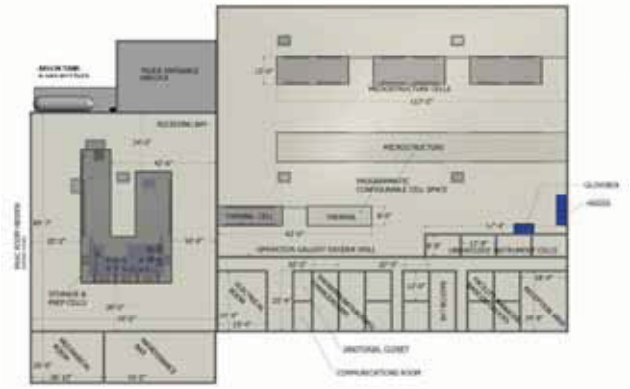
PDC1 and MEC1 at PNNL Facility Floor Plan

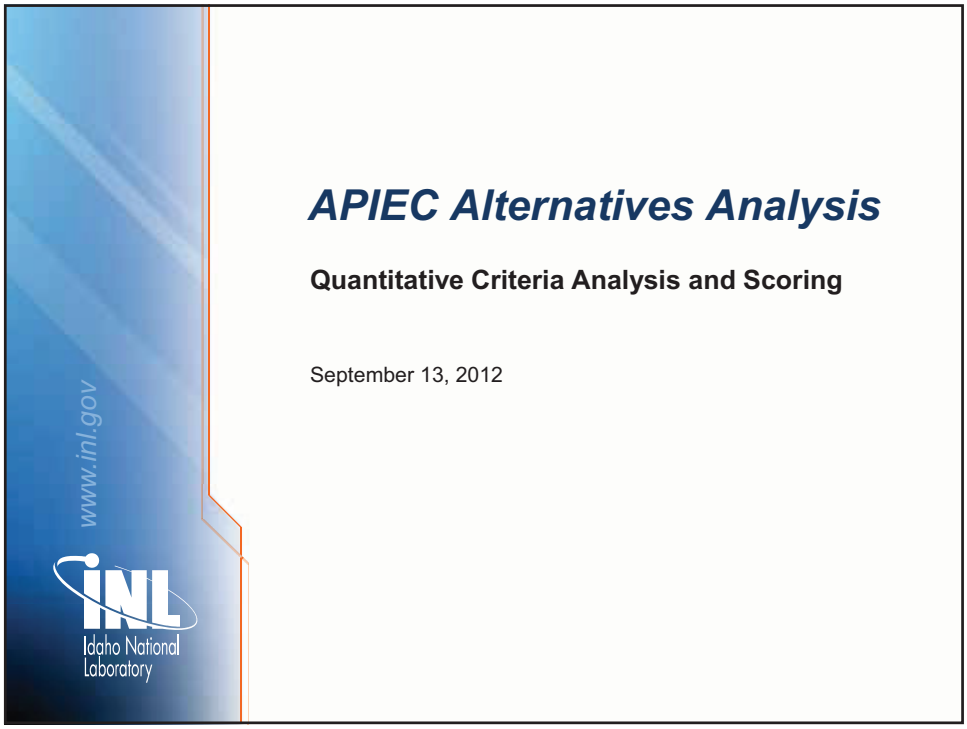


SRNL Shielded Cells Facility Floor Plan

Plan View E-Wing Cell Blocks A & B and Cells' Support Space

APEX Facility Floor Plan




APIEC Alternatives Analysis
Quantitative Criteria Analysis and Scoring
September 13, 2012
www.inl.gov
INL
Idaho National Laboratory

INL Idaho National Laboratory
Quantitative Criteria
• Goal 1 – Develop and Maintain National Knowledge Base
– None
• Goal 2 – Maximize Access, Usability, & Maintainability
– Logistics
– Intra-APIEC Transportation
• Goal 3 – Maximize APIE Shielded Instrument Space Reconfigurability
– Hot Cell Size and Footprint
• Goal 4 – Minimize Costs
– Initial Capital Cost of APIEC
– Direct Experiment Cost
– Operating, Maintenance and Refurbishment Costs
– Time to Receive Data
• Goal 5 – Minimize Risks
– Risk to Public and Environment
– Risk to Workers

Logistics – Description

- Assesses the type and complexity of radioactive material transfers
- Based on the numbers of on- and off-site transfers and destinations for analyzing irradiation experiments within each alternative.
- Includes shipment from the irradiation facility; receipt at an NDE/sizing facility; and subsequent transfer(s) from the NDE/sizing facility to the APIEC facility(ies).
- Score Calculation:

Logistics score = (total number of yearly on-site shipments) + 4 × (total number of yearly off-site shipments) + (total number of required off-site destinations per year)

Note: The weighting factor of 4 applied to the number of off-site shipments was selected to reflect the relative difficulty/complexity of making off-site shipments as compared to on-site shipments.

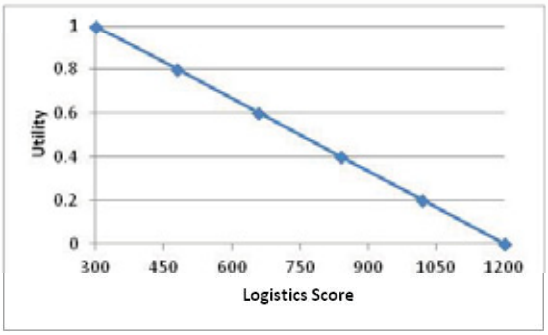
Logistics – Assumptions

1. 100 experiments irradiated per year
2. 80% of experiments are irradiated at ATR, 10% irradiated at HFIR, and 10% are irradiated at "other" facilities (e.g., commercial NPPs, MURR, MITR, international)
3. Experiment NDE, size reduction, and/or repackaging needed for all experiments:
   - at HFEF for experiments irradiated at ATR
   - at IFEL for experiments irradiated at HFIR
   - equal split between HFEF and IFEL for experiments irradiated at all other facilities
4. Shipments between ATR and HFEF are batched (i.e., 20 experiments per shipment) based on past practice. All other APIEC shipments are assumed to be 1 per experiment (with rented cask used for irradiator-to-APIEC and off-site shipments).
5. In the distributed and consolidated alternatives, the sample is cut into an appropriate number of pieces (based on the number of facilities participating in the APIEC)
6. In the distributed and consolidated alternatives, all of the experiment pieces going off-site are placed in a single cask which then makes a circuit to all of the other facilities involved in that alternative via the shortest route
7. APIEC performs two cask handling "events" per on-site shipment (with DOE-owned cask)
8. Shipments from "other" irradiators require only one handling event -- when received.
9. Off-site shipments require a cask handling event at the NDE/Sizing facility and one at each destination (APIEC facility)

Note: A cask handling event is defined as an open, package/unpackage, and close sequence.

Logistics – Raw Scores and Utility Curve

Alt #	Logistics Score
2	1178
3a	863
3b	793
3c	878
4a	338
4b	618
4c	678



Intra-APIEC Transportation – Description

- Assesses APIEC alternatives' transport needs after sample preparation
- Based on the types of mechanisms present to perform transfers of specimens within each alternative
- Score Calculation:

Sample Prep to Shielded Exam Cell(s) Mechanism Point Value × Number of Cells + **Sample Prep to Non-Shielded Space(s) Mechanism Point Value × Number of Spaces** + **Return to Storage / Waste Processing Mechanism Point Value × Number of Cells**

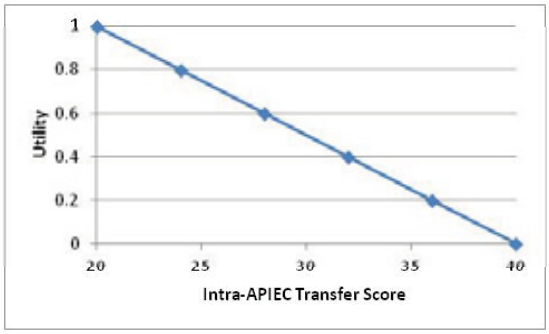
- Evaluates these mechanisms based on an assigned point value and the number of instances each mechanism is used in the alternative:
  - Intra-Facility Rabbit: 1 pt.
  - Manual Transfer Using Shielded/Unshielded Transfer Device - Intra-Building: 2 pts.
  - Manual Transfer Using Shielded/Unshielded Transfer Device - Inter-Building (same site Area): 3 pts.
  - Manual Transfer Using Shielded/Unshielded Transfer Device – Intra-Site (same Lab): 4 pts.

Intra-APIEC Transportation – Results

Alt #	Description	Sample Prep to Shielded Exam Cells	Sample Prep to Non-Shielded Instrument Space	Return to Storage from Shielded Exam Cells	Totals
2	IMCL @ INL	2 @ 2 pts = 4 pts	1 @ 2 pts = 2 pts	2 @ 2 pts = 4 pts	34
	CMR W9 @ LANL	1 @ 2 pts = 2 pts	N/A	1 @ 2 pts = 2 pts	
	RPL @ PNNL	1 @ 2 pts = 2 pts	1 @ 2 pts = 2 pts	1 @ 2 pts = 2 pts	
	REDC 7930 @ ORNL	2 @ 1 pt = 2 pts	1 @ 4 pts = 4 pts	2 @ 1 pt = 2 pts	
	SCF @ SRNL	1 @ 2 pts = 2 pts	1 @ 2 pts = 2 pts	1 @ 2 pts = 2 pts	
		Subtotal: 12 pts	Subtotal = 10 pts	Subtotal: 12 pts	
3a	IMCL @ INL	4 @ 2 pts = 8 pts	2 @ 2 pts = 4 pts	4 @ 2 pts = 8 pts	36
	CMR W9 @ LANL	3 @ 2 pts = 6 pts	2 @ 2 pts = 4 pts	3 @ 2 pts = 6 pts	
		Subtotal: 14 pts	Subtotal: 8 pts	Subtotal: 14 pts	
3b	CMR W9 @ LANL	3 @ 2 pts = 6 pts	2 @ 2 pts = 4 pts	3 @ 2 pts = 6 pts	32
	REDC 7930 @ ORNL	4 @ 1 pts = 4 pts	2 @ 4 pts = 8 pts	4 @ 1 pts = 4 pts	
		Subtotal: 10 pts	Subtotal: 12 pts	Subtotal: 10 pts	
3c	IMCL @ INL	3 @ 2 pts = 6 pts	2 @ 2 pts = 4 pts	3 @ 2 pts = 6 pts	32
	REDC 7930 @ ORNL	4 @ 1 pts = 4 pts	2 @ 4 pts = 8 pts	4 @ 1 pts = 4 pts	
		Subtotal: 10 pts	Subtotal: 12 pts	Subtotal: 10 pts	
4a	APEX @ INL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
4b	APEX @ ORNL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
4c	APEX @ LANL, PNNL, SNL, or SRNL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22

Intra-APIEC Transportation – Raw Scores and Utility Curve

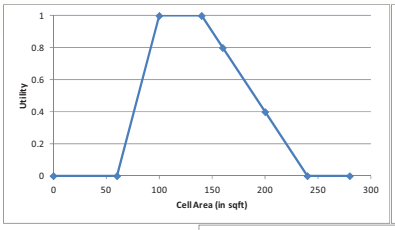
Alt #	Intra-APIEC Transfer Score
2	34
3a	36
3b	32
3c	32
4a	22
4b	22
4c	22

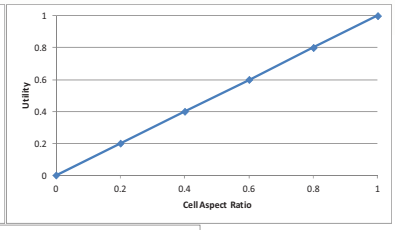


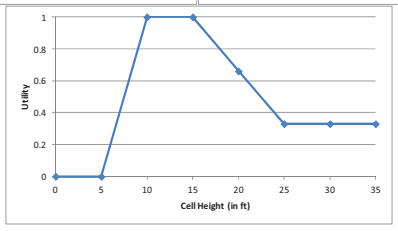
Hot Cell Size and Footprint – Description

- Assesses how well the shielded examination cells involved in each alternative meet the desired *area*, *aspect ratio*, and *height* sub-criteria.
- Score Calculation:
  - The three sub-criteria are evaluated for each hot cell included in an alternative using separate utility curves
  - Individual cell utility values are rolled up to a composite score for the alternative
  - The sub-criteria are weighted as follows for the roll-up calculation: Area – 30%; Aspect Ratio – 35%; and Height – 35%.
    - This weighting is approximately equal with the Area sub-criteria having slightly less value because the minimum cell size has already been supported by go/no go requirements.
  - Aggregate sub-criteria scores for an alternative are computed as a weighted averages of individual hot cell scores where each cell is given an equal weight (i.e., 1/7, or 14.3%, of the full capability).

Hot Cell Size and Footprint – Sub-criteria Utility Curves







Hot Cell Size and Footprint – Results

Alt #	Hot Cell Size and Footprint Score
2	0.718
3a	0.814
3b	0.705
3c	0.854
4a	1.000
4b	1.000
4c	1.000

Alt. #	Description	Area Score	Aspect Score	Height Score	Overall Score
2.	1. IMCL MSE-1	0.88	1.00	1.00	**0.718**
	2. IMCL MSE-2	0.88	1.00	1.00	
	3. CMR W9 Cell 1	0.30	0.50	1.00	
	4. REDC-7930 E-1	0.88	0.59	0.59	
	5. REDC-7930 E-2	0.88	0.59	0.59	
	6. PNNL RPL MEC1	0.30	0.50	0.70	
	7. SCF Cell 1	0.30	0.50	1.00	
	Aggregate:	**0.63**	**0.67**	**0.84**	
3a.	1. IMCL MSE-1	0.88	1.00	1.00	**0.814**
	2. IMCL MSE-2	0.88	1.00	1.00	
	3. IMCL MSE-3	0.88	1.00	1.00	
	4. IMCL MSE-4	0.88	1.00	1.00	
	5. CMR W9 Cell 1	0.30	0.50	1.00	
	6. CMR W9 Cell 2	0.30	0.50	1.00	
	7. CMR W9 Cell 3	0.30	0.50	1.00	
	Aggregate:	**0.63**	**0.79**	**1.00**	
3b.	1. CMR W9 Cell 1	0.30	0.50	1.00	**0.705**
	2. CMR W9 Cell 2	0.30	0.50	1.00	
	3. CMR W9 Cell 3	0.30	0.50	1.00	
	4. REDC-7930 E-1	0.88	0.59	0.59	
	5. REDC-7930 E-2	0.88	0.59	0.59	
	4. REDC-7930 D-1	0.98	0.63	1.00	
	5. REDC-7930 D-2	0.98	0.63	1.00	
	Aggregate:	**0.66**	**0.57**	**0.88**	
3c.	1. IMCL MSE-1	0.88	1.00	1.00	**0.854**
	2. IMCL MSE-2	0.88	1.00	1.00	
	3. IMCL MSE-3	0.88	1.00	1.00	
	4. REDC-7930 E-1	0.88	0.59	0.59	
	5. REDC-7930 E-2	0.88	0.59	0.59	
	4. REDC-7930 D-1	0.98	0.63	1.00	
	5. REDC-7930 D-2	0.98	0.63	1.00	
	Aggregate:	**0.91**	**0.78**	**0.88**	
4a, b, & c	1. APEX MSE-1	1.00	1.00	1.00	**1.000**
	2. APEX MSE-2	1.00	1.00	1.00	
	3. APEX MSE-3	1.00	1.00	1.00	
	4. APEX MSE-4	1.00	1.00	1.00	
	5. APEX MSE-5	1.00	1.00	1.00	
	6. APEX MSE-6	1.00	1.00	1.00	
	7. APEX MSE-7	1.00	1.00	1.00	
	Aggregate:	**1.00**	**1.00**	**1.00**	

Initial Capital Cost of APIEC - Description

- Uses Class 5 estimates for the total project cost of implementing each of the APIEC alternatives
- Prepared by INL Cost Estimating
- Based on the alternative descriptions contained in Section 2.5 of the report and assumptions about specific layouts and scope
- Includes 50% factor for estimation uncertainty and OMB discounting of constant dollars
- Included scope:
  - Project initiation/mission need costs
  - Project management oversight
  - Engineering and design development costs
  - Project & DOE 413.3B integration costs (deliverables, reviews, etc)
  - Construction costs (new and modifications as applicable)
  - Construction subcontract management costs
  - Operational readiness costs

Initial Capital Cost of APIEC – Assumptions

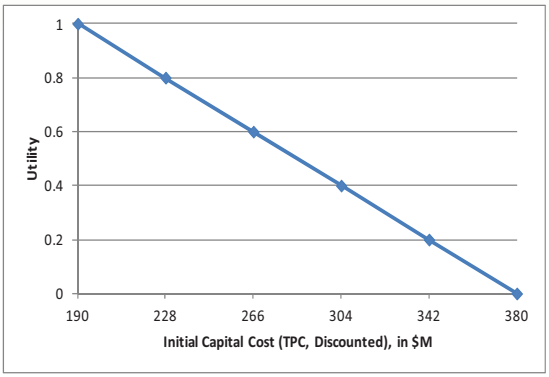
1. Selected facilities will be available to support the PIE program.
2. Project will not require converting non-hazard category (HC)-2 facilities to meet HC-2 and associated seismic/performance category requirements.
3. Facility modifications, if applicable, will not require wholesale replacement of existing fixed hot cells.
4. Seismic upgrade costs (provided by LANL) for the CMR facility includes all required code updates, including fire protection and alarm systems.
5. Half of the hot cells required for use at LANL will require minor decontamination.
6. Sixty percent of sample prep and rough sizing equipment required for the PIE LIB facility will be required for PIE examination at each facility (distributed).
7. Equipment to be removed from the existing MSE at PNNL is not contaminated.
8. Hot cells designated for use at ORNL have never been used and are not contaminated.
9. An environmental impact statement (EIS) will not be required for the project. Costs are included for an environmental assessment (EA) and finding of no significant impact (FONSI).

Initial Capital Cost of APIEC – Assumptions (cont.)

10. Work will be able to progress consecutively and will not require delays between work segments.
11. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
12. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.
13. Capital costs were adjusted by geographic location based on RS Means location factors.

Initial Capital Cost of APIEC – Raw Scores and Utility Curve

Alt #	TPC (in $M)
2	$375.5
3a	$247.5
3b	$277.1
3c	$209.5
4a	$196.2
4b	$194.8
4c	$207.4



Direct Experiment Cost – Description

- Assesses experiment/sample packaging and transportation (P&T) costs and staffing costs for sample receiving, preparation, specimen examination, results documentation, and waste processing for each alternative.
- Packaging and transportation costs are developed as part of the logistics analysis.
- Experiment staffing costs are based on staffing a new facility (i.e., APEX) with adjustments, as appropriate, for other alternatives

Direct Experiment Cost – Assumptions

- All off-site transports are assumed to be in-commerce shipments regulated by DOT as Type B shipments. A DOT certified cask (equivalent to the GE2000) will be used for these shipments.
- Shipments from ATR to HFEF, HFIR to IFEL, and all APIEC off-site shipments (after NDE/sizing/repackaging) require the use of a rental cask. Cost of the rental cask is based on GE2000 rental experience although GE is no longer in the rental business.
- The ORNL GE2000 cask is assumed to be unavailable to support HFIR to IFEL shipments due to its primary use for transferring HFIR fuel and the priority of that use.
- Shipments from "other" irradiators to the NDE/sizing/repackaging capability are assumed to be paid for by others. University shipments are assumed to use the existing BRR Cask and shipping paid for by other programs. Shipments from commercial and/or international entities will be at their expense.
- All experiments are assumed to be covered by the cask's C of C. No C of C revisions are assumed to be needed.
- Shipments from ATR to HFEF are assumed to use the new haul road (out-of-commerce). A DOT certified cask is assumed to be used (no Transportation Plan is req'd).
- On-site shipments downstream of NDE/sizing/repackaging are assumed to be performed using existing casks (either Type A or Type B) that are available at the site at no cost.

Direct Experiment Cost – Assumptions (cont.)

- A separate cask is assumed rented for each off-site shipment. For the distributed and consolidated alternatives, the portions of the sample to be examined at off-site facilities will be loaded into the same cask and sent in a circuit delivery route that minimizes the distance to be traveled.
- All on-site shipments, and off-site shipments within 500 miles, are assumed to occur within the base 10-day rental period. Additional days will be added at a rate of 1 day per 500 miles of transport distance for off-site shipments greater than 500 miles.
- Casks will return to the point of origin of the shipment after the last delivery in a circuit. Return of rented casks to the vendor after completion of the shipment is assumed to be covered by the rental fee.
- Operations and RadCon support costs are assumed to cover both loading and unloading the casks ($6000 and $5000 at each end, respectively).
- Direct experiment labor costs start once the cask has been received and the lid is off. They end after all specimens have been characterized/examined, results documented, samples placed in the archive or storage, and any associated waste is processed or packaged.

Direct Experiment Cost – Assumptions (cont.)

- The facility(ies) are fully utilized (i.e., at 100% capacity) and experiments arrive approximately once per week – that is, the staff is fully engaged in productive work for the full year.
- Functions that require staffing in other than whole FTEs can be staffed by personnel who are assigned to more than one function (i.e., assigned to multiple part-time functions) as long as the functions required similar skills or disciplines. The total headcount, however, must be a whole number.
- Productivity is constant regardless of the location of the facility(ies).
- The average direct labor rates and associated overhead and adders, by discipline, for staffing the alternatives was assumed to be similar across the DOE complex.
- The staffing includes those performing the APIEC functions to perform experiments in a facility. It does not include operating and maintenance staff.
- In the consolidated/distributed alternatives, some loss of efficiency occurs due to reverse economies of scale and limitations on using cross-training and resource sharing as a means to address less-than-full time positions thus resulting in increased staffing across the full alternative.
- In instances where APIEC elements were located in shared facilities, it was assumed that some resource sharing of certain disciplines could occur with other programs collocated in the facility.

Direct Experiment Cost – Results

- Packaging and Transportation Costs

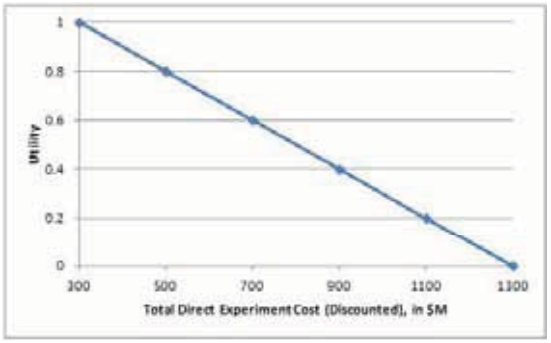
Alternatives	Annual P&T Cost (base, in $M)	Discounted 40-Year Cost (with 50% MR, in $M)
2.Distributed	$26.8	$956.1
3a.Consolidated (INL & LANL)	$15.3	$544.5
3b. Consolidated (LANL & ORNL)	$17.3	$619.3
3c. Consolidated (INL & ORNL)	$16.8	$599.7
4a. New Facility (INL)	$5.3	$189.5
4b. New Facility (ORNL)	$13.0	$462.6
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	$13.3 (range $12.8 to $14.8)	$476.2

- Experiment Staffing Costs

	Staffing Summary (in FTEs)			Cost Summary	
Alternative	Skilled Techs	Tech Leads	Support Personnel (e.g., work planning)	Annual Staffing Cost (base, in $M)	Discounted 40-year Staffing Cost (with 50% MR, in $M)
2.Distributed	19.5	5.0	10.0	$8.1	$288.9
3a.Consolidated (INL & LANL)	16.0	2.0	4.0	$4.8	$173.1
3b. Consolidated (LANL & ORNL)	16.0	2.0	4.0	$4.8	$173.1
3c. Consolidated (INL & ORNL)	16.0	2.0	4.0	$4.8	$173.1
4a. New Facility (INL)	14.0	2.0	4.0	$4.5	$159.0
4b. New Facility (ORNL)	14.0	2.0	4.0	$4.5	$159.0
4c. New Facility (LANL, PNNL, SNL, or SRNL; averaged)	14.0	2.0	4.0	$4.5	$159.0

Direct Experiment Cost – Raw Scores and Utility Curve

Alt #	Total Discounted 40-year Direct Experiment Costs (with MR, in $M)
2	$1244.9
3a	$717.5
3b	$792.4
3c	$772.8
4a	$348.5
4b	$621.7
4c	$635.2



Operating, Maintenance, and Refurbishment Costs – Description

- Assesses the total cost of operating, maintenance, refurbishment, and D&D over the 40 year evaluation period.
- Prepared by INL Cost Estimating
- Based on the alternative descriptions contained in Section 2.5 of the report and assumptions about specific layouts and scope
- Includes 50% factor for estimation uncertainty and OMB discounting of constant dollars
- Included scope:
  - Facility operations costs for 40 years. Includes sharing of operations staff with other resident program(s) in the facility, if applic. Also includes electrical power usage.
  - Facility maintenance costs for 40 years. Including annual facility maintenance costs, facility refurbishment costs, and equipment replacement costs. Annual maintenance and facility refurbishment costs are included only for the facility space to be used.
  - Deactivation, decommissioning, and demolition of facility (DD&D). Includes costs to DD&D the facility space to be used by the APIEC project.

Operating, Maintenance, and Refurbishment Costs – Assumptions

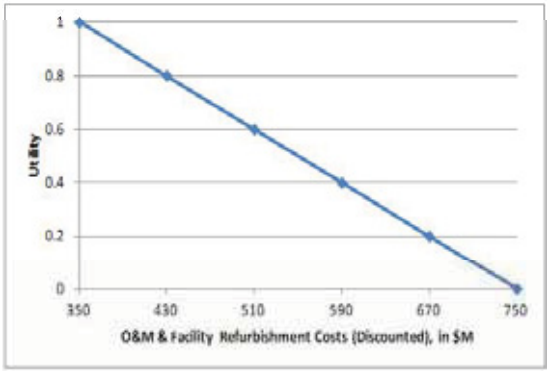
- INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
- Craft labor rates are based on information provided by the "INL Site Stabilization Agreement." Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
- Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.
- Refurbishments beginning in 2021 if facility operational life not known/provided (existing buildings). Refurbishments add 20 years of life. New facilities have a 40 year life.
- Facility operations staffing will require a minimum of one person per facility per operations role.
- Facility operations staffing will be shared with other resident program(s) in the facility (as applicable)

Operating, Maintenance, and Refurbishment Costs – Results

Alt #	Discounted 40-year O&M and Refurbishment Costs (with MR, in $M)	Discounted D&D Costs (with MR, in $M)
2	$688.6	$19.1
3a	$410.3	$8.1
3b	$369.3	$7.8
3c	$389.0	$9.9
4a	$378.2	$12.9
4b	$378.2	$12.8
4c	$378.2	$13.9

Operating, Maintenance, and Refurbishment Costs – Raw Scores and Utility Curve

Alt #	Total Discounted 40-year O&M, Refurb, & D&D Costs (with MR, in $M)
2	$707.8
3a	$418.4
3b	$377.1
3c	$398.9
4a	$391.1
4b	$391.0
4c	$392.1



Time to Receive Data – Description

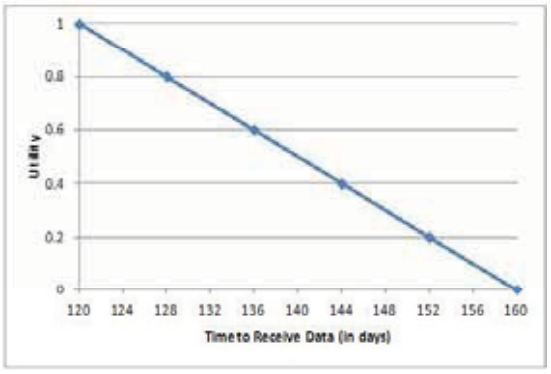
- Estimates the number of days it will take to obtain data from an experiment of average complexity for each APIEC alternative.
- Spans the duration from initial receipt at the NDE/sizing facility to completion of the examination data report.
- Durations for NDE, rough sizing, cask handling, sample preparation, examination, and preparing reports were consistent across all alternatives.
- Transport times and the number of handling events varies appropriately by alternative.

Time to Receive Data – Assumptions

- Average complexity experiment
- Five workdays per week, with only travel activities occurring over weekends
- Large cask handling event takes 4.5 days (average), experiment available for processing after day 2. Prepare and open on-site cask requires 1 workday, 1 workday to package or unpackage, and 1 workday to maintain and close. Shipping paperwork can be accomplished in parallel.
- NDE requires 20 workdays
- Experiment size reduction (after NDE) requires 3 workdays
- Distributed/Consolidated alternatives involve circuit (multi-stop) shipments and assume the shortest path is used. Analysis uses the time associated with the longest duration sequence of activities (typically the last stop on the circuit). On-site transfers are made after off-site shipments have been sent off.
- Travel duration assumes 500 miles traveled per day, rounded up to whole day increments. Distances between sites were estimated using Mapquest.
- Experiment examination requires 24 workdays with one workday to compile all results.
- Analysis reports require 15 workdays to draft and 15 workdays for review and finalization.

Time to Receive Data – Raw Scores and Utility Curve

Alt #	Time to Receive APIE Data (in Days)
2	155
3a	128
3b	129
3c	128
4a	122
4b	125
4c	124



Risk to Public and Environment – Description

- Assesses APIEC alternatives' real and perceived risk to the public and the environment due to samples being shipped over public roads
- All alternatives are required to meet DOE or equivalent standards and, therefore, risks to the public and the environment from operations within those facilities are essentially equivalent. Thus, the primary discriminator will be related to the transportation of experiments over public roads.
- Based on a tabulation of the total number of miles that nuclear fuels and materials are transported on public roads (i.e., in-commerce miles) each year for each alternative.

Risk to Public and Environment – Assumptions

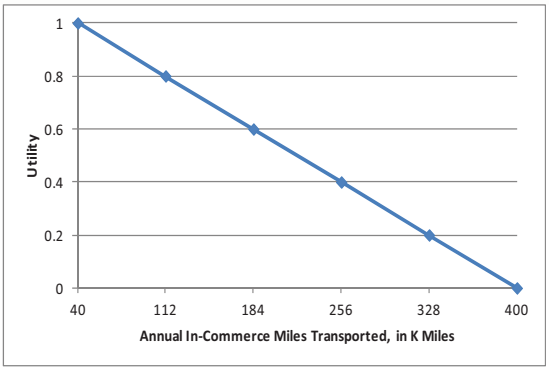
- Risk to Public and Environment uses the same base assumptions as the Logistics analysis and the assumptions below:
  - Shipments of empty casks back to the origination point (i.e., cask renter) are assumed to occur for each shipment but do not contribute to public risk perception because the casks are not placarded as a rad shipment on this return leg. These legs do add additional miles and days for costing purposes.
  - Shipments of empty casks to and from the renter do not contribute to public risk perception because the casks are not placarded as a rad shipment on these legs. The cost of these transports is covered by the rental fee.

Risk to Public and Environment – Results

Alternative		Annual In-Commerce Miles
Distributed	Alternative 2– INL, LANL, ORNL, PNNL, SRNL	367,250
Consolidated	Alternative 3a– INL & LANL	121,500
	Alternative 3b– LANL & ORNL	314,500
	Alternative 3c– INL & ORNL	202,000
New Facility "APEX"	Alternative 4a– INL	40,500
	Alternative 4b– ORNL	173,500
	Alternative 4c– Other	126,050

Risk to Public and Environment – Raw Scores and Utility Curve

Alt #	Total Annual In-Commerce Miles (in K)
2	367.3
3a	121.5
3b	314.5
3c	202.0
4a	40.5
4b	173.5
4c	126.1



Risk to Workers – Description

- Assesses APIEC alternatives' risk to facility workers
- All of the alternatives are assumed to be compliant with DOE and federal regulations, or equivalent standards. Thus, risks due to PIE activities such as sample preparation and instrument operation are considered to be the same for all alternatives and, thus, are not discriminators.
- Based on the number of handling operations. Each transport-related loading or unloading operation is a point where worker dose is incurred and where accidents could occur that might result in harm to a worker.
- Score Calculation:

Initial loading plus total number of off-site shipment legs for an alternative	**+**	**(Number of on-site shipments) X 2 ***	**=**	**Total number of handling events for the alternative**

* Two handling events for each, one at sending facility and one at receiving facility.

Risk to Workers – Assumptions

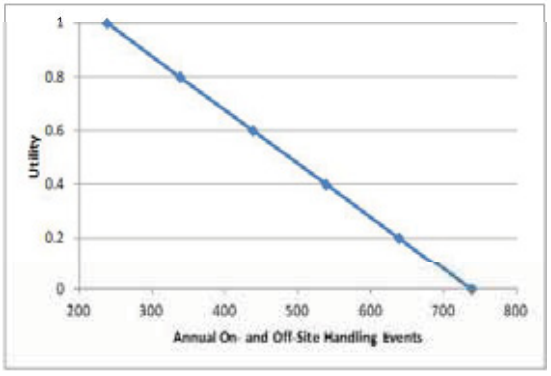
- Risks to workers uses the same base assumptions as the Logistics analysis. [Refer to Slide 4]

Risk to Workers – Results

Alternative		Estimated Number of Handling Events (annually)
Distributed	Alternative 2– INL, LANL, ORNL, PNNL, SRNL	738
Consolidated	Alternative 3a– INL & LANL	423
	Alternative 3b– LANL & ORNL	353
	Alternative 3c– ORNL & INL	438
New Facility "APEX"	Alternative 4a– INL	238
	Alternative 4b– ORNL	238
	Alternative 4c– Other	238

Risk to Workers – Raw Scores and Utility Curve

Alt #	Annual On- and Off-Site Handling Events
2	738
3a	423
3b	353
3c	438
4a	238
4b	238
4c	238



- Questions?

Path Forward

- Resolve and incorporate Workshop 2 comments
- Enter SRC averaged qualitative scores into QuickCompare to determine corresponding utility values
- Combine qualitative and quantitative weighted utility scores to determine overall alternative scores
- Incorporate qualitative results into the Alternatives Analysis Report
- Perform Sensitivity and Risk Analysis
- Identify preferred alternative
- Re-issue report prior to Workshop 3

- Back up slides

Logistics – Results

Alt #	# of On- & Off-Site Destinations
2	624
3a	324
3b	324
3c	324
4a	139
4b	209
4c	224

Annual Number of Experiments: 100 (assumed as a basis for comparison only)

Assumed Distribution	80 (percent)				10 (percent)				10 (percent)									
	80				10				10									
Irradiation Facility	ATR (INL)				HFIR (ORNL)				Other (various)									
		Shipments				Shipments						Shipments						
	80	4			10	10			5		5	10						
		(on-site)				(on-site)						(off-site)						
NDE / Sizing Facility	HFEF (INL)				IFEL (ORNL)				HFEF (INL)		IFEL (ORNL)							
Experiments to APIEC	80				10				5		5							
Shipment Type	On-Site	Off-Site			On-Site	Off-Site			On-Site	Off-Site	On-Site	Off-Site						
Alternative 2	80	80			10	10			5	5	5	5						
Shipment Type	On-Site	Off-Site			On-Site	Off-Site			On-Site	Off-Site	On-Site	Off-Site						
Alternative 3a	80	80			0	10			5	5	0	5						
Alternative 3b	0	80			10	10			0	5	5	5						
Alternative 3c	80	80			10	10			5	5	5	5						
Shipment Type	On-Site	Off-Site			On-Site	Off-Site			On-Site	Off-Site	On-Site	Off-Site						
Alternative 4a	80	0			0	10			5	0	0	5						
Alternative 4b	0	80			10	0			0	5	5	0						
Alternative 4c	0	80			0	10			0	5	0	5						

x1

x4

Shipment totals			Logistics
On-Site	Off-Site	Total	Score
114	110	224	1178
99	110	209	863
29	110	139	793
114	110	224	878
99	25	124	338
29	95	124	618
14	110	124	678

+

+

Hot Cell Size and Footprint – Cell Data

Alt. #	Description	W (in ft)	D (in ft)	H (in ft)	Area (in ft^2)
2.	1. IMCL MSE-1	9.75	9.75	11.75	95.1
	2. IMCL MSE-2	9.75	9.75	11.75	95.1
	3. CMR W9 Cell 1	12	6	11	72.0
	4. REDC-7930 E-1	16	9.5	21	152.0
	5. REDC-7930 E-2	16	9.5	21	152.0
	6. PNNL RPL MEC1	12	6	8.5	72.0
	7. SCF Cell 1	12	6	15	72.0
3a.	1. IMCL MSE-1	9.75	9.75	11.75	95.1
	2. IMCL MSE-2	9.75	9.75	11.75	95.1
	3. IMCL MSE-3	9.75	9.75	11.75	95.1
	4. IMCL MSE-4	9.75	9.75	11.75	95.1
	5. CMR W9 Cell 1	12	6	11	72.0
	6. CMR W9 Cell 2	12	6	11	72.0
	7. CMR W9 Cell 3	12	6	11	72.0
3b.	1. CMR W9 Cell 1	12	6	11	72.0
	2. CMR W9 Cell 2	12	6	11	72.0
	3. CMR W9 Cell 3	12	6	11	72.0
	4. REDC-7930 E-1	16	9.5	21	152.0
	5. REDC-7930 E-2	16	9.5	21	152.0
	4. REDC-7930 D-1	15	9.5	13	142.5
	5. REDC-7930 D-2	15	9.5	13	142.5
3c.	1. IMCL MSE-1	9.75	9.75	11.75	95.1
	2. IMCL MSE-2	9.75	9.75	11.75	95.1
	3. IMCL MSE-3	9.75	9.75	11.75	95.1
	4. REDC-7930 E-1	16	9.5	21	152.0
	5. REDC-7930 E-2	16	9.5	21	152.0
	4. REDC-7930 D-1	15	9.5	13	142.5
	5. REDC-7930 D-2	15	9.5	13	142.5
4a, b, & c	1. APEX MSE-1	10	10	12	100
	2. APEX MSE-2	10	10	12	100
	3. APEX MSE-3	10	10	12	100
	4. APEX MSE-4	10	10	12	100
	5. APEX MSE-5	10	10	12	100
	6. APEX MSE-6	10	10	12	100
	7. APEX MSE-7	10	10	12	100

Appendix C

Workshop 3 – SRC Review and Comments

Appendix C
Workshop 3 – SRC Review and Comments

Advanced PIE Capabilities Alternatives Analysis
Workshop 3 Meeting Minutes and Resolutions

October 29, 2012

Overview

Idaho National Laboratory (INL) is currently identifying and evaluating alternatives for providing Advanced Post-Irradiation Examination Capabilities (APIEC) for the Department of Energy's Office of Nuclear Energy (DOE-NE) in accordance with DOE Order DOE-O-413.3B, "Program and Project Management for the Acquisition of Capital Assets". As part of the alternatives analysis effort, a Stakeholder Review Committee (SCR) has been assembled to review and comment on the analysis as it proceeds. A series of workshops are planned during which the SRC members' comments will be obtained. These meeting minutes document the comments gathered during Workshop 3.

Attendees

The attendees at the workshop are listed below.

Name	Organization	Role
Jeffrey Bryan	INL Systems Engineering	Systems Engineer
Michael Cappiello	Consultant	SRC member
Kenneth Geelhood	Pacific Northwest National Laboratory	SRC member
Jody Henley	INL Systems Engineering	Meeting Facilitator
Porter Hill	INL Systems Engineering	Systems Engineer
Collin Knight	INL Nuclear Science and Technology	Scientific Coordinator
Marsha Lambregts	INL Technical Business Development	
William Landman	INL Facilities Engineering	APIEC Project Engineer
Erik Mader	Electric Power Research Institute	SRC member
Mitch Meyer for Kemal Pasamehmetoglu	INL Nuclear Science and Technology	SRC chair
Michael W. Patterson	INL Project Management	INL APIEC Project Manager
Dr. Jeff Terry	Illinois Institute of Technology	SRC member
Workshop 3 materials were also presented at an October 26, 2012, conference to the following participants.		
W. Greg Bass	DOE ID	DOE Federal Project Director
Andrew Griffith	DOE-NE	SRC member
Steven Zinkle	Oak Ridge National Laboratory	SRC member

Workshop Objective

The objective of Workshop 3 was to update the Stakeholder Review Committee on progress made since Workshop 2, including the weighting/scoring sensitivity analyses, risk analysis, alternatives analysis scoring results and the recommendation of a preferred alternative.

Workshop Products

The SRC members provided comments and concurred with the analysis outcomes and the recommended alternative.

Workshop Comments

October 26, 2012 Session Comments

- In the scoring results summary, Andrew Griffith observed that 4b was close to 4c. and that 4b leveraged HIFR. It was noted that ATR supplied 80% of the experiments so HIFR was not a controlling factor with 10% share. The remaining 10% being supplied by "other" reactors. (08:05)
- Andrew Griffith noted regarding the criteria scoring results slide (horizontal columns) that segment 6 (PIE material storage and waste disposition) distinguished 4a from 4b and 4c. (11:39)
- In the discussion on the weighting sensitivity analysis for Criterion 15, Andrew Griffith observed that the shared cost for the Alternative 3 sub-options worked to their advantage. Jeff Bryan noted that the shared facilities (particularly Alternative 3b) might not have included all the support costs for operation and maintenance of the facilities. (18:30)
- At the end of the sensitivity analysis discussion, Andrew Griffith remarked that this was a very good summary of the analysis. (24:46)
- During the qualitative criteria uncertainty analysis, Andrew Griffith questioned the fact that errors in score assignment were not addressed in the sensitivity analyses and asked if one SRC member's scores were not consistent with others, would that cause us to go back and review. Mike Patterson and Jeff Bryan responded that we did question some scores to assure they were captured correctly. (26:56)
- In the qualitative uncertainty discussion, Steve Zinkle noted that with the high end of the 4b and 4c, uncertainty overlapping the low end of the 4a uncertainty there might be a question but with all SRC members rating 4a highest, it looks like a good conclusion and consistent analysis. (34:00)
- Andrew Griffith had a question on the quantitative criteria sensitivity - What would have indicated that the result was not robust? Less than 25% would be a flag. For the 17% value on direct experiment cost, the INL team looked at the elements of direct experiment cost and whether there was a potential for the scope and cost to be in question. The transportation cost was the only part of the criterion that could be contributing much of a difference. The previous individual analysis, however, showed that this criterion did not have that much of an impact when considered individually. (43:31)
- Greg Bass asked about the definition of the Develop Integrate and Retain Knowledge Capital. Jeff responded that this criterion looked at where the knowledge would be developed. For example, overseas vs. U.S. – the experimenter would get the data but the experience in deployment of instruments in high radiation environment would be gained overseas and not in the U.S. It also considered the life cycle of the experiment itself in which the co-location would improve the integration of knowledge across all phases of the experiment. Greg Bass

summarized the criteria as the proximity of experimenters and engineers and the proximity of people doing similar PIE work. Mike Patterson noted it discriminated heavily against the overseas alternatives. Steve Zinkle noted that if the overseas option had been scored he would have been heavily against it. Similarly, a distributed case would not be very effective, either, because performing test A in one place, test B in a second and test C in a third would not contribute to the knowledge base. There is, however, a counter argument that you can become a "deep dive" expert if you are the only expert but wouldn't have the ability to walk down the hall to discuss with another expert. Different people on the SRC might score it differently but those options are also workable. Andrew Griffith noted that the new facility options would have some additional data management capabilities that would be very difficult to retrofit in existing facilities or disperse around. (54:20)

October 29, 2012 Session Comments

- Mike Cappiello asked what happened to other criteria while one criterion was being varied. Jeff Bryan responded that while one criterion was being varied from 0 to 100% (say at 80%) the remaining weight (20%) would be distributed among the other criteria in proportion to their respective weights. (16:50)
- The committee members agreed with the conclusion. (37:10)
- Jeff Terry noted that there was a comment in the past that Peter Hosemann had been able to do work in CMR Wing 9 at LANL. Jeff had discussed this with Peter and Stuart Malloy and they stated that there was no chance of a foreign national getting into CMR Wing 9. (37:50)
- Mike Cappiello asked what the path forward was. Mike Patterson said that we would be starting Conceptual Design and planned to obtain CD-1 at the end of FY-13. Mike Cappiello asked if two Conceptual Designs would be carried forward. Mike Patterson said that we are not planning on carrying two designs forward because the decision is robust and funding is limited. (38:39)
- Eric Mader asked what the difference between Alts. 4b and 4c. Jeff Bryan replied that Alt. 4b is a new facility at ORNL, to take advantage of co-location with HIFR and Alt. 4c looked at a facility that was not located near a reactor typically supplying irradiation experiments.
- Eric mentioned that he had received an email requesting additional information on his scoring input. It was concluded that those scores would not have affected the results and no additional input was required.
- Eric noted that this was a rigorous analysis. (1:08:51)

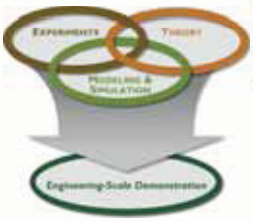
Workshop Presentations

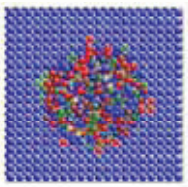
The following presentation was delivered during Workshop 3:

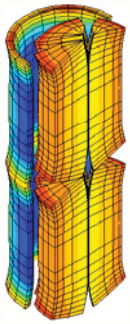
APIEC Alternatives Analysis

Scoring, Sensitivity, and Risk Analysis Results

October 26, 2012







www.inl.gov

Idaho National Laboratory

Agenda

- Background
  - Alternatives
  - Goals and Criteria
  - Alternative Status
- Scoring Results
- Goal/Criteria Weighting Sensitivity Analysis
- Qualitative Scoring Uncertainty Analysis
- Quantitative Score Sensitivity Analysis
- Scoring Refinement – Discriminating Criteria Only
- Risk Analysis
- Recommendation
- Questions/Comments

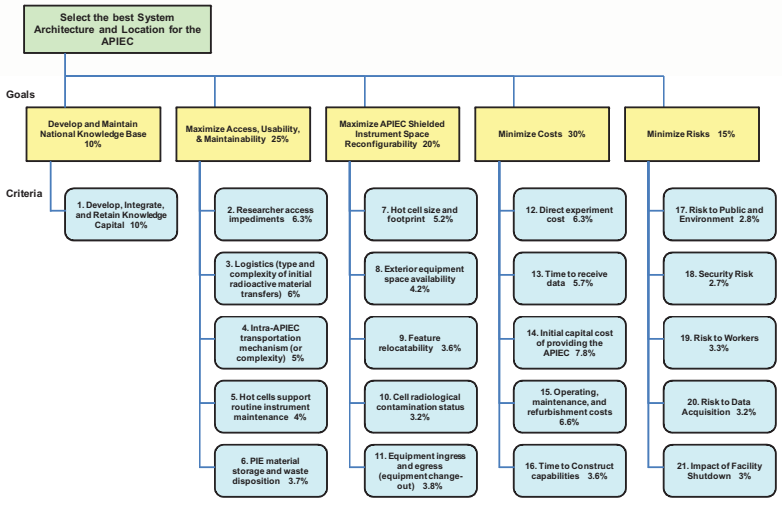
2

Background

- An alternatives analysis was performed for the APIEC Project in accordance with DOE O 413.3B
- Alternatives analysis considered six major alternatives:
  - Alt. #1 – No Action
  - Alt. #2 – Modify Existing DOE Facilities – capabilities distributed among multiple locations
  - Alt. #3 – Modify Existing DOE Facilities – capabilities consolidated at a few locations; 3 sub-alternatives considered:
    - (a) INL + LANL
    - (b) LANL + ORNL
    - (c) INL + ORNL
  - Alt. #4 – Construct New Facility – 3 location sub-alternatives considered:
    - (a) INL
    - (b) ORNL
    - (c) Other DOE lab
  - Alt. #5 – Commercial Partnership
  - Alt. #6 – International Partnerships

3

Background (cont.) – Goals and Criteria



4

Alternative Status

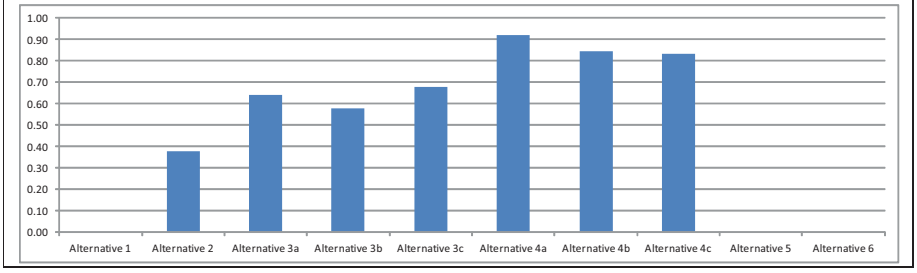
- Alternatives #1, 5, and 6 – Removed at Go/No Go Analysis
- Alternatives #2, 3a, 3b, 3c, 4a, 4b, and 4c evaluated using weighted qualitative and quantitative criteria
  - Goals and Criteria: Reviewed by Stakeholder Review Committee (SRC)*; comments incorporated
  - Goal and Criteria Weights: Provided by SRC members
  - Qualitative Criteria Scores: Provided by SRC members
  - Quantitative Criteria Scores: Reviewed by SRC members; comments incorporated

* Includes representatives from DOE labs, industry, and universities

5

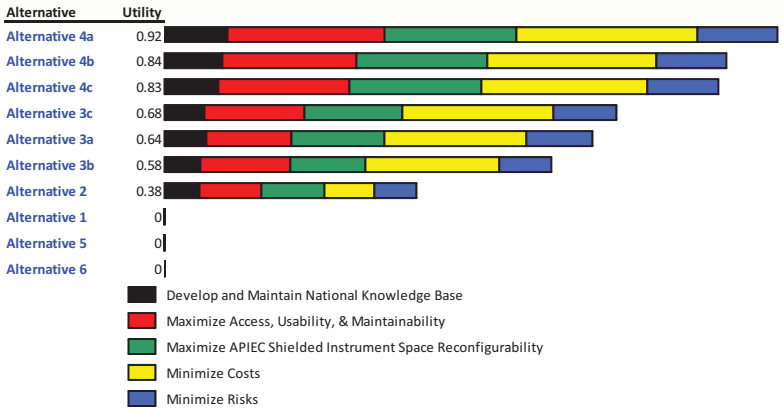
Scoring Results –
Rollup of Qual. & Quant. Criteria Weighted Utility Scores

	Alternative 1	Alternative 2	Alternative 3a	Alternative 3b	Alternative 3c	Alternative 4a	Alternative 4b	Alternative 4c	Alternative 5	Alternative 6
Score	0.00	0.38	0.64	0.58	0.68	0.92	0.84	0.83	0.00	0.00
Difference %	-100%	-59%	-30%	-37%	-26%	0%	-8%	-10%	-100%	-100%



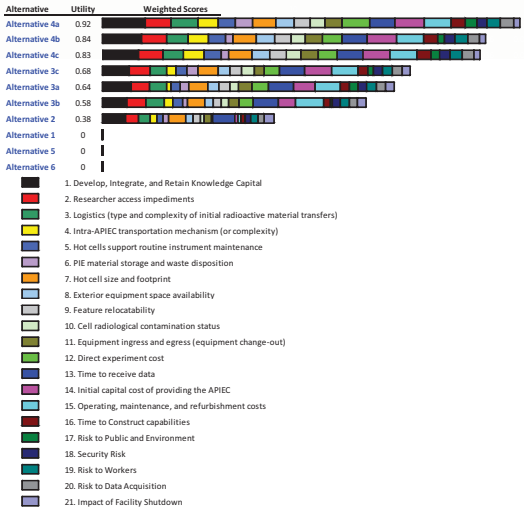
6

Scoring Results (cont.)
Alternative Ranking – Goal Summary



7

Scoring Results (cont.)
Alternative Ranking – Criteria Summary



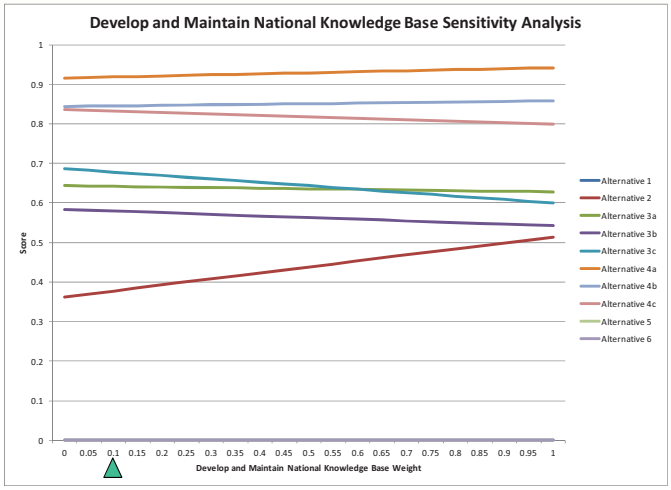
8

Goal/Criteria Weighting Sensitivity Analysis – Process

- Automated process in QuickCompare tool
- Varies each goal or criterion weight, one-at-a-time, parametrically (in 5% increments) from 0 to 100% of the total weight
- If less than 100% of the total weight, other goals or criteria are allocated the remaining weight proportional to their original assigned weight values
- Each alternative's overall weighted utility score is recalculated for each incremental change and charted so that changes in the highest scoring alternative can be easily identified.
- **Note:** *Switching out of the high scoring alternative is an expected event in this analysis because it is not typical for one alternative to be best performer relative to every goal or criterion.*
  - *Undesirable for a transition to occur in a region close to the original assigned goal or criteria weight.*

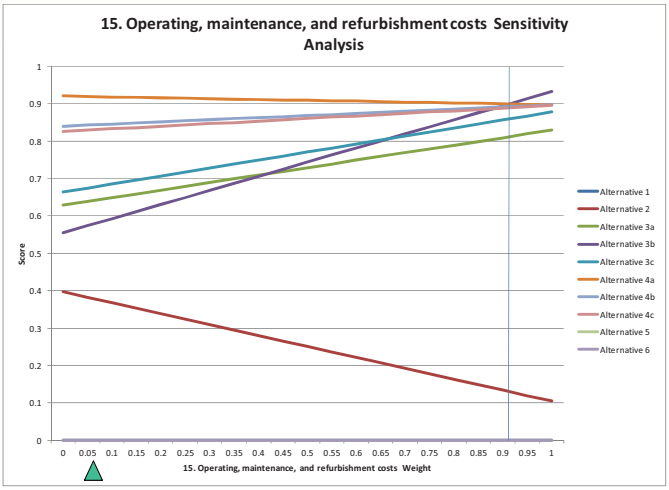
9

Weighting Sensitivity Analysis
Example Sensitivity Chart - Goal



10

Weighting Sensitivity Analysis
Example Sensitivity Chart - Criterion



11

Goal Weighting Sensitivity Analysis
Results

Goal	High Scoring Alternative	Sensitivity
Develop & Maintain National Knowledge Base	Alt 4a.– APEX at MFC	Completely insensitive – no change from 0 to 100%
Maximize Access, Usability, & Maintainability	Alt 4a.– APEX at MFC	Completely insensitive – no change from 0 to 100%
Maximize APIEC Shielded Instrument Space Reconfigurability	Alt 4a.– APEX at MFC	Insensitive – no change from 0 to 100%; Tie only at 100% - 4a,b,c
Minimize Costs	Alt 4a.– APEX at MFC	Completely insensitive – no change from 0 to 100%
Minimize Risks	Alt 4a.– APEX at MFC	Completely insensitive – no change from 0 to 100%

12

Criteria Weighting Sensitivity Analysis Results

Criterion	Type	High Scoring Alternative	Sensitivity
Develop, Integrate, and Retain Knowledge Capital	Qualitative	Alt 4a	Completely insensitive – no change from 0 to 100%
Researcher Access Impediments	Qualitative	Alt 4a	Completely insensitive – no change from 0 to 100%
Logistics (Rad mat'l transfers and Type of transfer)	Quant.	Alt 4a	Completely insensitive – no change from 0 to 100%
Intra-APIEC Transportation Mechanism (or complexity)	Quant.	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Hot Cells Support Routine Instrument Maintenance	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
PIE Material Storage and Waste Disposal	Qualitative	Alt 4a	Completely insensitive – no change from 0 to 100%
Hot Cell Size and Footprint	Quant.	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Exterior Equipment Space Availability	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Feature (window, MSM penetration) Relocatability	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Cell Radiological Contamination Status	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c

13

Criteria Weighting Sensitivity Analysis Results

Criterion	Type	High Scoring Alternative	Sensitivity
Equipment Ingress & Egress	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Direct Experiment Cost	Quant.	Alt 4a	Completely insensitive – no change from 0 to 100%
Time to receive Data	Quant.	Alt 4a	Completely insensitive – no change from 0 to 100%
Initial Capital Cost of APIEC	Quant.	Alt 4a / Alt 4b	Insensitive – Alt 4a from 0 to 93%; Alt 4b from 93% to 100%
Operating, Maintenance, and Upgrade Costs	Quant.	Alt 4a / Alt 3b	Insensitive – Alt 4a from 0 to 91%; Alt 3b from 91% to 100%
Time to Construct Capabilities	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Risk to Public and Environment	Quant.	Alt 4a	Completely insensitive – no change from 0 to 100%
Security Risk	Qualitative	Alt 4a	Insensitive – no change from 0 to 100%; tie only at 100% - 4a,b,c
Risk to Workers	Qualitative	Alt 4a	Completely insensitive – no change from 0 to 100%
Risk to Data Acquisition	Qualitative	Alt 4a	Completely Insensitive – no change from 0 to 100%
Impact of a Facility Shutdown	Qualitative	Alt 4a / Alt 3c / Alt 2	Insensitive – Alt 4a from 0 to 60%; Alt 3c from 60% to 78%; Alt. 2 from 78% to 100%

14

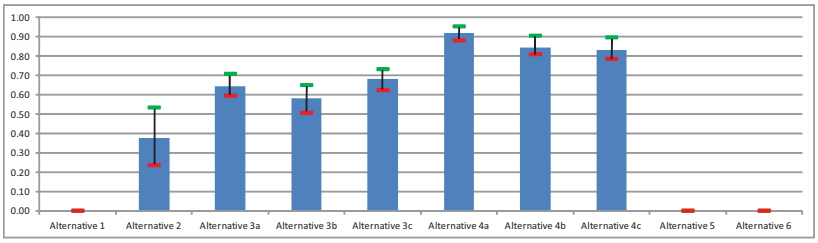
Qualitative Scoring Uncertainty Analysis – Process

- Evaluates the scoring uncertainty introduced by variations in scorer judgment and perspective.
- Applies only to the qualitative criteria scored by the SRC members.
- Errors in score assignment were not analyzed.
- Uncertainty range (i.e., upper and lower limits) was determined for each alternative by:
  - Calculating the overall weighted utility scores by individual SRC member.
  - Plotting the minimum and maximum of these values for each alternative.

15

Qualitative Criteria Scoring Uncertainty Results (all criteria with qualitative uncertainty shown)

	Alternative 1	Alternative 2	Alternative 3a	Alternative 3b	Alternative 3c	Alternative 4a	Alternative 4b	Alternative 4c	Alternative 5	Alternative 6
Score	0.00	0.38	0.64	0.58	0.68	0.92	0.84	0.83	0.00	0.00
Score Difference %	-100%	-59%	-30%	-37%	-26%	0%	-8%	-10%	-100%	-100%
Uncertainty Bar										
High	0	0.53	0.71	0.65	0.73	0.95	0.90	0.90	0	0
Low	0	0.24	0.59	0.51	0.62	0.88	0.81	0.78	0	0



- Height of blue bars reflect overall (i.e., quantitative and qualitative) weighted utility values with the SRC input averaged for each qualitative criterion
- Uncertainty ranges reflect the variation in scores provided by individual SRC members (relates to qualitative criteria only). Upper and lower limits reflect maximum and minimum observed values, respectively, for alternative overall scores calculated from individual SRC member inputs.
- Alt. 4 lower uncertainty limits are higher than upper uncertainty limits of Alts. 2, 3a, 3b, & 3c (no overlap implies reduced decision uncertainty)
- Every SRC member scored Alt. 4a higher overall than either Alt. 4b or Alt. 4c

16

Quantitative Criteria Score Sensitivity Analysis – Process

- Step 1 – Individual Criterion Sensitivity
  - Parametric analysis to evaluate sensitivity of the highest ranked alternative to potential metric estimation errors relative to other alternatives
    - Alt. 4a criterion metric value adjusted in 25% increments (in a direction to produce adverse score impact)
    - Determined increment at which the alternative ranking was affected
    - Repeated for each quantitative criterion
- Step 2 – Multiple Non-Independent Criterion Sensitivity
  - Parametric analysis for multiple metric values for Alternative 4a simultaneously
    - Evaluated quantitative criteria that were deemed to be somewhat dependent (e.g., common assumptions)
    - Adjustments made in 25% increments to produce adverse score impacts
    - Determined increment at which the alternative ranking was affected
    - Conducted for 2 groups of quantitative criteria

17

Quantitative Criteria Score Sensitivity Analysis – Results

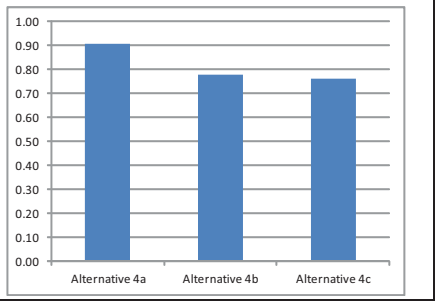
- Individual criterion estimation errors for 4a relative to 4b or 4c:
  - Any single quantitative criterion's contribution to Alternative 4a's overall weighted utility score can be reduced to 0 with Alt. 4a remaining top ranked alternative.
- Non-independent criterion estimation errors (group 1 – related by common assumptions):
  - Simultaneously, Alt. 4a metric values for logistics score and direct experiment cost were increased by a factor of 2 (higher values producing lower utility scores) and risk to public and environment cut by ½ (lower reductions in traffic incidents producing lower utility) with Alt. 4a remaining top ranked alternative.[a]
- Non-independent criterion estimation errors (group 2 – related by potential for cost bias and common assumptions):
  - Alt. 4a metric values for direct experiment cost, initial capital cost, and operating, maintenance, and refurbishment cost can be simultaneously increased by 50% of their original values (where higher values produce lower utility scores for these metrics) at which point Alternative 4a and 4b tie for the top ranking.[b]
- Conclusion: Alt. 4a is robust solution relative to potential quantitative scoring errors which are unlikely to be as large as asserted above.

[a] Represents 22.5%, 34.9%, and 44.4% of the utility curve ranges, respectively.
[b] Represents 17.4%, 39.2%, and 48.9% of the utility curve ranges, respectively.

18

Scoring Refinement - Discriminating Criteria Only

	Alternative 4a	Alternative 4b	Alternative 4c
Score	0.91	0.78	0.76
Difference % (from high score)	0%	-14%	-16%



- Removed non-discriminating criteria
- Renormalized goal and criteria weights
- Recalculated overall weighted utility scores

19

Risk Analysis

- Performed on Alternatives 4a, 4b, and 4c to further understand the effects of selecting a particular alternative for recommendation as the preferred alternative.
  - Addressed risk areas defined in DOE G 413.3-13, “Acquisition Strategy Guide for Capital Asset Projects.
- Risk analysis concluded that Alternative 4a had the least risk:
  - Smaller legal and regulatory risk (as a result of INL’s agreement with the state of Idaho regarding acceptance of research quantities of used nuclear fuel)
  - Smaller risk from immature scope definition impacting funding and cost due to the ability to leverage IMCL to provide instrument development/ demonstration capability and additional PIE capability at the least cost
  - Smaller interface and integration risk (based on the co-location of the irradiation, NDE, and examination facilities).

20

Summary

- Recommended alternative for implementing the APIEC:

Alt. 4a – Construct a new facility at the MFC at INL

  - Highest ranked alternative (based on qualitative/quantitative weighted scores)
  - Ranked highest by every SRC member
  - Sensitivity analyses verify ranking is robust for a wide range of goal/criteria weighting and scoring uncertainty
  - Risk analysis indicates Alt. 4a carries the least risk

21

Questions/Comments?

22

This page intentionally left blank.

Appendix D

DOE Comments and Resolutions

Appendix D
DOE Comments and Resolutions

U.S. Department of Energy reviewers had no comments on the APIEC Alternatives Analysis Report.

Appendix E

Summary Cost Estimates

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman, Project Engineer

From: R. D. Allen / B. W. Wallace, Cost Estimators RA

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #2

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $9,300,000,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, and markup sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate and/or schedule and should be reviewed by me. If you have any questions or comments, do not

hesitate to contact Ross Allen at 526-0769 or e-mail Ross.Allen@inl.gov or Bruce Wallace at 526-5896 or email Bruce.Wallace@inl.gov.

Attachments

cc: Estimate File 8B26

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Project Number: ***8B26***

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		152.47%	*49.99%*	
Total Estimated Cost (TEC)	$2,462,052,003	$3,753,963,833	$3,107,252,740	$9,323,268,576
		152.47%	*49.99%*	
Total Cost	$2,462,052,003	$3,753,963,833	$3,107,252,740	$9,323,268,576
Rounded Total Cost (Rounded to the nearest $ 100000000)				$9,300,000,000

		Remarks
Type of Estimate:	Alternative Analysis - Class 5	Includes APIEC Distributed to INL, LANL, ORNL, PNNL, and SRNL
Estimator:	R. D. Allen / B. W. Wallace	
Checked By:	SNW	
Approved By:	John Baker /mb	

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #2
Estimator:	R. D. Allen / B. W. Wallace
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**
The objective of this work is to modify existing DOE-owned facilities located at Idaho National Laboratory (INL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), and Savannah River National Laboratory (SRNL) to support advanced post irradiation examination (PIE) activities for highly-irradiated nuclear fuels and materials.

B. **Included:**
This cost estimate includes life-cycle costs (LCC) as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs, including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration, including DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Equipment procurement and modifications to the existing facilities, including the following:
   a. INL
   Equipment procurement and modifications to the Irradiated Materials Characterization Laboratory (IMCL), including the following:
      (i) Transfer cask with 8" inside diameter.
      (ii) Rough sizing, sample preparation, and waste packaging equipment.
      (iii) Specimen transfer device for transportation of source material between cells.

(iv) Storage racks for shielded sample storage and prepared specimen storage.
(v) Post irradiation examination instrumentation.
(vi) Add metal stud wall and suspended acoustical ceiling to enclose non-shielded examination area.
(vii) Acoustical and electromagnetic interference (EMI) protection for examination equipment in non-shielded area.
(viii) Miscellaneous utility modifications in non-shielded area.
(ix) One 10'x20'x12' modular shielded enclosure (MSE) for sample preparation activities.
(x) Two 10'x10'x12' MSEs for examination activities.
(xi) Tie-in MSEs into existing facility utilities and exhaust system.
(xii) Five 6'x6'x5' inert confinement enclosures (ICE).
(xiii) Add facility infrastructure to supply inert gas to new ICEs.
(xiv) Inert gas purification system for new ICEs.
(xv) Provide temperature control for the two MSEs and non-shielded area containing examination equipment.
(xvi) One 6'x6'x6' shielded confinement box within the sample preparation MSE for shielded sample storage.

b. LANL

Equipment procurement and modifications to Wing 9 of the Chemistry and Metallurgy Research (CMR) facility at LANL, including the following:

(i) Seismically upgrade facility to withstand a 7.2 magnitude earthquake.
(ii) Restart high efficiency particulate air (HEPA) filtration facility exhaust system.
(iii) Minor decontamination of four hot cells.
(iv) Rough sizing, sample preparation, and waste packaging equipment.
(v) Specimen transfer device for transportation of source material between cells.
(vi) Storage rack for prepared specimen storage.
(vii) Post irradiation examination instrumentation.
(viii) Remove and replace 5-ton overhead crane.
(ix) Four 6'x6'x5' ICEs.
(x) Remove and replace six pair of manipulators with new heavy-duty manipulators designed to work within new ICEs.
(xi) Add facility infrastructure to supply inert gas to new ICEs.
(xii) Inert gas purification system for new ICEs.
(xiii) Tie-in new ICEs to existing facility exhaust system.
(xiv) Acoustical, vibration, and EMI protection for new examination equipment in existing hot cell.
(xv) Provide temperature control for one hot cell containing examination equipment.
(xvi) Four new access ports into existing hot cells.

(xvii) Fifteen small hot cell penetrations for instrumentation and controls cabling.

c. ORNL

Equipment procurement and modifications to the Radiochemical Engineering Development Center (REDC) at ORNL, including the following:

(i) Secondary facility ventilation requirements to provide a credited secondary system.
(ii) Rough sizing, sample preparation, and waste packaging equipment.
(iii) Eight pair of heavy-duty manipulators.
(iv) Eight 4'x4'x5' oiled filled shielded windows.
(v) Four 12" thick steel hot cell wall plugs.
(vi) New 12" thick steel shielding walls and concrete and steel false floor.
(vii) Storage racks for shielded sample storage and prepared specimen storage.
(viii) Post irradiation examination instrumentation.
(ix) Miscellaneous utility modifications in non-shielded area.
(x) Add fire detection system to existing hot cells.
(xi) Add wet pipe fire suppression system to existing hot cells.
(xii) Install a new material transfer system for material transfer between existing hot cells.
(xiii) Add transport loading port from D-Cell to B-Cell.
(xiv) Five new 6'x6'x5' ICEs.
(xv) Add facility infrastructure to supply inert gas to new ICEs.
(xvi) Inert gas purification system for new ICEs.
(xvii) Tie-in new ICEs to existing facility exhaust system.
(xviii) Acoustical, vibration, and EMI protection for examination equipment in two hot cells and one non-shielded area.
(xix) Provide temperature control for two hot cells and non-shielded area containing examination equipment.
(xx) Five new access ports into existing hot cells.
(xxi) Install four new access doors into existing hot cells.
(xxii) Eighteen small hot cell penetrations for instrumentation and controls cabling.

d. PNNL

Modifications to the Radiochemistry Processing Laboratory at PNNL, including the following:

(i) Decontamination of B-Cell.
(ii) Remove existing equipment from existing MSEs.
(iii) Transfer cask with 8" inside diameter.
(iv) Rough sizing, sample preparation, and waste packaging equipment.
(v) Specimen transfer device for transportation of source material between cells.

(vi) Storage racks for shielded sample storage and prepared specimen storage.
(vii) Post irradiation examination instrumentation.
(viii) Miscellaneous utility modifications in non-shielded area.
(ix) Three new 6'x6'x5' ICEs.
(x) Add facility infrastructure to supply inert gas to new ICEs.
(xi) Inert gas purification system for new ICEs.
(xii) Tie-in new ICEs to existing facility exhaust system.
(xiii) Acoustical, vibration, and EMI protection for examination equipment in an existing hot cell and non-shielded area.
(xiv) Provide temperature control for one hot cell and non-shielded area containing examination equipment.
(xv) Two new access ports into existing hot cells.
(xvi) Fifteen small hot cell penetrations for instrumentation and controls cabling.

e. SRNL

Modifications to the Shielded Cell Facility at SRNL, including the following:
(i) Decontamination of six 6'x6' hot cells.
(ii) Overhead crane maintenance and modifications.
(iii) Rough sizing, sample preparation, and waste packaging equipment.
(iv) Acoustical, vibration, and EMI protection for examination equipment in an existing hot cell and non-shielded area.
(v) Specimen transfer device for transportation of source material between cells.
(vi) Storage racks for shielded sample storage and prepared specimen storage.
(vii) Post irradiation examination instrumentation.
(viii) New 12" thick steel shielding walls.
(ix) Miscellaneous utility modifications in non-shielded area.
(x) Four new 6'x6'x5' ICEs.
(xi) Remove and replace four pair of existing manipulators with new heavy-duty manipulators designed to work within new ICEs.
(xii) Add facility infrastructure to supply inert gas to new ICEs.
(xiii) Inert gas purification system for new ICEs.
(xiv) Tie-in new ICEs to existing facility exhaust system.
(xv) Provide temperature control for one hot cell and one non-shielded area containing examination equipment.
(xvi) Minor modifications to hot cell exhaust system due to the adding of shielded partitions.
(xvii) Five new access ports into existing hot cells.
(xviii) Install two new access doors into existing hot cells.
(xix) Fifteen small hot cell penetrations for instrumentation and controls cabling.

6. Construction subcontract management costs.
7. Operational readiness costs, including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR at each location.
8. Facility operations costs for 40 years. Includes sharing of operations staff with other resident program(s) in the facility. Also includes electrical power usage. See cost estimate back-up file for more details.
9. Facility maintenance costs for 40 years. Including annual facility maintenance costs, facility refurbishment costs, and equipment replacement costs. Annual maintenance and facility refurbishment costs are included only for the facility space to be used by the APIEC project.
10. Post irradiation examination activities for 40 years.
11. Off-site and on-site transportation costs for 100 experiments per year for 40 years.
12. Deactivation, decommissioning, and demolition of facility (DD&D). Includes costs to DD&D the facility space to be used by the APIEC project. See cost estimate back-up file for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Utilities upgrades exterior to the facility.
3. Physical security personnel costs.

III. ESTIMATE METHODOLOGY: *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of the methods are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled Low Level Waste project. Engineering and design development costs are based on the DOE Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range. It was assumed that each of the five DOE sites requiring facility modifications will require separate design efforts, thus, increasing overall project design costs; therefore 25 percent was used.

Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

"Forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning, and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. BASIS OF THE ESTIMATE: *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association for the Advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012,

developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th and 9th, 2012.

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. The operating contractor for each laboratory will provide resources for all project management and construction management resources.
2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by the laboratory operating contractor.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.
4. Sales tax on materials is based on an average rate of 6%.
5. Contractor markup rates are based on this estimator's judgment. The application of markups varies based on cost basis and estimate methodology used.
6. Construction and procurement costs were adjusted by geographic location based on RS Means location factors.
7. The following estimates and or projects were used as a cost basis.

a. Modular Enclosure and Transfer Cask; BEA estimate File #1C66-B.
b. PIE Line Item Building (LIB); BEA estimate File #1B33-D.
c. ANL-W Lab Upgrade CDR.
d. Advanced Test Reactor Loop 2A.

8. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.
9. Estimate allowances have been carried for specific scopes of work that have no design definition. These allowances are:
   a. Seismic upgrade Wing 9 of the LANL CMR facility, allowance provided by LANL.
   b. Restart of Wing 9 of the LANL CMR facility HEPA filtration facility exhaust system, allowance developed by the project team.
   c. Upgrade secondary facility ventilation requirements to provide a credited secondary system of the ORNL IFEL facility, allowance developed by the project team.

V. ESTIMATE QUALITY ASSURANCE: *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. ASSUMPTIONS: *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Per the requester:
   1. Selected facilities will be available to support the PIE program.
   2. Project will not require converting non-hazard category (HC)-2 facilities to meet HC-2 and associated seismic/performance category requirements.
   3. Facility modifications will not require wholesale replacement of existing fixed hot cells.
   4. Seismic upgrade costs (provided by LANL) for the CMR facility includes all required code updates, including fire protection and alarm systems.
   5. Equipment to be removed from the existing MSE at PNNL is not contaminated.

6. Half of the hot cells required for use at LANL will require minor decontamination.
7. Sixty percent of sample prep and rough sizing equipment required for the PIE LIB facility will be required for PIE examination at each facility.
8. Equipment to be removed from the existing MSE at PNNL is not contaminated.
9. Hot cells designated for use at ORNL have never been used and are not contaminated.
10. Facility operations staffing will require a minimum of one person per facility per operations role.
11. Facility operations staffing will be shared with other resident program(s) in the facility.
12. Shipments from ATR to HFEF, HFIR to IFEL, and all APIEC off-site shipments require the use of a rental cask.
13. Shipments from other irradiators to the NDE/sizing/repackaging capability are assumed to be paid for by others. University shipments are assumed to use the existing BRR Cask and shipping paid for by other programs. Shipments from commercial and/or international entities will be at their expense.
14. On-site shipments downstream of NDE/sizing/repackaging are assumed to be performed using existing casks that are available at the site at no cost.
15. Off-site shipments will require the rental of only one cask per experiment.
16. Facility maintenance, refurbishment, and DD&D costs will be allocated to the project based on facility area usage.
17. An environmental impact statement (EIS) will not be required for this project. Costs are included for an environmental assessment (EA) and finding of no significant impact (FONSI).

VII. MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

A blanket MR rate of 50% was applied to this cost estimate. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.

2. Unknown facility upgrades not included in this cost estimate may be required.
3. Currently facilities selected for use may become unavailable.
4. The facility operations estimate is based on the assumption of sharing operations costs with other resident programs. Costs could increase if current programs are terminated.
5. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be greater than anticipated, project costs may be impacted.
6. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is greater than assumed, project costs may be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased productivity, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be less than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed, project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not

contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:

None.

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation (Spent Costs)	$1,510,356	$0	$0	0.00%	$1,510,356
2	Capital Costs (TPC)	$260,423,816	$47,638,180	$154,030,998	50.00%	$462,092,994
2.1	. . . . Idaho National Laboratory	$44,807,499	$7,712,140	$26,259,819	50.00%	$78,779,458
2.1.1	. . . . . Project Management	$4,622,800	$588,482	$2,605,641	50.00%	$7,816,924
2.1.2	. . . . . Engineering and Design Development	$5,778,500	$735,603	$3,257,052	50.00%	$9,771,155
2.1.3	. . . . . Project Integration and DOE 413 Deliverables Integration	$5,316,220	$479,523	$2,897,872	50.00%	$8,693,615
2.1.4	. . . . . Procurement	$15,875,344	$2,757,557	$9,316,451	50.00%	$27,949,352
2.1.4.1	. . . . . Civil Modifications	$5,222,866	$1,003,094	$3,112,980	50.00%	$9,338,940
2.1.4.1.1	*. . . . . Transfer Cask*	*$181,125*	*$29,831*	*$105,478*	*50.00%*	*$316,434*
2.1.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.1.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.1.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,411*	*$4,990*	*50.00%*	*$14,971*
2.1.4.1.5	*. . . . . Examination Equipment*	*$3,201,270*	*$527,249*	*$1,864,260*	*50.00%*	*$5,592,779*
2.1.4.2	. . . . . Mechanical Modifications	$10,652,478	$1,754,463	$6,203,471	50.00%	$18,610,412
2.1.4.2.1	*. . . . . Shielded Confinement Box*	*$562,850*	*$92,701*	*$327,775*	*50.00%*	*$983,326*
2.1.4.2.2	*. . . . . Inert Confinement Enclosure*	*$2,022,563*	*$333,116*	*$1,177,839*	*50.00%*	*$3,533,518*
2.1.4.2.3	*. . . . . Modular Shielded Enclosures*	*$8,067,066*	*$1,328,646*	*$4,697,856*	*50.00%*	*$14,093,568*
2.1.5	. . . . . Construction	$7,238,712	$1,861,016	$4,549,864	50.00%	$13,649,593
2.1.5.1	. . . . . Civil Modifications	$5,719,897	$1,610,868	$3,665,383	50.00%	$10,996,148
2.1.5.1.1	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.1.5.1.2	*. . . . . Acoustical Isolation*	*$32,580*	*$6,624*	*$19,602*	*50.00%*	*$58,805*
2.1.5.1.3	*. . . . . EMI/RFI Protection Installation*	*$57,041*	*$11,596*	*$34,319*	*50.00%*	*$102,956*
2.1.5.1.4	*. . . . . Metal Stud Wall and Suspended Ceiling Modifications*	*$12,981*	*$2,639*	*$7,810*	*50.00%*	*$23,430*
2.1.5.1.5	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.1.5.1.6	*. . . . . Examination Equipment*	*$1,430,947*	*$405,387*	*$918,167*	*50.00%*	*$2,754,502*

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.1.5.2	. . . . . Mechanical Modifications	$1,518,815	$250,149	$884,482	50.00%	$2,653,445
2.1.5.2.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$285,897*	*$47,087*	*$166,492*	*50.00%*	*$499,476*
2.1.5.2.2	*. . . . . Modular Shielded Enclosure Utility Tie-ins*	*$140,878*	*$23,203*	*$82,040*	*50.00%*	*$246,120*
2.1.5.2.3	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$24,139*	*$85,353*	*50.00%*	*$256,059*
2.1.5.2.4	*. . . . . Inert Gas Purification System*	*$132,825*	*$21,876*	*$77,351*	*50.00%*	*$232,052*
2.1.5.2.5	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$210,631*	*$34,691*	*$122,661*	*50.00%*	*$367,983*
2.1.5.2.6	*. . . . . Temperature Control*	*$24,704*	*$4,069*	*$14,386*	*50.00%*	*$43,159*
2.1.5.2.7	*. . . . . Shielded Confinement Box Installation*	*$13,563*	*$2,234*	*$7,898*	*50.00%*	*$23,695*
2.1.5.2.8	*. . . . . Inert Confinement Enclosure Installation*	*$230,580*	*$37,977*	*$134,278*	*50.00%*	*$402,835*
2.1.5.2.9	*. . . . . Modular Shielded Enclosure Installation*	*$333,171*	*$54,873*	*$194,022*	*50.00%*	*$582,066*
2.1.6	**. . . . . Construction Management**	**$1,617,980**	**$266,481**	**$942,231**	**50.00%**	**$2,826,692**
2.1.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.1.8	**. . . . . General and Administrative Costs**	**$867,943**	**$176,453**	**$522,198**	**50.00%**	**$1,566,593**
2.2	**. . . . Los Alamos National Laboratory**	**$86,473,088**	**$15,434,139**	**$50,953,613**	**50.00%**	**$152,860,840**
2.2.1	**. . . . . Project Management**	**$8,962,800**	**$1,140,964**	**$5,051,882**	**50.00%**	**$15,155,647**
2.2.2	**. . . . . Engineering and Design Development**	**$11,203,500**	**$1,426,206**	**$6,314,853**	**50.00%**	**$18,944,558**
2.2.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$10,307,220**	**$929,711**	**$5,618,466**	**50.00%**	**$16,855,397**
2.2.4	**. . . . . Procurement**	**$6,879,441**	**$1,542,764**	**$4,211,102**	**50.00%**	**$12,633,307**
2.2.4.1	. . . . . Civil Modifications	$5,261,391	$1,276,271	$3,268,831	50.00%	$9,806,493
2.2.4.1.1	*. . . . . Manipulators*	*$2,303,910*	*$559,159*	*$1,431,534*	*50.00%*	*$4,294,603*
2.2.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.2.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.2.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,411*	*$4,990*	*50.00%*	*$14,971*
2.2.4.1.5	*. . . . . Examination Equipment*	*$1,117,010*	*$271,098*	*$694,054*	*50.00%*	*$2,082,162*
2.2.4.2	. . . . . Mechanical Modifications	$1,618,050	$266,493	$942,271	50.00%	$2,826,814

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.4.2.1	*. . . . . Inert Confinement Enclosure*	*$1,618,050*	*$266,493*	*$942,271*	*50.00%*	*$2,826,814*
2.2.5	**. . . . . Construction**	**$37,933,873**	**$8,103,910**	**$23,018,891**	**50.00%**	**$69,056,674**
2.2.5.1	. . . . . Siesmic Upgrade	$30,000,000	$6,099,000	$18,049,500	50.00%	$54,148,500
2.2.5.2	. . . . . Decontamination	$530,000	$107,749	$318,875	50.00%	$956,624
2.2.5.3	. . . . . Civil Modifications	$5,763,278	$1,563,628	$3,663,453	50.00%	$10,990,359
2.2.5.3.1	*. . . . . Crane Replacement*	*$85,411*	*$17,364*	*$51,387*	*50.00%*	*$154,162*
2.2.5.3.2	*. . . . . Manipulator Installation*	*$33,327*	*$9,442*	*$21,384*	*50.00%*	*$64,153*
2.2.5.3.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.2.5.3.4	*. . . . . Vibration Isolation*	*$140,192*	*$28,501*	*$84,347*	*50.00%*	*$253,040*
2.2.5.3.5	*. . . . . Acoustical Isolation*	*$38,938*	*$7,916*	*$23,427*	*50.00%*	*$70,282*
2.2.5.3.6	*. . . . . EMI/RFI Protection Installation*	*$29,263*	*$5,949*	*$17,606*	*50.00%*	*$52,818*
2.2.5.3.7	*. . . . . Specimen Storage Racks*	*$8,569*	*$1,742*	*$5,156*	*50.00%*	*$15,467*
2.2.5.3.8	*. . . . . Access Ports*	*$470,925*	*$95,739*	*$283,332*	*50.00%*	*$849,996*
2.2.5.3.9	*. . . . . Instrument Penetrations*	*$90,563*	*$18,411*	*$54,487*	*50.00%*	*$163,461*
2.2.5.3.10	*. . . . . Examination Equipment*	*$696,880*	*$197,426*	*$447,153*	*50.00%*	*$1,341,459*
2.2.5.4	. . . . . Mechanical Modifications	$1,640,595	$333,533	$987,064	50.00%	$2,961,192
2.2.5.4.1	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.2.5.4.2	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.2.5.4.3	*. . . . . Restart HEPA Exhaust System*	*$1,000,000*	*$203,300*	*$601,650*	*50.00%*	*$1,804,950*
2.2.5.4.4	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$168,505*	*$34,257*	*$101,381*	*50.00%*	*$304,143*
2.2.5.4.5	*. . . . . Temperature Control*	*$8,235*	*$1,674*	*$4,954*	*50.00%*	*$14,863*
2.2.5.4.6	*. . . . . Inert Confinement Enclosure Installation*	*$184,464*	*$37,502*	*$110,983*	*50.00%*	*$332,949*
2.2.6	**. . . . . Construction Management**	**$3,136,980**	**$516,661**	**$1,826,820**	**50.00%**	**$5,480,461**
2.2.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.2.8	**. . . . . General and Administrative Costs**	**$974,154**	**$198,045**	**$586,100**	**50.00%**	**$1,758,299**
2.2.9	**. . . . . Location Factor Adjustment**	**$3,585,120**	**$728,855**	**$2,156,987**	**50.00%**	**$6,470,962**

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3	. . . . Oakridge National Laboratory	$65,843,889	$12,244,374	$39,044,131	50.00%	$117,132,394
2.3.1	**. . . . . Project Management**	**$7,042,400**	**$896,498**	**$3,969,449**	**50.00%**	**$11,908,346**
2.3.2	**. . . . . Engineering and Design Development**	**$8,803,000**	**$1,120,622**	**$4,961,811**	**50.00%**	**$14,885,433**
2.3.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$8,098,760**	**$730,508**	**$4,414,634**	**50.00%**	**$13,243,902**
2.3.4	**. . . . . Procurement**	**$15,633,814**	**$3,636,567**	**$9,635,191**	**50.00%**	**$28,905,572**
2.3.4.1	. . . . . Civil Modifications	$13,611,252	$3,303,451	$8,457,351	50.00%	$25,372,054
2.3.4.1.1	*. . . . . Manipulators*	*$3,071,880*	*$745,545*	*$1,908,713*	*50.00%*	*$5,726,138*
2.3.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.3.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.3.4.1.4	*. . . . . Shielded Windows*	*$5,506,200*	*$1,336,355*	*$3,421,277*	*50.00%*	*$10,263,832*
2.3.4.1.5	*. . . . . Examination Equipment*	*$3,201,270*	*$776,948*	*$1,989,109*	*50.00%*	*$5,967,327*
2.3.4.2	. . . . . Mechanical Modifications	$2,022,563	$333,116	$1,177,839	50.00%	$3,533,518
2.3.4.2.1	*. . . . . Inert Confinement Enclosure*	*$2,022,563*	*$333,116*	*$1,177,839*	*50.00%*	*$3,533,518*
2.3.5	**. . . . . Construction**	**$19,577,503**	**$4,458,062**	**$12,017,782**	**50.00%**	**$36,053,347**
2.3.5.1	. . . . . Civil Modifications	$13,501,797	$3,222,871	$8,362,334	50.00%	$25,087,002
2.3.5.1.1	*. . . . . New Internal Material Transfer Device*	*$329,853*	*$93,447*	*$211,650*	*50.00%*	*$634,950*
2.3.5.1.2	*. . . . . Manipulator Installation*	*$44,436*	*$12,589*	*$28,512*	*50.00%*	*$85,537*
2.3.5.1.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.3.5.1.4	*. . . . . Vibration Isolation*	*$280,384*	*$57,002*	*$168,693*	*50.00%*	*$506,080*
2.3.5.1.5	*. . . . . Acoustical Isolation*	*$84,575*	*$17,194*	*$50,885*	*50.00%*	*$152,654*
2.3.5.1.6	*. . . . . EMI/RFI Protection Installation*	*$188,680*	*$38,359*	*$113,519*	*50.00%*	*$340,557*
2.3.5.1.7	*. . . . . Transport Loading*	*$120,750*	*$24,548*	*$72,649*	*50.00%*	*$217,948*
2.3.5.1.8	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.3.5.1.9	*. . . . . Steel Shielding Walls*	*$4,725,294*	*$960,652*	*$2,842,973*	*50.00%*	*$8,528,919*
2.3.5.1.9.1	*. . . . . 12" Thick Steel Shielding Walls*	*$4,662,820*	*$947,951*	*$2,805,386*	*50.00%*	*$8,416,157*

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.5.1.9.2	*. . . . . Concrete and Steel False Floor*	*$62,474*	*$12,701*	*$37,587*	*50.00%*	*$112,762*
2.3.5.1.10	*. . . . . Shielded Windows Installation*	*$77,280*	*$15,711*	*$46,496*	*50.00%*	*$139,487*
2.3.5.1.11	*. . . . . Shielded Wall Plug*	*$108,675*	*$22,094*	*$65,384*	*50.00%*	*$196,153*
2.3.5.1.12	*. . . . . Access Ports*	*$588,656*	*$119,674*	*$354,165*	*50.00%*	*$1,062,495*
2.3.5.1.13	*. . . . . Install Access Door*	*$1,227,243*	*$249,499*	*$738,371*	*50.00%*	*$2,215,113*
2.3.5.1.13.1	*. . . . . Contractor Support*	*$283,275*	*$57,590*	*$170,433*	*50.00%*	*$511,298*
2.3.5.1.13.2	*. . . . . Subcontractor Access Door Installation*	*$943,968*	*$191,909*	*$567,938*	*50.00%*	*$1,703,815*
2.3.5.1.14	*. . . . . Instrument Penetrations*	*$108,675*	*$22,094*	*$65,384*	*50.00%*	*$196,153*
2.3.5.1.15	*. . . . . Examination Equipment*	*$1,430,947*	*$405,387*	*$918,167*	*50.00%*	*$2,754,502*
2.3.5.2	. . . . . Mechanical Modifications	$6,031,204	$1,226,144	$3,628,674	50.00%	$10,886,021
2.3.5.2.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$285,897*	*$58,123*	*$172,010*	*50.00%*	*$516,030*
2.3.5.2.2	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.3.5.2.3	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.3.5.2.4	*. . . . . Secondary Ventilation System Modifications*	*$5,000,000*	*$1,016,500*	*$3,008,250*	*50.00%*	*$9,024,750*
2.3.5.2.5	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$210,631*	*$42,821*	*$126,726*	*50.00%*	*$380,179*
2.3.5.2.6	*. . . . . Temperature Control*	*$24,704*	*$5,022*	*$14,863*	*50.00%*	*$44,589*
2.3.5.2.7	*. . . . . Inert Confinement Enclosure Installation*	*$230,580*	*$46,877*	*$138,729*	*50.00%*	*$416,186*
2.3.5.3	. . . . . Fire Protection Modifications	$44,502	$9,047	$26,774	50.00%	$80,323
2.3.5.3.1	*. . . . . Fire Alarm System Upgrade*	*$23,287*	*$4,734*	*$14,011*	*50.00%*	*$42,033*
2.3.5.3.2	*. . . . . Fire Protection System Upgrade*	*$21,214*	*$4,313*	*$12,764*	*50.00%*	*$38,291*
2.3.6	**. . . . . Construction Management**	**$2,464,840**	**$405,959**	**$1,435,400**	**50.00%**	**$4,306,199**
2.3.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.3.8	**. . . . . General and Administrative Costs**	**$1,085,692**	**$220,721**	**$653,207**	**50.00%**	**$1,959,620**
2.3.9	**. . . . . Location Factor Adjustment**	**($352,120)**	**($71,586)**	**($211,853)**	**50.00%**	**($635,559)**
2.4	**. . . . Pacific Northwest National Laboratory**	**$27,537,413**	**$5,457,044**	**$16,497,228**	**50.00%**	**$49,491,685**
2.4.1	**. . . . . Project Management**	**$2,451,600**	**$312,089**	**$1,381,844**	**50.00%**	**$4,145,533**

BEA

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.4.2	**. . . . . Engineering and Design Development**	**$3,064,500**	**$390,111**	**$1,727,305**	**50.00%**	**$5,181,916**
2.4.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$2,819,340**	**$254,304**	**$1,536,822**	**50.00%**	**$4,610,467**
2.4.4	**. . . . . Procurement**	**$5,319,393**	**$1,181,565**	**$3,250,479**	**50.00%**	**$9,751,437**
2.4.4.1	. . . . . Civil Modifications	$4,105,856	$981,695	$2,543,776	50.00%	$7,631,327
2.4.4.1.1	*. . . . . Transfer Cask*	*$181,125*	*$29,831*	*$105,478*	*50.00%*	*$316,434*
2.4.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.4.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.4.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,411*	*$4,990*	*50.00%*	*$14,971*
2.4.4.1.5	*. . . . . Examination Equipment*	*$2,084,260*	*$505,850*	*$1,295,055*	*50.00%*	*$3,885,165*
2.4.4.2	. . . . . Mechanical Modifications	$1,213,538	$199,870	$706,704	50.00%	$2,120,111
2.4.4.2.1	*. . . . . Inert Confinement Enclosure*	*$1,213,538*	*$199,870*	*$706,704*	*50.00%*	*$2,120,111*
2.4.5	**. . . . . Construction**	**$6,938,317**	**$1,802,822**	**$4,370,569**	**50.00%**	**$13,111,708**
2.2.5.2	. . . . . Decontamination	$530,000	$107,749	$318,875	50.00%	$956,624
2.4.5.1	. . . . . Equipment Removal	$22,167	$4,507	$13,337	50.00%	$40,010
2.4.5.2	. . . . . Civil Modifications	$5,539,666	$1,518,476	$3,529,071	50.00%	$10,587,213
2.4.5.2.1	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.4.5.2.2	*. . . . . Vibration Isolation*	*$210,288*	*$42,752*	*$126,520*	*50.00%*	*$379,560*
2.4.5.2.3	*. . . . . Acoustical Isolation*	*$63,431*	*$12,896*	*$38,164*	*50.00%*	*$114,491*
2.4.5.2.4	*. . . . . EMI/RFI Protection Installation*	*$55,730*	*$11,330*	*$33,530*	*50.00%*	*$100,591*
2.4.5.2.5	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.4.5.2.6	*. . . . . Access Ports*	*$235,463*	*$47,870*	*$141,666*	*50.00%*	*$424,998*
2.4.5.2.7	*. . . . . Instrument Penetrations*	*$54,338*	*$11,047*	*$32,692*	*50.00%*	*$98,076*
2.4.5.2.8	*. . . . . Examination Equipment*	*$734,067*	*$207,961*	*$471,014*	*50.00%*	*$1,413,042*
2.4.5.3	. . . . . Mechanical Modifications	$846,484	$172,090	$509,287	50.00%	$1,527,862
2.4.5.3.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$285,897*	*$58,123*	*$172,010*	*50.00%*	*$516,030*

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.4.5.3.2	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.4.5.3.3	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.4.5.3.4	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$126,379*	*$25,693*	*$76,036*	*50.00%*	*$228,107*
2.4.5.3.5	*. . . . . Temperature Control*	*$16,469*	*$3,348*	*$9,909*	*50.00%*	*$29,726*
2.4.5.3.6	*. . . . . Inert Confinement Enclosure Installation*	*$138,348*	*$28,126*	*$83,237*	*50.00%*	*$249,711*
2.4.6	**. . . . . Construction Management**	**$858,060**	**$141,322**	**$499,691**	**50.00%**	**$1,499,074**
2.4.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.4.8	**. . . . . General and Administrative Costs**	**$512,343**	**$104,159**	**$308,251**	**50.00%**	**$924,753**
2.4.9	**. . . . . Location Factor Adjustment**	**$2,083,860**	**$423,649**	**$1,253,754**	**50.00%**	**$3,761,263**
2.5	**. . . . Savanah River National Laboratory**	**$35,761,928**	**$6,790,484**	**$21,276,206**	**50.00%**	**$63,828,617**
2.5.1	**. . . . . Project Management**	**$3,698,600**	**$470,832**	**$2,084,716**	**50.00%**	**$6,254,148**
2.5.2	**. . . . . Engineering and Design Development**	**$4,623,250**	**$588,540**	**$2,605,895**	**50.00%**	**$7,817,685**
2.5.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$4,253,390**	**$383,656**	**$2,318,523**	**50.00%**	**$6,955,569**
2.5.4	**. . . . . Procurement**	**$7,078,721**	**$1,591,129**	**$4,334,925**	**50.00%**	**$13,004,775**
2.5.4.1	. . . . . Civil Modifications	$5,460,671	$1,324,636	$3,392,654	50.00%	$10,177,961
2.5.4.1.1	*. . . . . Manipulators*	*$1,535,940*	*$372,773*	*$954,356*	*50.00%*	*$2,863,069*
2.5.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.5.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.5.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,411*	*$4,990*	*50.00%*	*$14,971*
2.5.4.1.5	*. . . . . Examination Equipment*	*$2,084,260*	*$505,850*	*$1,295,055*	*50.00%*	*$3,885,165*
2.5.4.2	. . . . . Mechanical Modifications	$1,618,050	$266,493	$942,271	50.00%	$2,826,814
2.5.4.2.1	*. . . . . Inert Confinement Enclosure*	*$1,618,050*	*$266,493*	*$942,271*	*50.00%*	*$2,826,814*
2.5.5	**. . . . . Construction**	**$11,413,899**	**$2,714,485**	**$7,064,192**	**50.00%**	**$21,192,576**
2.5.5.1	. . . . . Decontamination	$3,185,624	$647,637	$1,916,631	50.00%	$5,749,892
2.5.5.2	. . . . . Civil Modifications	$7,293,548	$1,876,818	$4,585,183	50.00%	$13,755,549
2.5.5.2.1	*. . . . . Crane Modifications*	*$27,708*	*$5,633*	*$16,670*	*50.00%*	*$50,011*

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.5.5.2.2	*. . . . . Manipulator Installation*	*$22,218*	*$6,294*	*$14,256*	*50.00%*	*$42,769*
2.5.5.2.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.5.5.2.4	*. . . . . Vibration Isolation*	*$210,288*	*$42,752*	*$126,520*	*50.00%*	*$379,560*
2.5.5.2.5	*. . . . . Acoustical Isolation*	*$63,431*	*$12,896*	*$38,164*	*50.00%*	*$114,491*
2.5.5.2.6	*. . . . . EMI/RFI Protection Installation*	*$55,730*	*$11,330*	*$33,530*	*50.00%*	*$100,591*
2.5.5.2.7	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.5.5.2.8	*. . . . . Steel Shielding Walls*	*$362,865*	*$73,771*	*$218,318*	*50.00%*	*$654,954*
2.5.5.2.8.1	*. . . . . 12" Thick Steel Sheilding Walls*	*$362,865*	*$73,771*	*$218,318*	*50.00%*	*$654,954*
2.5.5.2.9	*. . . . . Access Ports*	*$588,656*	*$119,674*	*$354,165*	*50.00%*	*$1,062,495*
2.5.5.2.10	*. . . . . Install Access Door*	*$951,673*	*$193,475*	*$572,574*	*50.00%*	*$1,717,721*
2.5.5.2.10.1	*. . . . . Contractor Support*	*$225,069*	*$45,756*	*$135,413*	*50.00%*	*$406,238*
2.5.5.2.10.2	*. . . . . Subcontractor Access Door Installation*	*$726,604*	*$147,719*	*$437,161*	*50.00%*	*$1,311,484*
2.5.5.2.11	*. . . . . Instrument Penetrations*	*$90,563*	*$18,411*	*$54,487*	*50.00%*	*$163,461*
2.5.5.2.12	*. . . . . Examination Equipment*	*$734,067*	*$207,961*	*$471,014*	*50.00%*	*$1,413,042*
2.5.5.3	. . . . . Mechanical Modifications	$934,727	$190,030	$562,378	50.00%	$1,687,135
2.5.5.3.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$285,897*	*$58,123*	*$172,010*	*50.00%*	*$516,030*
2.5.5.3.2	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.5.5.3.3	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.5.5.3.4	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$168,505*	*$34,257*	*$101,381*	*50.00%*	*$304,143*
2.5.5.3.5	*. . . . . Temperature Control*	*$16,469*	*$3,348*	*$9,909*	*50.00%*	*$29,726*
2.5.5.3.6	*. . . . . Inert Confinement Enclosure Installation*	*$184,464*	*$37,502*	*$110,983*	*50.00%*	*$332,949*
2.5.6	**. . . . . Construction Management**	**$1,294,510**	**$213,206**	**$753,858**	**50.00%**	**$2,261,574**
2.5.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.5.8	**. . . . . General and Administrative Costs**	**$1,019,138**	**$207,191**	**$613,164**	**50.00%**	**$1,839,493**
2.5.9	**. . . . . Location Factor Adjustment**	**($1,109,580)**	**($225,578)**	**($667,579)**	**50.00%**	**($2,002,736)**

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3	Facility Operations and Maintenance	$770,939,291	$1,265,867,417	$***,***,***	50.00%	$3,055,210,061
3.1	. . . . Year 1	$17,586,575	$5,719,154	$11,652,865	50.00%	$34,958,594
3.1.1	. . . . . Facility Maintenance	$4,033,120	$1,311,571	$2,672,345	50.00%	$8,017,036
3.1.2	. . . . . Facility Operations	$12,196,155	$3,966,190	$8,081,172	50.00%	$24,243,517
3.1.3	. . . . . Electrical Power Usage	$1,357,300	$441,394	$899,347	50.00%	$2,698,041
3.2	. . . . Year 2	$17,586,575	$6,480,653	$12,033,614	50.00%	$36,100,842
3.2.1	. . . . . Facility Maintenance	$4,033,120	$1,486,205	$2,759,662	50.00%	$8,278,987
3.2.2	. . . . . Facility Operations	$12,196,155	$4,494,283	$8,345,219	50.00%	$25,035,657
3.2.3	. . . . . Electrical Power Usage	$1,357,300	$500,165	$928,733	50.00%	$2,786,198
3.3	. . . . Year 3	$22,258,502	$9,197,213	$15,727,858	50.00%	$47,183,573
3.3.1	. . . . . Facility Maintenance	$4,033,120	$1,666,485	$2,849,803	50.00%	$8,549,408
3.3.2	. . . . . Facility Operations	$12,196,155	$5,039,451	$8,617,803	50.00%	$25,853,409
3.3.3	. . . . . Facility Refurbishment	$4,671,927	$1,930,440	$3,301,184	50.00%	$9,903,551
3.3.4	. . . . . Electrical Power Usage	$1,357,300	$560,836	$959,068	50.00%	$2,877,205
3.4	. . . . Year 4	$17,586,575	$8,077,514	$12,832,044	50.00%	$38,496,133
3.4.1	. . . . . Facility Maintenance	$4,033,120	$1,852,412	$2,942,766	50.00%	$8,828,298
3.4.2	. . . . . Facility Operations	$12,196,155	$5,601,694	$8,898,924	50.00%	$26,696,773
3.4.3	. . . . . Electrical Power Usage	$1,357,300	$623,408	$990,354	50.00%	$2,971,062
3.5	. . . . Year 5	$17,586,575	$8,916,394	$13,251,484	50.00%	$39,754,453
3.5.1	. . . . . Facility Maintenance	$4,033,120	$2,044,792	$3,038,956	50.00%	$9,116,868
3.5.2	. . . . . Facility Operations	$12,196,155	$6,183,451	$9,189,803	50.00%	$27,569,408
3.5.3	. . . . . Electrical Power Usage	$1,357,300	$688,151	$1,022,726	50.00%	$3,068,177
3.6	. . . . Year 6	$18,751,655	$10,429,671	$14,590,663	50.00%	$43,771,988
3.6.1	. . . . . Facility Maintenance	$4,033,120	$2,243,221	$3,138,171	50.00%	$9,414,512
3.6.2	. . . . . Facility Operations	$12,196,155	$6,783,501	$9,489,828	50.00%	$28,469,485
3.6.3	. . . . . Facility Refurbishment	$1,165,080	$648,017	$906,549	50.00%	$2,719,646

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.6.4	. . . . . Electrical Power Usage	$1,357,300	$754,930	$1,056,115	50.00%	$3,168,345
3.7	. . . . Year 7	$17,586,575	$10,676,810	$14,131,692	50.00%	$42,395,077
3.7.1	. . . . . Facility Maintenance	$4,033,120	$2,448,507	$3,240,814	50.00%	$9,722,441
3.7.2	. . . . . Facility Operations	$12,196,155	$7,404,286	$9,800,220	50.00%	$29,400,661
3.7.3	. . . . . Electrical Power Usage	$1,357,300	$824,017	$1,090,658	50.00%	$3,271,975
3.8	. . . . Year 8	$17,586,575	$11,600,105	$14,593,340	50.00%	$43,780,020
3.8.1	. . . . . Facility Maintenance	$4,033,120	$2,660,246	$3,346,683	50.00%	$10,040,049
3.8.2	. . . . . Facility Operations	$12,196,155	$8,044,584	$10,120,369	50.00%	$30,361,108
3.8.3	. . . . . Electrical Power Usage	$1,357,300	$895,275	$1,126,288	50.00%	$3,378,863
3.9	. . . . Year 9	$17,515,751	$12,502,743	$15,009,247	50.00%	$45,027,741
3.9.1	. . . . . Facility Maintenance	$3,962,296	$2,828,287	$3,395,291	50.00%	$10,185,874
3.9.2	. . . . . Facility Operations	$12,196,155	$8,705,615	$10,450,885	50.00%	$31,352,656
3.9.3	. . . . . Electrical Power Usage	$1,357,300	$968,841	$1,163,070	50.00%	$3,489,211
3.10	. . . . Year 10	$35,325,671	$27,193,702	$31,259,686	50.00%	$93,779,059
3.10.1	. . . . . Facility Maintenance	$4,033,120	$3,104,696	$3,568,908	50.00%	$10,706,724
3.10.2	. . . . . Facility Operations	$12,196,155	$9,388,600	$10,792,378	50.00%	$32,377,133
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.10.4	. . . . . Electrical Power Usage	$1,357,300	$1,044,850	$1,201,075	50.00%	$3,603,224
3.11	. . . . Year 11	$17,586,575	$14,554,649	$16,070,612	50.00%	$48,211,837
3.11.1	. . . . . Facility Maintenance	$4,033,120	$3,337,810	$3,685,465	50.00%	$11,056,395
3.11.2	. . . . . Facility Operations	$12,196,155	$10,093,538	$11,144,846	50.00%	$33,434,539
3.11.3	. . . . . Electrical Power Usage	$1,357,300	$1,123,301	$1,240,301	50.00%	$3,720,902
3.12	. . . . Year 12	$17,586,575	$15,604,568	$16,595,571	50.00%	$49,786,714
3.12.1	. . . . . Facility Maintenance	$4,033,120	$3,578,587	$3,805,854	50.00%	$11,417,561
3.12.2	. . . . . Facility Operations	$12,196,155	$10,821,648	$11,508,902	50.00%	$34,526,705
3.12.3	. . . . . Electrical Power Usage	$1,357,300	$1,204,332	$1,280,816	50.00%	$3,842,448

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.13	. . . . Year 13	$17,586,575	$16,687,901	$17,137,238	50.00%	$51,411,714
3.13.1	. . . . . Facility Maintenance	$4,033,120	$3,827,028	$3,930,074	50.00%	$11,790,221
3.13.2	. . . . . Facility Operations	$12,196,155	$11,572,931	$11,884,543	50.00%	$35,653,630
3.13.3	. . . . . Electrical Power Usage	$1,357,300	$1,287,942	$1,322,621	50.00%	$3,967,863
3.14	. . . . Year 14	$17,586,575	$17,808,166	$17,697,370	50.00%	$53,092,111
3.14.1	. . . . . Facility Maintenance	$4,033,120	$4,083,937	$4,058,529	50.00%	$12,175,586
3.14.2	. . . . . Facility Operations	$12,196,155	$12,349,827	$12,272,991	50.00%	$36,818,972
3.14.3	. . . . . Electrical Power Usage	$1,357,300	$1,374,402	$1,365,851	50.00%	$4,097,553
3.15	. . . . Year 15	$17,586,575	$20,157,732	$18,872,154	50.00%	$56,616,461
3.15.1	. . . . . Facility Maintenance	$4,033,120	$4,622,762	$4,327,941	50.00%	$12,983,823
3.15.2	. . . . . Facility Operations	$12,196,155	$13,979,233	$13,087,694	50.00%	$39,263,082
3.15.3	. . . . . Electrical Power Usage	$1,357,300	$1,555,737	$1,456,519	50.00%	$4,369,556
3.16	. . . . Year 16	$17,586,575	$20,157,732	$18,872,154	50.00%	$56,616,461
3.16.1	. . . . . Facility Maintenance	$4,033,120	$4,622,762	$4,327,941	50.00%	$12,983,823
3.16.2	. . . . . Facility Operations	$12,196,155	$13,979,233	$13,087,694	50.00%	$39,263,082
3.16.3	. . . . . Electrical Power Usage	$1,357,300	$1,555,737	$1,456,519	50.00%	$4,369,556
3.17	. . . . Year 17	$17,586,575	$21,390,551	$19,488,563	50.00%	$58,465,689
3.17.1	. . . . . Facility Maintenance	$4,033,120	$4,905,484	$4,469,302	50.00%	$13,407,906
3.17.2	. . . . . Facility Operations	$12,196,155	$14,834,183	$13,515,169	50.00%	$40,545,507
3.17.3	. . . . . Electrical Power Usage	$1,357,300	$1,650,884	$1,504,092	50.00%	$4,512,276
3.18	. . . . Year 18	$17,586,575	$22,663,819	$20,125,197	50.00%	$60,375,591
3.18.1	. . . . . Facility Maintenance	$4,033,120	$5,197,482	$4,615,301	50.00%	$13,845,903
3.18.2	. . . . . Facility Operations	$12,196,155	$15,717,185	$13,956,670	50.00%	$41,870,010
3.18.3	. . . . . Electrical Power Usage	$1,357,300	$1,749,153	$1,553,226	50.00%	$4,659,679
3.19	. . . . Year 19	$17,586,575	$23,979,295	$20,782,935	50.00%	$62,348,805
3.19.1	. . . . . Facility Maintenance	$4,033,120	$5,499,159	$4,766,140	50.00%	$14,298,419

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.19.2	. . . . . Facility Operations	$12,196,155	$16,629,457	$14,412,806	50.00%	$43,238,419
3.19.3	. . . . . Electrical Power Usage	$1,357,300	$1,850,679	$1,603,989	50.00%	$4,811,968
3.20	**. . . . Year 20**	**$35,325,671**	**$50,893,694**	**$43,109,683**	**50.00%**	**$129,329,048**
3.20.1	. . . . . Facility Maintenance	$4,033,120	$5,810,516	$4,921,818	50.00%	$14,765,454
3.20.2	. . . . . Facility Operations	$12,196,155	$17,571,001	$14,883,578	50.00%	$44,650,733
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.20.4	. . . . . Electrical Power Usage	$1,357,300	$1,955,462	$1,656,381	50.00%	$4,969,143
3.21	**. . . . Year 21**	**$17,586,575**	**$26,738,629**	**$22,162,602**	**50.00%**	**$66,487,805**
3.21.1	. . . . . Facility Maintenance	$4,033,120	$6,131,956	$5,082,538	50.00%	$15,247,613
3.21.2	. . . . . Facility Operations	$12,196,155	$18,543,034	$15,369,595	50.00%	$46,108,784
3.21.3	. . . . . Electrical Power Usage	$1,357,300	$2,063,639	$1,710,469	50.00%	$5,131,408
3.22	**. . . . Year 22**	**$17,586,575**	**$28,187,762**	**$22,887,169**	**50.00%**	**$68,661,506**
3.22.1	. . . . . Facility Maintenance	$4,033,120	$6,464,285	$5,248,702	50.00%	$15,746,107
3.22.2	. . . . . Facility Operations	$12,196,155	$19,547,997	$15,872,076	50.00%	$47,616,228
3221.3	. . . . . Electrical Power Usage	$1,357,300	$2,175,480	$1,766,390	50.00%	$5,299,171
3.23	**. . . . Year 23**	**$22,258,502**	**$37,567,900**	**$29,913,201**	**50.00%**	**$89,739,603**
3.23.1	. . . . . Facility Maintenance	$4,033,120	$6,807,100	$5,420,110	50.00%	$16,260,330
3.23.2	. . . . . Facility Operations	$12,196,155	$20,584,670	$16,390,413	50.00%	$49,171,238
3.23.3	. . . . . Facility Refurbishment	$4,671,927	$7,885,278	$6,278,603	50.00%	$18,835,808
3.23.4	. . . . . Electrical Power Usage	$1,357,300	$2,290,851	$1,824,075	50.00%	$5,472,226
3.24	**. . . . Year 24**	**$17,586,575**	**$31,226,723**	**$24,406,649**	**50.00%**	**$73,219,946**
3.24.1	. . . . . Facility Maintenance	$4,033,120	$7,161,208	$5,597,164	50.00%	$16,791,492
3.24.2	. . . . . Facility Operations	$12,196,155	$21,655,493	$16,925,824	50.00%	$50,777,472
3.24.3	. . . . . Electrical Power Usage	$1,357,300	$2,410,022	$1,883,661	50.00%	$5,650,983
3.25	**. . . . Year 25**	**$17,586,575**	**$32,821,825**	**$25,204,200**	**50.00%**	**$75,612,600**
3.25.1	. . . . . Facility Maintenance	$4,033,120	$7,527,012	$5,780,066	50.00%	$17,340,198

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.25.2	. . . . . Facility Operations	$12,196,155	$22,761,684	$17,478,920	50.00%	$52,436,759
3.25.3	. . . . . Electrical Power Usage	$1,357,300	$2,533,129	$1,945,214	50.00%	$5,835,643
3.26	**. . . . Year 26**	**$18,751,655**	**$36,751,369**	**$27,751,512**	**50.00%**	**$83,254,535**
3.26.1	. . . . . Facility Maintenance	$4,033,120	$7,904,512	$5,968,816	50.00%	$17,906,448
3.26.2	. . . . . Facility Operations	$12,196,155	$23,903,244	$18,049,700	50.00%	$54,149,099
3.26.3	. . . . . Facility Refurbishment	$1,165,080	$2,283,440	$1,724,260	50.00%	$5,172,780
3.26.4	. . . . . Electrical Power Usage	$1,357,300	$2,660,172	$2,008,736	50.00%	$6,026,208
3.27	**. . . . Year 27**	**$17,586,575**	**$36,168,550**	**$26,877,563**	**50.00%**	**$80,632,688**
3.27.1	. . . . . Facility Maintenance	$4,033,120	$8,294,515	$6,163,817	50.00%	$18,491,452
3.27.2	. . . . . Facility Operations	$12,196,155	$25,082,612	$18,639,384	50.00%	$55,918,151
3.27.3	. . . . . Electrical Power Usage	$1,357,300	$2,791,423	$2,074,362	50.00%	$6,223,085
3.28	**. . . . Year 28**	**$17,586,575**	**$37,923,690**	**$27,755,133**	**50.00%**	**$83,265,398**
3.28.1	. . . . . Facility Maintenance	$4,033,120	$8,697,020	$6,365,070	50.00%	$19,095,210
3.28.2	. . . . . Facility Operations	$12,196,155	$26,299,789	$19,247,972	50.00%	$57,743,915
3.28.3	. . . . . Electrical Power Usage	$1,357,300	$2,926,882	$2,142,091	50.00%	$6,426,273
3.29	**. . . . Year 29**	**$17,586,575**	**$39,736,866**	**$28,661,721**	**50.00%**	**$85,985,162**
3.29.1	. . . . . Facility Maintenance	$4,033,120	$9,112,835	$6,572,977	50.00%	$19,718,932
3.29.2	. . . . . Facility Operations	$12,196,155	$27,557,212	$19,876,684	50.00%	$59,630,051
3.29.3	. . . . . Electrical Power Usage	$1,357,300	$3,066,819	$2,212,060	50.00%	$6,636,179
3.30	**. . . . Year 30**	**$35,325,671**	**$83,580,538**	**$59,453,104**	**50.00%**	**$178,359,313**
3.30.1	. . . . . Facility Maintenance	$4,033,120	$9,542,362	$6,787,741	50.00%	$20,363,223
3.30.2	. . . . . Facility Operations	$12,196,155	$28,856,103	$20,526,129	50.00%	$61,578,387
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.30.4	. . . . . Electrical Power Usage	$1,357,300	$3,211,372	$2,284,336	50.00%	$6,853,008
3.31	**. . . . Year 31**	**$17,586,575**	**$43,544,360**	**$30,565,467**	**50.00%**	**$91,696,402**
3.31.1	. . . . . Facility Maintenance	$4,033,120	$9,986,005	$7,009,563	50.00%	$21,028,688

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.31.2	. . . . . Facility Operations	$12,196,155	$30,197,680	$21,196,917	50.00%	$63,590,752
3.31.3	. . . . . Electrical Power Usage	$1,357,300	$3,360,675	$2,358,987	50.00%	$7,076,962
3.32	. . . . Year 32	$20,242,388	$52,417,664	$36,330,026	50.00%	$108,990,078
3.32.1	. . . . . Facility Maintenance	$4,033,120	$10,443,764	$7,238,442	50.00%	$21,715,326
3.32.2	. . . . . Facility Operations	$12,196,155	$31,581,943	$21,889,049	50.00%	$65,667,148
3.32.3	. . . . . Facility Refurbishment	$2,655,813	$6,877,228	$4,766,520	50.00%	$14,299,561
3.32.4	. . . . . Electrical Power Usage	$1,357,300	$3,514,728	$2,436,014	50.00%	$7,308,043
3.33	. . . . Year 33	$17,586,575	$47,603,341	$32,594,958	50.00%	$97,784,874
3.33.1	. . . . . Facility Maintenance	$4,033,120	$10,916,849	$7,474,985	50.00%	$22,424,954
3.33.2	. . . . . Facility Operations	$12,196,155	$33,012,552	$22,604,354	50.00%	$67,813,061
3.33.3	. . . . . Electrical Power Usage	$1,357,300	$3,673,940	$2,515,620	50.00%	$7,546,859
3.34	. . . . Year 34	$17,586,575	$49,733,075	$33,659,825	50.00%	$100,979,476
3.34.1	. . . . . Facility Maintenance	$4,033,120	$11,405,260	$7,719,190	50.00%	$23,157,570
3.34.2	. . . . . Facility Operations	$12,196,155	$34,489,507	$23,342,831	50.00%	$70,028,493
3.34.3	. . . . . Electrical Power Usage	$1,357,300	$3,838,309	$2,597,804	50.00%	$7,793,413
3.35	. . . . Year 35	$17,586,575	$51,931,397	$34,758,986	50.00%	$104,276,958
3.35.1	. . . . . Facility Maintenance	$4,033,120	$11,909,400	$7,971,260	50.00%	$23,913,780
3.35.2	. . . . . Facility Operations	$12,196,155	$36,014,026	$24,105,091	50.00%	$72,315,272
3.35.3	. . . . . Electrical Power Usage	$1,357,300	$4,007,971	$2,682,636	50.00%	$8,047,907
3.36	. . . . Year 36	$17,586,575	$54,201,824	$35,894,200	50.00%	$107,682,599
3.36.1	. . . . . Facility Maintenance	$4,033,120	$12,430,076	$8,231,598	50.00%	$24,694,794
3.36.2	. . . . . Facility Operations	$12,196,155	$37,588,550	$24,892,352	50.00%	$74,677,057
3.36.3	. . . . . Electrical Power Usage	$1,357,300	$4,183,199	$2,770,249	50.00%	$8,310,748
3.37	. . . . Year 37	$17,586,575	$56,547,873	$37,067,224	50.00%	$111,201,672
3.37.1	. . . . . Facility Maintenance	$4,033,120	$12,968,094	$8,500,607	50.00%	$25,501,821
3.37.2	. . . . . Facility Operations	$12,196,155	$39,215,517	$25,705,836	50.00%	$77,117,508

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.37.3	. . . . . Electrical Power Usage	$1,357,300	$4,364,262	$2,860,781	50.00%	$8,582,344
3.38	. . . . Year 38	$17,586,575	$58,969,545	$38,278,060	50.00%	$114,834,179
3.38.1	. . . . . Facility Maintenance	$4,033,120	$13,523,455	$8,778,287	50.00%	$26,334,862
3.38.2	. . . . . Facility Operations	$12,196,155	$40,894,927	$26,545,541	50.00%	$79,636,623
3.38.3	. . . . . Electrical Power Usage	$1,357,300	$4,551,163	$2,954,231	50.00%	$8,862,694
3.39	. . . . Year 39	$17,586,575	$61,470,356	$39,528,465	50.00%	$118,585,396
3.39.1	. . . . . Facility Maintenance	$4,033,120	$14,096,964	$9,065,042	50.00%	$27,195,127
3.39.2	. . . . . Facility Operations	$12,196,155	$42,629,221	$27,412,688	50.00%	$82,238,063
3.39.3	. . . . . Electrical Power Usage	$1,357,300	$4,744,171	$3,050,735	50.00%	$9,152,206
3.40	. . . . Year 40	$17,586,575	$64,052,065	$40,819,320	50.00%	$122,457,960
3.40.1	. . . . . Facility Maintenance	$4,033,120	$14,689,026	$9,361,073	50.00%	$28,083,220
3.40.2	. . . . . Facility Operations	$12,196,155	$44,419,616	$28,307,886	50.00%	$84,923,657
3.40.3	. . . . . Electrical Power Usage	$1,357,300	$4,943,422	$3,150,361	50.00%	$9,451,083
4	Post Irradiation Examination	$323,656,920	$536,056,774	$429,856,847	50.00%	$1,289,570,541
4.1	. . . . Year 1	$8,091,423	$2,631,331	$5,361,377	50.00%	$16,084,131
4.2	. . . . Year 2	$8,091,423	$2,981,689	$5,536,556	50.00%	$16,609,669
4.3	. . . . Year 3	$8,091,423	$3,343,376	$5,717,399	50.00%	$17,152,198
4.4	. . . . Year 4	$8,091,423	$3,716,391	$5,903,907	50.00%	$17,711,720
4.5	. . . . Year 5	$8,091,423	$4,102,351	$6,096,887	50.00%	$18,290,662
4.6	. . . . Year 6	$8,091,423	$4,500,449	$6,295,936	50.00%	$18,887,809
4.7	. . . . Year 7	$8,091,423	$4,912,303	$6,501,863	50.00%	$19,505,589
4.8	. . . . Year 8	$8,091,423	$5,337,103	$6,714,263	50.00%	$20,142,788
4.9	. . . . Year 9	$8,091,423	$5,775,658	$6,933,540	50.00%	$20,800,621
4.10	. . . . Year 10	$8,091,423	$6,228,777	$7,160,100	50.00%	$21,480,301
4.11	. . . . Year 11	$8,091,423	$6,696,462	$7,393,942	50.00%	$22,181,827

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.12	. . . . Year 12	$8,091,423	$7,179,520	$7,635,471	50.00%	$22,906,414
4.13	. . . . Year 13	$8,091,423	$7,677,951	$7,884,687	50.00%	$23,654,061
4.14	. . . . Year 14	$8,091,423	$8,193,375	$8,142,399	50.00%	$24,427,197
1.15	. . . . Year 15	$8,091,423	$9,274,389	$8,682,906	50.00%	$26,048,718
4.16	. . . . Year 16	$8,091,423	$9,274,389	$8,682,906	50.00%	$26,048,718
4.17	. . . . Year 17	$8,091,423	$9,841,598	$8,966,510	50.00%	$26,899,531
4.18	. . . . Year 18	$8,091,423	$10,427,417	$9,259,420	50.00%	$27,778,260
4.19	. . . . Year 19	$8,091,423	$11,032,655	$9,562,039	50.00%	$28,686,117
4.20	. . . . Year 20	$8,091,423	$11,657,313	$9,874,368	50.00%	$29,623,104
4.21	. . . . Year 21	$8,091,423	$12,302,200	$10,196,811	50.00%	$30,590,434
4.22	. . . . Year 22	$8,091,423	$12,968,933	$10,530,178	50.00%	$31,590,534
4.23	. . . . Year 23	$8,091,423	$13,656,704	$10,874,063	50.00%	$32,622,190
4.24	. . . . Year 24	$8,091,423	$14,367,131	$11,229,277	50.00%	$33,687,831
4.25	. . . . Year 25	$8,091,423	$15,101,023	$11,596,223	50.00%	$34,788,669
4.26	. . . . Year 26	$8,091,423	$15,858,380	$11,974,901	50.00%	$35,924,704
4.27	. . . . Year 27	$8,091,423	$16,640,821	$12,366,122	50.00%	$37,098,365
4.28	. . . . Year 28	$8,091,423	$17,448,345	$12,769,884	50.00%	$38,309,651
4.29	. . . . Year 29	$8,091,423	$18,282,570	$13,186,997	50.00%	$39,560,990
4.30	. . . . Year 30	$8,091,423	$19,144,307	$13,617,865	50.00%	$40,853,595
4.31	. . . . Year 31	$8,091,423	$20,034,363	$14,062,893	50.00%	$42,188,680
4.32	. . . . Year 32	$8,091,423	$20,952,740	$14,522,081	50.00%	$43,566,244
4.33	. . . . Year 33	$8,091,423	$21,901,864	$14,996,643	50.00%	$44,989,930
4.34	. . . . Year 34	$8,091,423	$22,881,735	$15,486,579	50.00%	$46,459,737
4.35	. . . . Year 35	$8,091,423	$23,893,163	$15,992,293	50.00%	$47,976,879

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.36	. . . . Year 36	$8,091,423	$24,937,766	$16,514,594	50.00%	$49,543,783
4.37	. . . . Year 37	$8,091,423	$26,017,162	$17,054,292	50.00%	$51,162,877
4.38	. . . . Year 38	$8,091,423	$27,131,350	$17,611,387	50.00%	$52,834,160
4.39	. . . . Year 39	$8,091,423	$28,281,951	$18,186,687	50.00%	$54,560,061
4.40	. . . . Year 40	$8,091,423	$29,469,772	$18,780,597	50.00%	$56,341,792
5	Transportation	$1,071,192,000	$1,774,161,750	$***,***,***	50.00%	$4,268,030,625
5.1	. . . . Year 1	$26,779,800	$8,708,791	$17,744,295	50.00%	$53,232,886
5.2	. . . . Year 2	$26,779,800	$9,868,356	$18,324,078	50.00%	$54,972,234
5.3	. . . . Year 3	$26,779,800	$11,065,413	$18,922,607	50.00%	$56,767,820
5.4	. . . . Year 4	$26,779,800	$12,299,962	$19,539,881	50.00%	$58,619,643
5.5	. . . . Year 5	$26,779,800	$13,577,359	$20,178,579	50.00%	$60,535,738
5.6	. . . . Year 6	$26,779,800	$14,894,925	$20,837,362	50.00%	$62,512,087
5.7	. . . . Year 7	$26,779,800	$16,258,017	$21,518,908	50.00%	$64,556,725
5.8	. . . . Year 8	$26,779,800	$17,663,956	$22,221,878	50.00%	$66,665,634
5.9	. . . . Year 9	$26,779,800	$19,115,421	$22,947,611	50.00%	$68,842,832
5.10	. . . . Year 10	$26,779,800	$20,615,090	$23,697,445	50.00%	$71,092,335
5.11	. . . . Year 11	$26,779,800	$22,162,962	$24,471,381	50.00%	$73,414,144
5.12	. . . . Year 12	$26,779,800	$23,761,717	$25,270,758	50.00%	$75,812,275
5.13	. . . . Year 13	$26,779,800	$25,411,352	$26,095,576	50.00%	$78,286,728
5.14	. . . . Year 14	$26,779,800	$27,117,225	$26,948,513	50.00%	$80,845,538
5.15	. . . . Year 15	$26,779,800	$30,695,007	$28,737,403	50.00%	$86,212,210
5.16	. . . . Year 16	$26,779,800	$30,695,007	$28,737,403	50.00%	$86,212,210
5.17	. . . . Year 17	$26,779,800	$32,572,271	$29,676,035	50.00%	$89,028,106
5.18	. . . . Year 18	$26,779,800	$34,511,128	$30,645,464	50.00%	$91,936,392

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.19	. . . . Year 19	$26,779,800	$36,514,257	$31,647,029	50.00%	$94,941,086
5.20	. . . . Year 20	$26,779,800	$38,581,658	$32,680,729	50.00%	$98,042,187
5.21	. . . . Year 21	$26,779,800	$40,716,008	$33,747,904	50.00%	$101,243,712
5.22	. . . . Year 22	$26,779,800	$42,922,663	$34,851,232	50.00%	$104,553,695
5.23	. . . . Year 23	$26,779,800	$45,198,946	$35,989,373	50.00%	$107,968,120
5.24	. . . . Year 24	$26,779,800	$47,550,213	$37,165,006	50.00%	$111,495,019
5.25	. . . . Year 25	$26,779,800	$49,979,141	$38,379,470	50.00%	$115,138,411
5.25	. . . . Year 26	$26,779,800	$52,485,730	$39,632,765	50.00%	$118,898,295
5.27	. . . . Year 27	$26,779,800	$55,075,337	$40,927,568	50.00%	$122,782,705
5.28	. . . . Year 28	$26,779,800	$57,747,961	$42,263,880	50.00%	$126,791,641
5.29	. . . . Year 29	$26,779,800	$60,508,958	$43,644,379	50.00%	$130,933,137
5.30	. . . . Year 30	$26,779,800	$63,361,007	$45,070,403	50.00%	$135,211,210
5.31	. . . . Year 31	$26,779,800	$66,306,785	$46,543,292	50.00%	$139,629,877
5.32	. . . . Year 32	$26,779,800	$69,346,292	$48,063,046	50.00%	$144,189,138
5.33	. . . . Year 33	$26,779,800	$72,487,563	$49,633,681	50.00%	$148,901,044
5.34	. . . . Year 34	$26,779,800	$75,730,596	$51,255,198	50.00%	$153,765,595
5.35	. . . . Year 35	$26,779,800	$79,078,071	$52,928,936	50.00%	$158,786,807
5.36	. . . . Year 36	$26,779,800	$82,535,344	$54,657,572	50.00%	$163,972,715
5.37	. . . . Year 37	$26,779,800	$86,107,769	$56,443,784	50.00%	$169,331,353
5.38	. . . . Year 38	$26,779,800	$89,795,347	$58,287,574	50.00%	$174,862,721
5.39	. . . . Year 39	$26,779,800	$93,603,435	$60,191,617	50.00%	$180,574,852
5.40	. . . . Year 40	$26,779,800	$97,534,710	$62,157,255	50.00%	$186,471,764
6	Deactivation and Demolition	$34,329,620	$130,239,712	$82,284,666	50.00%	$246,853,999

Project Summary Report

Project Name: ***APIEC Distributed - Alternative #2***

Project Location: ***INL/LANL/ORNL/PNNL/SRNL***
Estimate Number: ***8B26***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
Total	**APIEC Distributed - Alternative #2**	**$2,462,052,003**	**$3,753,963,833**	**$3,107,252,740**	**49.99%**	**$9,323,268,576**

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman, Project Engineer

From: R. D. Allen / B. W. Wallace, Cost Estimators RA

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #3A

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $5,400,00,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, and markup sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate and/or schedule and should be reviewed by me. If you have any questions or comments, do not

hesitate to contact Ross Allen at 526-0769 or e-mail Ross.Allen@inl.gov or Bruce Wallace at 526-5896 or email Bruce.Wallace@inl.gov.

Attachments

cc: Estimate File 8B26-A

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Project Number: ***8B26-A***

Summary Report

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		150.13%	*49.98%*	
Total Estimated Cost (TEC)	$1,447,707,249	$2,173,474,218	$1,809,835,555	$5,431,017,022
		150.13%	*49.98%*	
Total Cost	$1,447,707,249	$2,173,474,218	$1,809,835,555	$5,431,017,022
Rounded Total Cost (Rounded to the nearest $ 100000000)				$5,400,000,000

		Remarks
Type of Estimate:	Alternative Analysis - Class 5	Includes APIEC Consolidated to INL and LANL.
Estimator:	R. D. Allen / B. W. Wallace	
Checked By:	SNW	
Approved By:		

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #3A
Estimator:	R. D. Allen / B. W. Wallace
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26-A
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**
The objective of this work is to modify existing DOE-owned facilities located at Idaho National Laboratory (INL) and Los Alamos National Laboratory (LANL) to support advanced post irradiation examination (PIE) activities for highly-irradiated nuclear fuels and materials.

B. **Included:**
This cost estimate includes life-cycle costs (LCC) as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs, including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration. Includes DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Equipment procurement and modifications to the existing facilities, including the following:
   a. INL
   Equipment procurement and modifications to the Irradiated Materials Characterization Laboratory (IMCL), including the following:
   (i) Transfer cask with 8" inside diameter.
   (ii) Rough sizing, sample preparation, and waste packaging equipment.
   (iii) Specimen transfer device for transportation of source material between cells.
   (iv) Storage racks for shielded sample storage and prepared specimen storage.

(v) Post irradiation examination instrumentation.
(vi) Add metal stud wall and suspended acoustical ceiling to enclose two non-shielded examination areas.
(vii) Acoustical and electromagnetic interference (EMI) protection for examination equipment in non-shielded areas.
(viii) Miscellaneous utility modifications in non-shielded areas.
(ix) One 10'x20'x12' modular shielded enclosure (MSE) for sample preparation activities.
(x) Four 10'x10'x12' MSEs for examination activities.
(xi) Tie-in MSEs into existing facility utilities and exhaust system.
(xii) Seven 6'x6'x5' inert confinement enclosures (ICE).
(xiii) Add facility infrastructure to supply inert gas to new ICEs.
(xiv) Inert gas purification system for new ICEs.
(xv) Provide temperature control for the four MSEs and two non-shielded areas containing examination equipment.
(xvi) One 6'x6'x6' shielded confinement box within the sample preparation MSE for shielded sample storage.

b. LANL

Equipment procurement and modifications to Wing 9 of the Chemistry and Metallurgy Research (CMR) facility at LANL, including the following:

(i) Seismically upgrade facility to withstand a 7.2 magnitude earthquake.
(ii) Restart high efficiency particulate air (HEPA) filtration facility exhaust system.
(iii) Minor decontamination of six hot cells.
(iv) Rough sizing, sample preparation, and waste packaging equipment.
(v) Specimen transfer device for transportation of source material between cells.
(vi) Storage rack for prepared specimen storage.
(vii) Post irradiation examination instrumentation.
(viii) Remove and replace two 5-ton overhead cranes.
(ix) Six 6'x6'x5' ICEs.
(x) Remove and replace eight pair of manipulators with new heavy-duty manipulators designed to work within new ICEs.
(xi) Add facility infrastructure to supply inert gas to new ICEs.
(xii) Inert gas purification system for new ICEs.
(xiii) Tie-in new ICEs to existing facility exhaust system.
(xiv) Acoustical, vibration, and EMI protection for new examination equipment in existing hot cells and non-shielding areas.
(xv) Provide temperature control for three hot cells and two non-shielded areas containing examination equipment.
(xvi) Six new access ports into existing hot cells.
(xvii) Twenty-one small hot cell penetrations for instrumentation and controls cabling.

6. Construction subcontract management costs.
7. Operational readiness costs, including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR.
8. Facility operations costs for 40 years. Includes sharing of operations staff with other resident program(s) in the facility. See estimate back-up for more details.
9. Facility maintenance costs for 40 years. Including annual facility maintenance costs, facility refurbishment costs, and equipment replacement costs. Annual maintenance and facility refurbishment costs are included only for the facility space to be used by the APIEC project.
10. Post irradiation examination activities for 40 years.
11. Off-site and on-site transportation costs for 100 experiments per year.
12. Deactivation, decommissioning, and demolition of facility (DD&D). Includes costs to DD&D the facility space to be used by the APIEC project. See estimate back-up for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Utilities upgrades exterior to the facility.
3. Physical security personnel costs.

III. ESTIMATE METHODOLOGY: *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of the methods are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled Low Level Waste project. Engineering and design development costs are based on the DOE Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range. It was assumed that each of the five DOE sites requiring facility modifications will require separate design efforts, thus, increasing overall project design costs; therefore 25 percent was used.

Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a

similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

"Forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning, and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. BASIS OF THE ESTIMATE: *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association for the Advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012, developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th and 9th, 2012.

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. The operating contractor for each laboratory will provide resources for all project management and construction management resources.
2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by the laboratory operating contractor.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.
4. Sales tax on materials is based on an average rate of 6%.
5. Contractor markup rates are based on this estimator's judgment. The application of markups varies based on cost basis and estimate methodology used.
6. Construction and procurement costs were adjusted by geographic location based on RS Means location factors.
7. The following estimates and or projects were used as a cost basis.
   a. Modular Enclosure and Transfer Cask; BEA estimate File #1C66-B.
   b. PIE Line Item Building (LIB); BEA estimate File #1B33-D.
   c. ANL-W Lab Upgrade CDR.

d. Advanced Test Reactor Loop 2A.

8. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.
9. Estimate allowances have been carried for specific scopes of work that have no design definition. These allowances are:
   a. Seismic upgrade Wing 9 of the LANL CMR facility, allowance provided by LANL.
   b. Restart of Wing 9 of the LANL CMR facility HEPA filtration facility exhaust system, allowance developed by the project team.

V. ESTIMATE QUALITY ASSURANCE: *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. ASSUMPTIONS: *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Per the requester:
   1. Selected facilities will be available to support the PIE program.
   2. Project will not require converting non-hazard category (HC)-2 facilities to meet HC-2 and associated seismic/performance category requirements.
   3. Facility modifications will not require wholesale replacement of existing fixed hot cells.
   4. Seismic upgrade costs (provided by LANL) for the CMR facility includes all required code updates, including fire protection and alarm systems.
   5. Sixty percent of sample prep and rough sizing equipment required for the PIE LIB facility will be required for PIE examination at each facility.
   6. Equipment to be removed from the existing MSE at PNNL is not contaminated.
   7. Half of the hot cells required for use at LANL will require minor decontamination.
   8. Facility operations staffing will require a minimum of one person per facility per operations role.

9. Facility operations staffing will be shared with other resident program(s) in the facility.
10. Shipments from ATR to HFEF, HFIR to IFEL, and all APIEC off-site shipments require the use of a rental cask.
11. Shipments from other irradiators to the NDE/sizing/repackaging capability are assumed to be paid for by others. University shipments are assumed to use the existing BRR Cask and shipping paid for by other programs. Shipments from commercial and/or international entities will be at their expense.
12. On-site shipments downstream of NDE/sizing/repackaging are assumed to be performed using existing casks that are available at the site at no cost.
13. Off-site shipments will require the rental of only one cask per experiment.
14. Facility maintenance, refurbishment, and DD&D costs will be allocated to the project based on facility area usage.
15. An environmental impact statement (EIS) will not be required for this project. Costs are included for an environmental assessment (EA) and finding of no significant impact (FONSI).

VII. MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

A blanket MR rate of 50% was applied to this cost estimate. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.
2. Unknown facility upgrades not included in this cost estimate may be required.
3. Currently facilities selected for use may become unavailable.
4. The facility operations estimate is based on the assumption of sharing operations costs with other resident programs. Costs could increase if current programs are terminated.
5. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis

or facility area usage is determined to be greater than anticipated, project costs may be impacted.

6. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is greater than assumed, project costs may be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased productivity, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be less than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed, project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:

None.

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation	$1,510,356	$0	$0	0.00%	$1,510,356
2	Capital Costs (TPC)	$167,183,646	$30,322,063	$98,752,855	50.00%	$296,258,564
2.1	. . . . Idaho National Laboratory	$64,385,911	$11,317,107	$37,851,509	50.00%	$113,554,526
2.1.1	. . . . . Project Management	$6,688,600	$851,459	$3,770,029	50.00%	$11,310,088
2.1.2	. . . . . Engineering and Design Development	$8,360,750	$1,064,323	$4,712,537	50.00%	$14,137,610
2.1.3	. . . . . Project Integration and DOE 413 Deliverables Integration	$7,691,890	$693,808	$4,192,849	50.00%	$12,578,548
2.1.4	. . . . . Procurement	$23,919,172	$4,581,774	$14,250,473	50.00%	$42,751,419
2.1.4.1	. . . . . Civil Modifications	$8,424,136	$2,029,742	$5,226,939	50.00%	$15,680,816
2.1.4.1.1	*. . . . . Transfer Cask*	*$181,125*	*$29,831*	*$105,478*	*50.00%*	*$316,434*
2.1.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.1.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.1.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,411*	*$4,990*	*50.00%*	*$14,971*
2.1.4.1.5	*. . . . . Examination Equipment*	*$6,402,540*	*$1,553,896*	*$3,978,218*	*50.00%*	*$11,934,655*
2.1.4.2	. . . . . Mechanical Modifications	$15,495,036	$2,552,032	$9,023,534	50.00%	$27,070,603
2.1.4.2.1	*. . . . . Shielded Confinement Box*	*$562,850*	*$92,701*	*$327,775*	*50.00%*	*$983,326*
2.1.4.2.2	*. . . . . Inert Confinement Enclosure*	*$2,831,588*	*$466,362*	*$1,648,975*	*50.00%*	*$4,946,925*
2.1.4.2.3	*. . . . . Modular Shielded Enclosures*	*$12,100,599*	*$1,992,969*	*$7,046,784*	*50.00%*	*$21,140,351*
2.1.5	. . . . . Construction	$9,523,324	$2,411,097	$5,967,210	50.00%	$17,901,631
2.1.5.1	. . . . . Civil Modifications	$7,256,920	$2,037,820	$4,647,370	50.00%	$13,942,109
2.1.5.1.1	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.1.5.1.2	*. . . . . Acoustical Isolation*	*$77,877*	*$15,832*	*$46,855*	*50.00%*	*$140,564*
2.1.5.1.3	*. . . . . EMI/RFI Protection Installation*	*$114,081*	*$23,193*	*$68,637*	*50.00%*	*$205,911*
2.1.5.1.4	*. . . . . Metal Stud Wall and Suspended Ceiling Modifications*	*$16,719*	*$3,399*	*$10,059*	*50.00%*	*$30,176*
2.1.5.1.5	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.1.5.1.6	*. . . . . Examination Equipment*	*$2,861,894*	*$810,775*	*$1,836,334*	*50.00%*	*$5,509,003*

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.1.5.2	. . . . . Mechanical Modifications	$2,266,404	$373,277	$1,319,840	50.00%	$3,959,521
2.1.5.2.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$571,794*	*$94,174*	*$332,984*	*50.00%*	*$998,953*
2.1.5.2.2	*. . . . . Modular Shielded Enclosure Utility Tie-ins*	*$234,796*	*$38,671*	*$136,734*	*50.00%*	*$410,201*
2.1.5.2.3	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$24,139*	*$85,353*	*50.00%*	*$256,059*
2.1.5.2.4	*. . . . . Inert Gas Purification System*	*$132,825*	*$21,876*	*$77,351*	*50.00%*	*$232,052*
2.1.5.2.5	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$294,883*	*$48,567*	*$171,725*	*50.00%*	*$515,176*
2.1.5.2.6	*. . . . . Temperature Control*	*$49,408*	*$8,137*	*$28,773*	*50.00%*	*$86,318*
2.1.5.2.7	*. . . . . Shielded Confinement Box Installation*	*$13,563*	*$2,234*	*$7,898*	*50.00%*	*$23,695*
2.1.5.2.8	*. . . . . Inert Confinement Enclosure Installation*	*$322,812*	*$53,167*	*$187,990*	*50.00%*	*$563,969*
2.1.5.2.9	*. . . . . Modular Shielded Enclosure Installation*	*$499,756*	*$82,310*	*$291,033*	*50.00%*	*$873,099*
2.1.6	**. . . . . Construction Management**	**$2,341,010**	**$385,564**	**$1,363,287**	**50.00%**	**$4,089,862**
2.1.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.1.8	**. . . . . General and Administrative Costs**	**$2,371,165**	**$482,058**	**$1,426,611**	**50.00%**	**$4,279,834**
2.2	**. . . . Los Alamos National Laboratory**	**$102,797,736**	**$19,004,956**	**$60,901,346**	**50.00%**	**$182,704,038**
2.2.1	**. . . . . Project Management**	**$10,670,800**	**$1,358,393**	**$6,014,596**	**50.00%**	**$18,043,789**
2.2.2	**. . . . . Engineering and Design Development**	**$13,338,500**	**$1,697,991**	**$7,518,246**	**50.00%**	**$22,554,737**
2.2.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$12,271,420**	**$1,106,882**	**$6,689,151**	**50.00%**	**$20,067,453**
2.2.4	**. . . . . Procurement**	**$12,624,956**	**$3,381,798**	**$8,003,377**	**50.00%**	**$24,010,132**
2.2.4.1	. . . . . Civil Modifications	$10,197,881	$2,888,374	$6,543,128	50.00%	$19,629,383
2.2.4.1.1	*. . . . . Manipulators*	*$3,071,880*	*$870,264*	*$1,971,072*	*50.00%*	*$5,913,215*
2.2.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$235,678*	*$533,790*	*50.00%*	*$1,601,369*
2.2.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$283,300*	*$641,650*	*50.00%*	*$1,924,950*
2.2.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,742*	*$5,156*	*50.00%*	*$15,467*
2.2.4.1.5	*. . . . . Examination Equipment*	*$5,285,530*	*$1,497,391*	*$3,391,460*	*50.00%*	*$10,174,381*
2.2.4.2	. . . . . Mechanical Modifications	$2,427,075	$493,424	$1,460,250	50.00%	$4,380,749

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.4.2.1	*. . . . . Inert Confinement Enclosure*	*$2,427,075*	*$493,424*	*$1,460,250*	*50.00%*	*$4,380,749*
2.2.5	**. . . . . Construction**	**$40,728,168**	**$8,790,329**	**$24,759,248**	**50.00%**	**$74,277,745**
2.2.5.1	. . . . . Seismic Upgrade	$30,000,000	$6,099,000	$18,049,500	50.00%	$54,148,500
2.2.5.2	. . . . . Decontamination	$795,000	$161,624	$478,312	50.00%	$1,434,935
2.2.5.3	. . . . . Civil Modifications	$8,083,149	$2,153,597	$5,118,373	50.00%	$15,355,120
2.2.5.3.1	*. . . . . Crane Replacement*	*$170,821*	*$34,728*	*$102,775*	*50.00%*	*$308,324*
2.2.5.3.2	*. . . . . Manipulator Installation*	*$44,436*	*$12,589*	*$28,512*	*50.00%*	*$85,537*
2.2.5.3.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.2.5.3.4	*. . . . . Vibration Isolation*	*$350,480*	*$71,253*	*$210,867*	*50.00%*	*$632,600*
2.2.5.3.5	*. . . . . Acoustical Isolation*	*$194,692*	*$39,581*	*$117,137*	*50.00%*	*$351,410*
2.2.5.3.6	*. . . . . EMI/RFI Protection Installation*	*$146,751*	*$29,834*	*$88,293*	*50.00%*	*$264,878*
2.2.5.3.7	*. . . . . Specimen Storage Racks*	*$8,569*	*$1,742*	*$5,156*	*50.00%*	*$15,467*
2.2.5.3.8	*. . . . . Access Ports*	*$706,388*	*$143,609*	*$424,998*	*50.00%*	*$1,274,994*
2.2.5.3.9	*. . . . . Instrument Penetrations*	*$126,788*	*$25,776*	*$76,282*	*50.00%*	*$228,845*
2.2.5.3.10	*. . . . . Examination Equipment*	*$2,165,014*	*$613,349*	*$1,389,181*	*50.00%*	*$4,167,544*
2.2.5.4	. . . . . Mechanical Modifications	$1,850,018	$376,109	$1,113,063	50.00%	$3,339,190
2.2.5.4.1	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.2.5.4.2	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.2.5.4.3	*. . . . . Restart HEPA Exhaust System*	*$1,000,000*	*$203,300*	*$601,650*	*50.00%*	*$1,804,950*
2.2.5.4.4	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$252,757*	*$51,386*	*$152,071*	*50.00%*	*$456,214*
2.2.5.4.5	*. . . . . Temperature Control*	*$41,173*	*$8,371*	*$24,772*	*50.00%*	*$74,316*
2.2.5.4.6	*. . . . . Inert Confinement Enclosure Installation*	*$276,696*	*$56,252*	*$166,474*	*50.00%*	*$499,423*
2.2.6	**. . . . . Construction Management**	**$3,734,780**	**$615,118**	**$2,174,949**	**50.00%**	**$6,524,847**
2.2.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.2.8	**. . . . . General and Administrative Costs**	**$1,670,792**	**$339,672**	**$1,005,232**	**50.00%**	**$3,015,696**
2.2.9	**. . . . . Location Factor Adjustment**	**$4,268,320**	**$867,749**	**$2,568,035**	**50.00%**	**$7,704,104**

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3	Facility Operations and Maintenance	$460,473,013	$756,272,757	$608,372,885	50.00%	$1,825,118,654
3.1	. . . . Year 1	$10,036,333	$3,263,815	$6,650,074	50.00%	$19,950,223
3.1.1	. . . . . Facility Maintenance	$2,008,344	$653,113	$1,330,729	50.00%	$3,992,186
3.1.2	. . . . . Facility Operations	$7,352,104	$2,390,904	$4,871,504	50.00%	$14,614,512
3.1.3	. . . . . Electrical Power Usage	$675,885	$219,798	$447,841	50.00%	$1,343,524
3.2	. . . . Year 2	$10,036,333	$3,698,389	$6,867,361	50.00%	$20,602,083
3.2.1	. . . . . Facility Maintenance	$2,008,344	$740,075	$1,374,209	50.00%	$4,122,628
3.2.2	. . . . . Facility Operations	$7,352,104	$2,709,250	$5,030,677	50.00%	$15,092,031
3.2.3	. . . . . Electrical Power Usage	$675,885	$249,064	$462,474	50.00%	$1,387,423
3.3	. . . . Year 3	$11,609,629	$4,797,099	$8,203,364	50.00%	$24,610,092
3.3.1	. . . . . Facility Maintenance	$2,008,344	$829,848	$1,419,096	50.00%	$4,257,288
3.3.2	. . . . . Facility Operations	$7,352,104	$3,037,889	$5,194,997	50.00%	$15,584,990
3.3.3	. . . . . Facility Refurbishment	$1,573,296	$650,086	$1,111,691	50.00%	$3,335,073
3.3.4	. . . . . Electrical Power Usage	$675,885	$279,276	$477,580	50.00%	$1,432,741
3.4	. . . . Year 4	$10,036,333	$4,609,688	$7,323,010	50.00%	$21,969,031
3.4.1	. . . . . Facility Maintenance	$2,008,344	$922,432	$1,465,388	50.00%	$4,396,165
3.4.2	. . . . . Facility Operations	$7,352,104	$3,376,821	$5,364,463	50.00%	$16,093,388
3.4.3	. . . . . Electrical Power Usage	$675,885	$310,434	$493,159	50.00%	$1,479,478
3.5	. . . . Year 5	$10,036,333	$5,088,421	$7,562,377	50.00%	$22,687,131
3.5.1	. . . . . Facility Maintenance	$2,008,344	$1,018,230	$1,513,287	50.00%	$4,539,862
3.5.2	. . . . . Facility Operations	$7,352,104	$3,727,517	$5,539,810	50.00%	$16,619,431
3.5.3	. . . . . Electrical Power Usage	$675,885	$342,674	$509,279	50.00%	$1,527,838
3.6	. . . . Year 6	$10,036,333	$5,582,208	$7,809,271	50.00%	$23,427,812
3.6.1	. . . . . Facility Maintenance	$2,008,344	$1,117,041	$1,562,692	50.00%	$4,688,077
3.6.2	. . . . . Facility Operations	$7,352,104	$4,089,240	$5,720,672	50.00%	$17,162,016
3.6.3	. . . . . Electrical Power Usage	$675,885	$375,927	$525,906	50.00%	$1,577,718

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.7	. . . . Year 7	$10,036,333	$6,093,058	$8,064,695	50.00%	$24,194,086
3.7.1	. . . . . Facility Maintenance	$2,008,344	$1,219,266	$1,613,805	50.00%	$4,841,414
3.7.2	. . . . . Facility Operations	$7,352,104	$4,463,462	$5,907,783	50.00%	$17,723,350
3.7.3	. . . . . Electrical Power Usage	$675,885	$410,330	$543,107	50.00%	$1,629,322
3.8	. . . . Year 8	$10,036,333	$6,619,965	$8,328,149	50.00%	$24,984,447
3.8.1	. . . . . Facility Maintenance	$2,008,344	$1,324,704	$1,666,524	50.00%	$4,999,572
3.8.2	. . . . . Facility Operations	$7,352,104	$4,849,448	$6,100,776	50.00%	$18,302,328
3.8.3	. . . . . Electrical Power Usage	$675,885	$445,814	$560,849	50.00%	$1,682,548
3.9	. . . . Year 9	$10,036,333	$7,163,934	$8,600,134	50.00%	$25,800,401
3.9.1	. . . . . Facility Maintenance	$2,008,344	$1,433,556	$1,720,950	50.00%	$5,162,850
3.9.2	. . . . . Facility Operations	$7,352,104	$5,247,932	$6,300,018	50.00%	$18,900,054
3.9.3	. . . . . Electrical Power Usage	$675,885	$482,447	$579,166	50.00%	$1,737,498
3.10	. . . . Year 10	$27,775,429	$21,381,525	$24,578,477	50.00%	$73,735,431
3.10.1	. . . . . Facility Maintenance	$2,008,344	$1,546,023	$1,777,184	50.00%	$5,331,551
3.10.2	. . . . . Facility Operations	$7,352,104	$5,659,650	$6,505,877	50.00%	$19,517,630
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.10.4	. . . . . Electrical Power Usage	$675,885	$520,296	$598,091	50.00%	$1,794,272
3.11	. . . . Year 11	$10,036,333	$8,306,069	$9,171,201	50.00%	$27,513,603
3.11.1	. . . . . Facility Maintenance	$2,008,344	$1,662,105	$1,835,225	50.00%	$5,505,674
3.11.2	. . . . . Facility Operations	$7,352,104	$6,084,601	$6,718,353	50.00%	$20,155,058
3.11.3	. . . . . Electrical Power Usage	$675,885	$559,362	$617,624	50.00%	$1,852,871
3.12	. . . . Year 12	$10,036,333	$8,905,238	$9,470,786	50.00%	$28,412,357
3.12.1	. . . . . Facility Maintenance	$2,008,344	$1,782,004	$1,895,174	50.00%	$5,685,521
3.12.2	. . . . . Facility Operations	$7,352,104	$6,523,522	$6,937,813	50.00%	$20,813,439
3.12.3	. . . . . Electrical Power Usage	$675,885	$599,713	$637,799	50.00%	$1,913,397
3.13	. . . . Year 13	$10,036,333	$9,523,476	$9,779,905	50.00%	$29,339,714

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.13.1	. . . . . Facility Maintenance	$2,008,344	$1,905,718	$1,957,031	50.00%	$5,871,092
3.13.2	. . . . . Facility Operations	$7,352,104	$6,976,411	$7,164,258	50.00%	$21,492,773
3.13.3	. . . . . Electrical Power Usage	$675,885	$641,347	$658,616	50.00%	$1,975,848
3.14	. . . . Year 14	$10,036,333	$10,162,791	$10,099,562	50.00%	$30,298,686
3.14.1	. . . . . Facility Maintenance	$2,008,344	$2,033,649	$2,020,997	50.00%	$6,062,990
3.14.2	. . . . . Facility Operations	$7,352,104	$7,444,741	$7,398,422	50.00%	$22,195,267
3.14.3	. . . . . Electrical Power Usage	$675,885	$684,401	$680,143	50.00%	$2,040,429
3.15	. . . . Year 15	$10,036,333	$11,503,645	$10,769,989	50.00%	$32,309,967
3.15.1	. . . . . Facility Maintenance	$2,008,344	$2,301,964	$2,155,154	50.00%	$6,465,462
3.15.2	. . . . . Facility Operations	$7,352,104	$8,426,982	$7,889,543	50.00%	$23,668,628
3.15.3	. . . . . Electrical Power Usage	$675,885	$774,699	$725,292	50.00%	$2,175,877
3.16	. . . . Year 16	$10,036,333	$11,503,645	$10,769,989	50.00%	$32,309,967
3.16.1	. . . . . Facility Maintenance	$2,008,344	$2,301,964	$2,155,154	50.00%	$6,465,462
3.16.2	. . . . . Facility Operations	$7,352,104	$8,426,982	$7,889,543	50.00%	$23,668,628
3.16.3	. . . . . Electrical Power Usage	$675,885	$774,699	$725,292	50.00%	$2,175,877
3.17	. . . . Year 17	$10,036,333	$12,207,192	$11,121,762	50.00%	$33,365,287
3.17.1	. . . . . Facility Maintenance	$2,008,344	$2,442,749	$2,225,546	50.00%	$6,676,639
3.17.2	. . . . . Facility Operations	$7,352,104	$8,942,364	$8,147,234	50.00%	$24,441,702
3.17.3	. . . . . Electrical Power Usage	$675,885	$822,079	$748,982	50.00%	$2,246,946
3.18	. . . . Year 18	$10,036,333	$12,933,822	$11,485,078	50.00%	$34,455,233
3.18.1	. . . . . Facility Maintenance	$2,008,344	$2,588,153	$2,298,248	50.00%	$6,894,745
3.18.2	. . . . . Facility Operations	$7,352,104	$9,474,656	$8,413,380	50.00%	$25,240,141
3.18.3	. . . . . Electrical Power Usage	$675,885	$871,013	$773,449	50.00%	$2,320,347
3.19	. . . . Year 19	$10,036,333	$13,684,540	$11,860,437	50.00%	$35,581,310
3.19.1	. . . . . Facility Maintenance	$2,008,344	$2,738,377	$2,373,361	50.00%	$7,120,082
3.19.2	. . . . . Facility Operations	$7,352,104	$10,024,594	$8,688,349	50.00%	$26,065,047

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.19.3	. . . . . Electrical Power Usage	$675,885	$921,569	$798,727	50.00%	$2,396,181
3.20	. . . . Year 20	$27,775,429	$40,016,061	$33,895,745	50.00%	$101,687,234
3.20.1	. . . . . Facility Maintenance	$2,008,344	$2,893,421	$2,450,883	50.00%	$7,352,648
3.20.2	. . . . . Facility Operations	$7,352,104	$10,592,176	$8,972,140	50.00%	$26,916,420
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.20.4	. . . . . Electrical Power Usage	$675,885	$973,748	$824,816	50.00%	$2,474,449
3.21	. . . . Year 21	$10,036,333	$15,259,241	$12,647,787	50.00%	$37,943,361
3.21.1	. . . . . Facility Maintenance	$2,008,344	$3,053,486	$2,530,915	50.00%	$7,592,745
3.21.2	. . . . . Facility Operations	$7,352,104	$11,178,139	$9,265,121	50.00%	$27,795,364
3.21.3	. . . . . Electrical Power Usage	$675,885	$1,027,616	$851,750	50.00%	$2,555,251
3.22	. . . . Year 22	$10,036,333	$16,086,235	$13,061,284	50.00%	$39,183,851
3.22.1	. . . . . Facility Maintenance	$2,008,344	$3,218,974	$2,613,659	50.00%	$7,840,977
3.22.2	. . . . . Facility Operations	$7,352,104	$11,783,952	$9,568,028	50.00%	$28,704,084
3.22.3	. . . . . Electrical Power Usage	$675,885	$1,083,308	$879,597	50.00%	$2,638,790
3.23	. . . . Year 23	$11,609,629	$19,594,732	$15,602,180	50.00%	$46,806,541
3.23.1	. . . . . Facility Maintenance	$2,008,344	$3,389,683	$2,699,014	50.00%	$8,097,041
3.23.2	. . . . . Facility Operations	$7,352,104	$12,408,881	$9,880,493	50.00%	$29,641,478
3.23.3	. . . . . Facility Refurbishment	$1,573,296	$2,655,409	$2,114,352	50.00%	$6,343,057
3.23.4	. . . . . Electrical Power Usage	$675,885	$1,140,759	$908,322	50.00%	$2,724,966
3.24	. . . . Year 24	$10,036,333	$17,820,513	$13,928,423	50.00%	$41,785,269
3.24.1	. . . . . Facility Maintenance	$2,008,344	$3,566,016	$2,787,180	50.00%	$8,361,539
3.24.2	. . . . . Facility Operations	$7,352,104	$13,054,396	$10,203,250	50.00%	$30,609,750
3.24.3	. . . . . Electrical Power Usage	$675,885	$1,200,101	$937,993	50.00%	$2,813,980
3.25	. . . . Year 25	$10,036,333	$18,730,808	$14,383,571	50.00%	$43,150,712
3.25.1	. . . . . Facility Maintenance	$2,008,344	$3,748,172	$2,878,258	50.00%	$8,634,775
3.25.2	. . . . . Facility Operations	$7,352,104	$13,721,232	$10,536,668	50.00%	$31,610,004

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.25.3	. . . . . Electrical Power Usage	$675,885	$1,261,404	$968,645	50.00%	$2,905,934
3.26	. . . . Year 26	$10,036,333	$19,670,209	$14,853,271	50.00%	$44,559,813
3.26.1	. . . . . Facility Maintenance	$2,008,344	$3,936,153	$2,972,249	50.00%	$8,916,746
3.26.2	. . . . . Facility Operations	$7,352,104	$14,409,389	$10,880,746	50.00%	$32,642,239
3.26.3	. . . . . Electrical Power Usage	$675,885	$1,324,667	$1,000,276	50.00%	$3,000,828
3.27	. . . . Year 27	$10,036,333	$20,640,722	$15,338,528	50.00%	$46,015,583
3.27.1	. . . . . Facility Maintenance	$2,008,344	$4,130,360	$3,069,352	50.00%	$9,208,056
3.27.2	. . . . . Facility Operations	$7,352,104	$15,120,337	$11,236,221	50.00%	$33,708,662
3.27.3	. . . . . Electrical Power Usage	$675,885	$1,390,025	$1,032,955	50.00%	$3,098,865
3.28	. . . . Year 28	$10,036,333	$21,642,348	$15,839,341	50.00%	$47,518,022
3.28.1	. . . . . Facility Maintenance	$2,008,344	$4,330,793	$3,169,569	50.00%	$9,508,706
3.28.2	. . . . . Facility Operations	$7,352,104	$15,854,077	$11,603,091	50.00%	$34,809,272
3.28.3	. . . . . Electrical Power Usage	$675,885	$1,457,478	$1,066,682	50.00%	$3,200,045
3.29	. . . . Year 29	$10,036,333	$22,677,094	$16,356,714	50.00%	$49,070,141
3.29.1	. . . . . Facility Maintenance	$2,008,344	$4,537,853	$3,273,099	50.00%	$9,819,296
3.29.2	. . . . . Facility Operations	$7,352,104	$16,612,079	$11,982,091	50.00%	$35,946,274
3.29.3	. . . . . Electrical Power Usage	$675,885	$1,527,162	$1,101,524	50.00%	$3,304,571
3.30	. . . . Year 30	$27,775,429	$65,716,665	$46,746,047	50.00%	$140,238,141
3.30.1	. . . . . Facility Maintenance	$2,008,344	$4,751,742	$3,380,043	50.00%	$10,140,129
3.30.2	. . . . . Facility Operations	$7,352,104	$17,395,078	$12,373,591	50.00%	$37,120,773
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.30.4	. . . . . Electrical Power Usage	$675,885	$1,599,144	$1,137,514	50.00%	$3,412,543
3.31	. . . . Year 31	$10,036,333	$24,849,961	$17,443,147	50.00%	$52,329,440
3.31.1	. . . . . Facility Maintenance	$2,008,344	$4,972,660	$3,490,502	50.00%	$10,471,506
3.31.2	. . . . . Facility Operations	$7,352,104	$18,203,810	$12,777,957	50.00%	$38,333,870
3.31.3	. . . . . Electrical Power Usage	$675,885	$1,673,491	$1,174,688	50.00%	$3,524,064

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.32	. . . . Year 32	$12,692,146	$32,866,312	$22,779,229	50.00%	$68,337,687
3.32.1	. . . . . Facility Maintenance	$2,008,344	$5,200,607	$3,604,475	50.00%	$10,813,426
3.32.2	. . . . . Facility Operations	$7,352,104	$19,038,273	$13,195,189	50.00%	$39,585,566
3.32.3	. . . . . Facility Refurbishment	$2,655,813	$6,877,228	$4,766,520	50.00%	$14,299,561
3.32.4	. . . . . Electrical Power Usage	$675,885	$1,750,204	$1,213,045	50.00%	$3,639,134
3.33	. . . . Year 33	$10,036,333	$27,166,346	$18,601,340	50.00%	$55,804,019
3.33.1	. . . . . Facility Maintenance	$2,008,344	$5,436,186	$3,722,265	50.00%	$11,166,794
3.33.2	. . . . . Facility Operations	$7,352,104	$19,900,675	$13,626,390	50.00%	$40,879,169
3.33.3	. . . . . Electrical Power Usage	$675,885	$1,829,486	$1,252,685	50.00%	$3,758,056
3.34	. . . . Year 34	$10,036,333	$28,381,746	$19,209,040	50.00%	$57,627,119
3.34.1	. . . . . Facility Maintenance	$2,008,344	$5,679,396	$3,843,870	50.00%	$11,531,610
3.34.2	. . . . . Facility Operations	$7,352,104	$20,791,015	$14,071,559	50.00%	$42,214,678
3.34.3	. . . . . Electrical Power Usage	$675,885	$1,911,335	$1,293,610	50.00%	$3,880,830
3.35	. . . . Year 35	$10,036,333	$29,636,288	$19,836,310	50.00%	$59,508,931
3.35.1	. . . . . Facility Maintenance	$2,008,344	$5,930,439	$3,969,391	50.00%	$11,908,174
3.35.2	. . . . . Facility Operations	$7,352,104	$21,710,028	$14,531,066	50.00%	$43,593,198
3.35.3	. . . . . Electrical Power Usage	$675,885	$1,995,821	$1,335,853	50.00%	$4,007,559
3.36	. . . . Year 36	$10,036,333	$30,931,978	$20,484,156	50.00%	$61,452,467
3.36.1	. . . . . Facility Maintenance	$2,008,344	$6,189,716	$4,099,030	50.00%	$12,297,090
3.36.2	. . . . . Facility Operations	$7,352,104	$22,659,185	$15,005,644	50.00%	$45,016,933
3.36.3	. . . . . Electrical Power Usage	$675,885	$2,083,078	$1,379,481	50.00%	$4,138,444
3.37	. . . . Year 37	$10,036,333	$32,270,825	$21,153,579	50.00%	$63,460,737
3.37.1	. . . . . Facility Maintenance	$2,008,344	$6,457,629	$4,232,987	50.00%	$12,698,960
3.37.2	. . . . . Facility Operations	$7,352,104	$23,639,955	$15,496,030	50.00%	$46,488,089
3.37.3	. . . . . Electrical Power Usage	$675,885	$2,173,241	$1,424,563	50.00%	$4,273,688
3.38	. . . . Year 38	$10,036,333	$33,652,828	$21,844,581	50.00%	$65,533,742

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.38.1	. . . . . Facility Maintenance	$2,008,344	$6,734,178	$4,371,261	50.00%	$13,113,783
3.38.2	. . . . . Facility Operations	$7,352,104	$24,652,340	$16,002,222	50.00%	$48,006,666
3.38.3	. . . . . Electrical Power Usage	$675,885	$2,266,310	$1,471,097	50.00%	$4,413,292
3.39	. . . . Year 39	$10,036,333	$35,079,995	$22,558,164	50.00%	$67,674,492
3.39.1	. . . . . Facility Maintenance	$2,008,344	$7,019,765	$4,514,054	50.00%	$13,542,163
3.39.2	. . . . . Facility Operations	$7,352,104	$25,697,809	$16,524,957	50.00%	$49,574,870
3.39.3	. . . . . Electrical Power Usage	$675,885	$2,362,421	$1,519,153	50.00%	$4,557,459
3.40	. . . . Year 40	$10,036,333	$36,553,328	$23,294,831	50.00%	$69,884,492
3.40.1	. . . . . Facility Maintenance	$2,008,344	$7,314,590	$4,661,467	50.00%	$13,984,401
3.40.2	. . . . . Facility Operations	$7,352,104	$26,777,098	$17,064,601	50.00%	$51,193,803
3.40.3	. . . . . Electrical Power Usage	$675,885	$2,461,641	$1,568,763	50.00%	$4,706,289
4	Post Irradiation Examination	$193,893,120	$321,135,480	$257,514,300	50.00%	$772,542,900
4.1	. . . . Year 1	$4,847,328	$1,576,351	$3,211,840	50.00%	$9,635,519
4.2	. . . . Year 2	$4,847,328	$1,786,240	$3,316,784	50.00%	$9,950,353
4.3	. . . . Year 3	$4,847,328	$2,002,916	$3,425,122	50.00%	$10,275,366
4.4	. . . . Year 4	$4,847,328	$2,226,378	$3,536,853	50.00%	$10,610,559
4.5	. . . . Year 5	$4,847,328	$2,457,595	$3,652,462	50.00%	$10,957,385
4.6	. . . . Year 6	$4,847,328	$2,696,084	$3,771,706	50.00%	$11,315,118
4.7	. . . . Year 7	$4,847,328	$2,942,813	$3,895,070	50.00%	$11,685,211
4.8	. . . . Year 8	$4,847,328	$3,197,298	$4,022,313	50.00%	$12,066,938
4.9	. . . . Year 9	$4,847,328	$3,460,023	$4,153,675	50.00%	$12,461,026
4.10	. . . . Year 10	$4,847,328	$3,731,473	$4,289,401	50.00%	$12,868,202
4.11	. . . . Year 11	$4,847,328	$4,011,649	$4,429,488	50.00%	$13,288,465
4.12	. . . . Year 12	$4,847,328	$4,301,034	$4,574,181	50.00%	$13,722,543
4.13	. . . . Year 13	$4,847,328	$4,599,630	$4,723,479	50.00%	$14,170,436

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.14	. . . . Year 14	$4,847,328	$4,908,404	$4,877,866	50.00%	$14,633,598
1.15	. . . . Year 15	$4,847,328	$5,556,007	$5,201,668	50.00%	$15,605,003
4.16	. . . . Year 16	$4,847,328	$5,556,007	$5,201,668	50.00%	$15,605,003
4.17	. . . . Year 17	$4,847,328	$5,895,805	$5,371,567	50.00%	$16,114,700
4.18	. . . . Year 18	$4,847,328	$6,246,752	$5,547,040	50.00%	$16,641,119
4.19	. . . . Year 19	$4,847,328	$6,609,332	$5,728,330	50.00%	$17,184,990
4.20	. . . . Year 20	$4,847,328	$6,983,545	$5,915,437	50.00%	$17,746,310
4.21	. . . . Year 21	$4,847,328	$7,369,877	$6,108,603	50.00%	$18,325,808
4.22	. . . . Year 22	$4,847,328	$7,769,297	$6,308,313	50.00%	$18,924,938
4.23	. . . . Year 23	$4,847,328	$8,181,320	$6,514,324	50.00%	$19,542,972
4.24	. . . . Year 24	$4,847,328	$8,606,916	$6,727,122	50.00%	$20,181,365
4.25	. . . . Year 25	$4,847,328	$9,046,568	$6,946,948	50.00%	$20,840,844
4.26	. . . . Year 26	$4,847,328	$9,500,278	$7,173,803	50.00%	$21,521,409
4.27	. . . . Year 27	$4,847,328	$9,969,015	$7,408,171	50.00%	$22,224,514
4.28	. . . . Year 28	$4,847,328	$10,452,778	$7,650,053	50.00%	$22,950,159
4.29	. . . . Year 29	$4,847,328	$10,952,538	$7,899,933	50.00%	$23,699,798
4.30	. . . . Year 30	$4,847,328	$11,468,778	$8,158,053	50.00%	$24,474,159
4.31	. . . . Year 31	$4,847,328	$12,001,984	$8,424,656	50.00%	$25,273,968
4.32	. . . . Year 32	$4,847,328	$12,552,156	$8,699,742	50.00%	$26,099,226
4.33	. . . . Year 33	$4,847,328	$13,120,747	$8,984,038	50.00%	$26,952,113
4.34	. . . . Year 34	$4,847,328	$13,707,759	$9,277,543	50.00%	$27,832,630
4.35	. . . . Year 35	$4,847,328	$14,313,675	$9,580,501	50.00%	$28,741,504
4.36	. . . . Year 36	$4,847,328	$14,939,465	$9,893,396	50.00%	$29,680,189
4.37	. . . . Year 37	$4,847,328	$15,586,098	$10,216,713	50.00%	$30,650,140

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.38	. . . . Year 38	$4,847,328	$16,253,576	$10,550,452	50.00%	$31,651,355
4.39	. . . . Year 39	$4,847,328	$16,942,866	$10,895,097	50.00%	$32,685,290
4.40	. . . . Year 40	$4,847,328	$17,654,453	$11,250,891	50.00%	$33,752,672
5	Transportation	$610,064,000	$1,010,418,500	$810,241,250	50.00%	$2,430,723,750
5.1	. . . . Year 1	$15,251,600	$4,959,820	$10,105,710	50.00%	$30,317,130
5.2	. . . . Year 2	$15,251,600	$5,620,215	$10,435,907	50.00%	$31,307,722
5.3	. . . . Year 3	$15,251,600	$6,301,961	$10,776,781	50.00%	$32,330,342
5.4	. . . . Year 4	$15,251,600	$7,005,060	$11,128,330	50.00%	$33,384,990
5.5	. . . . Year 5	$15,251,600	$7,732,561	$11,492,081	50.00%	$34,476,242
5.6	. . . . Year 6	$15,251,600	$8,482,940	$11,867,270	50.00%	$35,601,810
5.7	. . . . Year 7	$15,251,600	$9,259,246	$12,255,423	50.00%	$36,766,270
5.8	. . . . Year 8	$15,251,600	$10,059,955	$12,655,778	50.00%	$37,967,333
5.9	. . . . Year 9	$15,251,600	$10,886,592	$13,069,096	50.00%	$39,207,288
5.10	. . . . Year 10	$15,251,600	$11,740,682	$13,496,141	50.00%	$40,488,423
5.11	. . . . Year 11	$15,251,600	$12,622,224	$13,936,912	50.00%	$41,810,736
5.12	. . . . Year 12	$15,251,600	$13,532,745	$14,392,172	50.00%	$43,176,517
5.13	. . . . Year 13	$15,251,600	$14,472,243	$14,861,922	50.00%	$44,585,765
5.14	. . . . Year 14	$15,251,600	$15,443,770	$15,347,685	50.00%	$46,043,055
5.15	. . . . Year 15	$15,251,600	$17,481,384	$16,366,492	50.00%	$49,099,476
5.16	. . . . Year 16	$15,251,600	$17,481,384	$16,366,492	50.00%	$49,099,476
5.17	. . . . Year 17	$15,251,600	$18,550,521	$16,901,061	50.00%	$50,703,182
5.18	. . . . Year 18	$15,251,600	$19,654,737	$17,453,168	50.00%	$52,359,505
5.19	. . . . Year 19	$15,251,600	$20,795,557	$18,023,578	50.00%	$54,070,735
5.20	. . . . Year 20	$15,251,600	$21,972,980	$18,612,290	50.00%	$55,836,870

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.21	. . . . Year 21	$15,251,600	$23,188,533	$19,220,066	50.00%	$57,660,199
5.22	. . . . Year 22	$15,251,600	$24,445,264	$19,848,432	50.00%	$59,545,297
5.23	. . . . Year 23	$15,251,600	$25,741,650	$20,496,625	50.00%	$61,489,876
5.24	. . . . Year 24	$15,251,600	$27,080,741	$21,166,170	50.00%	$63,498,511
5.25	. . . . Year 25	$15,251,600	$28,464,061	$21,857,831	50.00%	$65,573,492
5.25	. . . . Year 26	$15,251,600	$29,891,611	$22,571,605	50.00%	$67,714,816
5.27	. . . . Year 27	$15,251,600	$31,366,441	$23,309,020	50.00%	$69,927,061
5.28	. . . . Year 28	$15,251,600	$32,888,550	$24,070,075	50.00%	$72,210,225
5.29	. . . . Year 29	$15,251,600	$34,460,990	$24,856,295	50.00%	$74,568,885
5.30	. . . . Year 30	$15,251,600	$36,085,286	$25,668,443	50.00%	$77,005,328
5.31	. . . . Year 31	$15,251,600	$37,762,962	$26,507,281	50.00%	$79,521,842
5.32	. . . . Year 32	$15,251,600	$39,494,018	$27,372,809	50.00%	$82,118,427
5.33	. . . . Year 33	$15,251,600	$41,283,031	$28,267,315	50.00%	$84,801,946
5.34	. . . . Year 34	$15,251,600	$43,130,000	$29,190,800	50.00%	$87,572,399
5.35	. . . . Year 35	$15,251,600	$45,036,450	$30,144,025	50.00%	$90,432,074
5.36	. . . . Year 36	$15,251,600	$47,005,431	$31,128,516	50.00%	$93,385,547
5.37	. . . . Year 37	$15,251,600	$49,039,995	$32,145,797	50.00%	$96,437,392
5.38	. . . . Year 38	$15,251,600	$51,140,140	$33,195,870	50.00%	$99,587,610
5.39	. . . . Year 39	$15,251,600	$53,308,917	$34,280,259	50.00%	$102,840,776
5.40	. . . . Year 40	$15,251,600	$55,547,852	$35,399,726	50.00%	$106,199,179
6	Deactivation and Demolition	$14,583,114	$55,325,418	$34,954,266	50.00%	$104,862,798

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3A***

Project Location: ***INL/LANL***
Estimate Number: ***8B26-A***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
Total	**Alternate #3A**	**$1,447,707,249**	**$2,173,474,218**	**$1,809,835,555**	**49.98%**	**$5,431,017,022**

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman, Project Engineer

From: R. D. Allen / B. W. Wallace, Cost Estimators RA

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #3B

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $5,600,000,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, and markup sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate and/or schedule and should be reviewed by me. If you have any questions or comments, do not

hesitate to contact Ross Allen at 526-0769 or e-mail Ross.Allen@inl.gov or Bruce Wallace at 526-5896 or email Bruce.Wallace@inl.gov.

Attachments

cc: Estimate File 8B26-B

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Project Number: ***8B26-B***

Summary Report

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		148.28%	*49.98%*	
Total Estimated Cost (TEC)	$1,504,281,551	$2,230,490,590	$1,866,630,892	$5,601,403,032
		148.28%	*49.98%*	
Total Cost	$1,504,281,551	$2,230,490,590	$1,866,630,892	$5,601,403,032
Rounded Total Cost (Rounded to the nearest $ 100000000)				$5,600,000,000

		Remarks
Type of Estimate:	Alternative Analysis - Class 5	Includes APIEC Consolidated to ORNL and LANL.
Estimator:	R. D. Allen / B. W. Wallace	
Checked By:	SNW	
Approved By:		

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #3B
Estimator:	R. D. Allen / B. W. Wallace
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26-B
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**
The objective of this work is to modify existing DOE-owned facilities located at Oak Ridge National Laboratory (ORNL) and Los Alamos National Laboratory (LANL) to support advanced post irradiation examination (PIE) activities for highly-irradiated nuclear fuels and materials.

B. **Included:**
This cost estimate includes life-cycle costs (LCC) as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs. Including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration. Includes DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Equipment procurement and modifications to the existing facilities, including the following:
   a. ORNL
      Equipment procurement and modifications to the Radiochemical Engineering Development Center (REDC) at ORNL, including the following:
      (i) Secondary facility ventilation requirements to provide a credited secondary system.
      (ii) Rough sizing, sample preparation, and waste packaging equipment.
      (iii) Eight pair of heavy-duty manipulators.
      (iv) Nine 4'x4'x5' oiled filled shielded windows.
      (v) Five 12" thick steel hot cell wall plugs.

(vi) New 12" thick steel shielding walls and concrete and steel false floor.
(vii) Storage racks for shielded sample storage and prepared specimen storage.
(viii) Post irradiation examination instrumentation.
(ix) Miscellaneous utility modifications in non-shielded areas.
(x) Add fire detection system to existing hot cells.
(xi) Add wet pipe fire suppression system to existing hot cells.
(xii) Install a new material transfer device for material transfer between existing hot cells.
(xiii) Add transport loading port from D-Cell to B-Cell.
(xiv) Seven new 6'x6'x5' inert confinement enclosures (ICE).
(xv) Add facility infrastructure to supply inert gas to new ICEs.
(xvi) Inert gas purification system for new ICEs.
(xvii) Tie-in new ICEs to existing facility exhaust system.
(xviii) Acoustical, vibration, and electromagnetic interference (EMI) protection for examination equipment in four instrument areas and two non-shielded areas.
(xix) Provide temperature control for instrumentation areas and two non-shielding areas containing examination equipment.
(xx) Seven new access ports into existing hot cells.
(xxi) Install four new access doors into existing hot cells.
(xxii) Twenty-four small hot cell penetrations for instrumentation and controls cabling.

b. LANL

Equipment procurement and modifications to Wing 9 of the Chemistry and Metallurgy Research (CMR) facility at LANL, including the following:

(i) Seismically upgrade facility to withstand a 7.2 magnitude earthquake.
(ii) Restart high efficiency particulate air (HEPA) filtration facility exhaust system.
(iii) Minor decontamination of six hot cells.
(iv) Rough sizing, sample preparation, and waste packaging equipment.
(v) Specimen transfer device for transportation of source material between cells.
(vi) Storage rack for prepared specimen storage.
(vii) Post irradiation examination instrumentation.
(viii) Remove and replace two 5-ton overhead cranes.
(ix) Six 6'x6'x5' ICEs.
(x) Remove and replace eight pair of manipulators with new heavy-duty manipulators designed to work within new ICEs.
(xi) Add facility infrastructure to supply inert gas to new ICEs.
(xii) Inert gas purification system for new ICEs.
(xiii) Tie-in new ICEs to existing facility exhaust system.

(xiv) Acoustical, vibration, and EMI protection for new examination equipment in existing hot cells and non-shielded areas.
(xv) Provide temperature control for three hot cells and two non-shielded areas containing examination equipment.
(xvi) Six new access ports into existing hot cells.
(xvii) Twenty-one small hot cell penetrations for instrumentation and controls cabling.

6. Construction subcontract management costs.
7. Operational readiness costs, including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR.
8. Facility operations costs for 40 years. Includes sharing of operations staff with other resident program(s) in the facility. See estimate back-up for more details.
9. Facility maintenance costs for 40 years. Including annual facility maintenance costs, facility refurbishment costs, and equipment replacement costs. Annual maintenance and facility refurbishment costs are included only for the facility space to be used by the APIEC project.
10. Post irradiation examination activities for 40 years.
11. Off-site and on-site transportation costs for 100 experiments per year.
12. Deactivation, decommissioning, and demolition of facility (DD&D). Includes costs to DD&D the facility space to be used by the APIEC project. See estimate back-up for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Utilities upgrades exterior to the facility.
3. Physical security personnel costs.

III. **ESTIMATE METHODOLOGY:** *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of the methods are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled

Low Level Waste project. Engineering and design development costs are based on the DOE Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range. It was assumed that each of the five DOE sites requiring facility modifications will require separate design efforts, thus, increasing overall project design costs; therefore 25 percent was used.
Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

"Forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning, and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. **BASIS OF THE ESTIMATE:** *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association for the Advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012, developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th and 9th, 2012.

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. The operating contractor for each laboratory will provide resources for all project management and construction management resources.
2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by the laboratory operating contractor.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.

4. Sales tax on materials is based on an average rate of 6%.
5. Contractor markup rates are based on this estimator's judgment. The application of markups varies based on cost basis and estimate methodology used.
6. Construction and procurement costs were adjusted by geographic location based on RS Means location factors.
7. The following estimates and or projects were used as a cost basis.
   a. Modular Enclosure and Transfer Cask; BEA estimate File #1C66-B.
   b. PIE Line Item Building (LIB); BEA estimate File #1B33-D.
   c. ANL-W Lab Upgrade CDR.
   d. Advanced Test Reactor Loop 2A.
8. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.
9. Estimate allowances have been carried for specific scopes of work that have no design definition. These allowances are:
   a. Seismic upgrade Wing 9 of the LANL CMR facility, allowance provided by LANL.
   b. Restart of Wing 9 of the LANL CMR facility HEPA filtration facility exhaust system, allowance developed by the project team.
   c. Upgrade secondary facility ventilation requirements to provide a credited secondary system of the ORNL IFEL facility, allowance developed by the project team.

V. **ESTIMATE QUALITY ASSURANCE:** *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. **ASSUMPTIONS:** *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Per the requester:
   1. Selected facilities will be available to support the PIE program.

2. Project will not require converting non-hazard category (HC)-2 facilities to meet HC-2 and associated seismic/performance category requirements.
3. Facility modifications will not require wholesale replacement of existing fixed hot cells.
4. Seismic upgrade costs (provided by LANL) for the CMR facility includes all required code updates, including fire protection and alarm systems.
5. Sixty percent of sample prep and rough sizing equipment required for the PIE LIB facility will be required for PIE examination at each facility.
6. Half of the hot cells required for use at LANL will require minor decontamination.
7. Facility operations staffing will require a minimum of one person per facility per operations role.
8. Facility operations staffing will be shared with other resident program(s) in the facility.
9. Shipments from ATR to HFEF, HFIR to IFEL, and all APIEC off-site shipments require the use of a rental cask.
10. Shipments from other irradiators to the NDE/sizing/repackaging capability are assumed to be paid for by others. University shipments are assumed to use the existing BRR Cask and shipping paid for by other programs. Shipments from commercial and/or international entities will be at their expense.
11. On-site shipments downstream of NDE/sizing/repackaging are assumed to be performed using existing casks that are available at the site at no cost.
12. Off-site shipments will require the rental of only one cask per experiment.
13. Facility maintenance, refurbishment, and DD&D costs will be allocated to the project based on facility area usage.
14. An environmental impact statement (EIS) will not be required for this project. Costs are included for an environmental assessment (EA) and finding of no significant impact (FONSI).

VII. MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

A blanket MR rate of 50% was applied to this cost estimate. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.
2. Unknown facility upgrades not included in this cost estimate may be required.
3. Currently facilities selected for use may become unavailable.
4. The facility operations estimate is based on the assumption of sharing operations costs with other resident programs. Costs could increase if current programs are terminated.
5. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be greater than anticipated, project costs may be impacted.
6. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is greater than assumed, project costs may be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased productivity, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be less than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed, project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. **OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:**

None.

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation (Spent Costs)	$1,510,356	$0	$0	0.00%	$1,510,356
2	Capital Costs (TPC)	$187,973,461	$34,880,193	$111,426,827	50.00%	$334,280,481
2.1	. . . . Los Alamos National Laboratory	$102,797,736	$19,004,956	$60,901,346	50.00%	$182,704,038
2.1.1	. . . . . Project Management	$10,670,800	$1,358,393	$6,014,596	50.00%	$18,043,789
2.1.2	. . . . . Engineering and Design Development	$13,338,500	$1,697,991	$7,518,246	50.00%	$22,554,737
2.1.3	. . . . . Project Integration and DOE 413 Deliverables Integration	$12,271,420	$1,106,882	$6,689,151	50.00%	$20,067,453
2.1.4	. . . . . Procurement	$12,624,956	$3,381,798	$8,003,377	50.00%	$24,010,132
2.1.4.1	. . . . . Civil Modifications	$10,197,881	$2,888,374	$6,543,128	50.00%	$19,629,383
2.1.4.1.1	*. . . . . Manipulators*	*$3,071,880*	*$870,264*	*$1,971,072*	*50.00%*	*$5,913,215*
2.1.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$235,678*	*$533,790*	*50.00%*	*$1,601,369*
2.1.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$283,300*	*$641,650*	*50.00%*	*$1,924,950*
2.1.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,742*	*$5,156*	*50.00%*	*$15,467*
2.1.4.1.5	*. . . . . Examination Equipment*	*$5,285,530*	*$1,497,391*	*$3,391,460*	*50.00%*	*$10,174,381*
2.1.4.2	. . . . . Mechanical Modifications	$2,427,075	$493,424	$1,460,250	50.00%	$4,380,749
2.1.4.2.1	*. . . . . Inert Confinement Enclosure*	*$2,427,075*	*$493,424*	*$1,460,250*	*50.00%*	*$4,380,749*
2.1.5	. . . . . Construction	$40,728,168	$8,790,329	$24,759,248	50.00%	$74,277,745
2.1.5.1	. . . . . Seismic Upgrade	$30,000,000	$6,099,000	$18,049,500	50.00%	$54,148,500
2.1.5.2	. . . . . Decontamination	$795,000	$161,624	$478,312	50.00%	$1,434,935
2.1.5.3	. . . . . Civil Modifications	$8,083,149	$2,153,597	$5,118,373	50.00%	$15,355,120
2.1.5.3.1	*. . . . . Crane Replacement*	*$170,821*	*$34,728*	*$102,775*	*50.00%*	*$308,324*
2.1.5.3.2	*. . . . . Manipulator Installation*	*$44,436*	*$12,589*	*$28,512*	*50.00%*	*$85,537*
2.1.5.3.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.1.5.3.4	*. . . . . Vibration Isolation*	*$350,480*	*$71,253*	*$210,867*	*50.00%*	*$632,600*
2.1.5.3.5	*. . . . . Acoustical Isolation*	*$194,692*	*$39,581*	*$117,137*	*50.00%*	*$351,410*
2.1.5.3.6	*. . . . . EMI/RFI Protection Installation*	*$146,751*	*$29,834*	*$88,293*	*50.00%*	*$264,878*

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.1.5.3.7	*. . . . . Specimen Storage Racks*	*$8,569*	*$1,742*	*$5,156*	*50.00%*	*$15,467*
2.1.5.3.8	*. . . . . Access Ports*	*$706,388*	*$143,609*	*$424,998*	*50.00%*	*$1,274,994*
2.1.5.3.9	*. . . . . Instrument Penetrations*	*$126,788*	*$25,776*	*$76,282*	*50.00%*	*$228,845*
2.1.5.3.10	*. . . . . Examination Equipment*	*$2,165,014*	*$613,349*	*$1,389,181*	*50.00%*	*$4,167,544*
2.1.5.4	. . . . . Mechanical Modifications	$1,850,018	$376,109	$1,113,063	50.00%	$3,339,190
2.1.5.4.1	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.1.5.4.2	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.1.5.4.3	*. . . . . Restart HEPA Exhaust System*	*$1,000,000*	*$203,300*	*$601,650*	*50.00%*	*$1,804,950*
2.1.5.4.4	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$252,757*	*$51,386*	*$152,071*	*50.00%*	*$456,214*
2.1.5.4.5	*. . . . . Temperature Control*	*$41,173*	*$8,371*	*$24,772*	*50.00%*	*$74,316*
2.1.5.4.6	*. . . . . Inert Confinement Enclosure Installation*	*$276,696*	*$56,252*	*$166,474*	*50.00%*	*$499,423*
2.1.6	**. . . . . Construction Management**	**$3,734,780**	**$615,118**	**$2,174,949**	**50.00%**	**$6,524,847**
2.1.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.1.8	**. . . . . General and Administrative Costs**	**$1,670,792**	**$339,672**	**$1,005,232**	**50.00%**	**$3,015,696**
2.1.9	**. . . . . Location Factor Adjustment**	**$4,268,320**	**$867,749**	**$2,568,035**	**50.00%**	**$7,704,104**
2.2	**. . . . Oakridge National Laboratory**	**$85,175,725**	**$15,875,237**	**$50,525,481**	**50.00%**	**$151,576,443**
2.2.1	**. . . . . Project Management**	**$8,745,633**	**$1,113,319**	**$4,929,476**	**50.00%**	**$14,788,428**
2.2.2	**. . . . . Engineering and Design Development**	**$10,932,041**	**$1,391,649**	**$6,161,845**	**50.00%**	**$18,485,535**
2.2.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$10,057,478**	**$907,185**	**$5,482,331**	**50.00%**	**$16,446,994**
2.2.4	**. . . . . Procurement**	**$20,332,384**	**$4,713,806**	**$12,523,095**	**50.00%**	**$37,569,285**
2.2.4.1	. . . . . Civil Modifications	$17,500,797	$4,247,443	$10,874,120	50.00%	$32,622,360
2.2.4.1.1	*. . . . . Manipulators*	*$3,071,880*	*$745,545*	*$1,908,713*	*50.00%*	*$5,726,138*
2.2.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.2.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.2.4.1.4	*. . . . . Shielded Windows*	*$6,194,475*	*$1,503,399*	*$3,848,937*	*50.00%*	*$11,546,811*
2.2.4.1.5	*. . . . . Examination Equipment*	*$6,402,540*	*$1,553,896*	*$3,978,218*	*50.00%*	*$11,934,655*

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.4.2	. . . . . Mechanical Modifications	$2,831,588	$466,362	$1,648,975	50.00%	$4,946,925
2.2.4.2.1	*. . . . . Inert Confinement Enclosure*	*$2,831,588*	*$466,362*	*$1,648,975*	*50.00%*	*$4,946,925*
2.2.5	**. . . . . Construction**	**$23,395,781**	**$5,348,794**	**$14,372,288**	**50.00%**	**$43,116,863**
2.2.5.1	. . . . . Civil Modifications	$17,118,888	$4,072,701	$10,595,794	50.00%	$31,787,383
2.2.5.1.1	*. . . . . New Internal Material Transfer Device*	*$329,853*	*$93,447*	*$211,650*	*50.00%*	*$634,950*
2.2.5.1.2	*. . . . . Manipulator Installation*	*$44,436*	*$12,589*	*$28,512*	*50.00%*	*$85,537*
2.2.5.1.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.2.5.1.4	*. . . . . Vibration Isolation*	*$420,577*	*$85,503*	*$253,040*	*50.00%*	*$759,120*
2.2.5.1.5	*. . . . . Acoustical Isolation*	*$233,631*	*$47,497*	*$140,564*	*50.00%*	*$421,692*
2.2.5.1.6	*. . . . . EMI/RFI Protection Installation*	*$283,020*	*$57,538*	*$170,279*	*50.00%*	*$510,836*
2.2.5.1.7	*. . . . . Transport Loading*	*$120,750*	*$24,548*	*$72,649*	*50.00%*	*$217,948*
2.2.5.1.8	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.2.5.1.9	*. . . . . Steel Shielding Walls*	*$5,813,890*	*$1,181,964*	*$3,497,927*	*50.00%*	*$10,493,781*
2.2.5.1.9.1	*. . . . . 12" Thick Steel Shielding Walls*	*$5,751,416*	*$1,169,263*	*$3,460,339*	*50.00%*	*$10,381,018*
2.2.5.1.9.2	*. . . . . Concrete and Steel False Floor*	*$62,474*	*$12,701*	*$37,587*	*50.00%*	*$112,762*
2.2.5.1.10	*. . . . . Shielded Windows Installation*	*$86,940*	*$17,675*	*$52,307*	*50.00%*	*$156,922*
2.2.5.1.11	*. . . . . Shielded Wall Plug*	*$271,688*	*$55,234*	*$163,461*	*50.00%*	*$490,382*
2.2.5.1.12	*. . . . . Access Ports*	*$824,119*	*$167,543*	*$495,831*	*50.00%*	*$1,487,493*
2.2.5.1.13	*. . . . . Install Access Door*	*$1,496,843*	*$304,308*	*$900,576*	*50.00%*	*$2,701,727*
2.2.5.1.13.1	*. . . . . Contractor Support*	*$302,811*	*$61,561*	*$182,186*	*50.00%*	*$546,558*
2.2.5.1.13.2	*. . . . . Subcontractor Access Door Installation*	*$1,194,033*	*$242,747*	*$718,390*	*50.00%*	*$2,155,169*
2.2.5.1.14	*. . . . . Instrument Penetrations*	*$144,900*	*$29,458*	*$87,179*	*50.00%*	*$261,537*
2.2.5.1.15	*. . . . . Examination Equipment*	*$2,861,894*	*$810,775*	*$1,836,334*	*50.00%*	*$5,509,003*
2.2.5.2	. . . . . Mechanical Modifications	$6,232,392	$1,267,045	$3,749,719	50.00%	$11,249,156
2.2.5.2.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$285,897*	*$58,123*	*$172,010*	*50.00%*	*$516,030*
2.2.5.2.2	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.5.2.3	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*
2.2.5.2.4	*. . . . . Secondary Ventilation System Modifications*	*$5,000,000*	*$1,016,500*	*$3,008,250*	*50.00%*	*$9,024,750*
2.2.5.2.5	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$294,883*	*$59,950*	*$177,417*	*50.00%*	*$532,250*
2.2.5.2.6	*. . . . . Temperature Control*	*$49,408*	*$10,045*	*$29,726*	*50.00%*	*$89,179*
2.2.5.2.7	*. . . . . Inert Confinement Enclosure Installation*	*$322,812*	*$65,628*	*$194,220*	*50.00%*	*$582,660*
2.2.5.3	. . . . . Fire Protection Modifications	$44,502	$9,047	$26,774	50.00%	$80,323
2.2.5.3.1	*. . . . . Fire Alarm System Upgrade*	*$23,287*	*$4,734*	*$14,011*	*50.00%*	*$42,033*
2.2.5.3.2	*. . . . . Fire Protection System Upgrade*	*$21,214*	*$4,313*	*$12,764*	*50.00%*	*$38,291*
2.2.6	**. . . . . Construction Management**	**$3,060,972**	**$504,142**	**$1,782,557**	**50.00%**	**$5,347,670**
2.2.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.2.8	**. . . . . General and Administrative Costs**	**$1,663,182**	**$338,125**	**$1,000,654**	**50.00%**	**$3,001,961**
2.2.9	**. . . . . Location Factor Adjustment**	**$3,498,253**	**$711,195**	**$2,104,724**	**50.00%**	**$6,314,172**
3	**Facility Operations and Maintenance**	**$413,050,502**	**$672,229,730**	**$542,640,116**	**50.00%**	**$1,627,920,349**
3.1	**. . . . Year 1**	**$8,793,647**	**$2,859,694**	**$5,826,671**	**50.00%**	**$17,480,012**
3.1.1	**. . . . . Facility Maintenance**	**$1,926,912**	**$626,632**	**$1,276,772**	**50.00%**	**$3,830,316**
3.1.2	**. . . . . Facility Operations**	**$6,318,355**	**$2,054,729**	**$4,186,542**	**50.00%**	**$12,559,626**
3.1.3	**. . . . . Electrical Power Usage**	**$548,380**	**$178,333**	**$363,357**	**50.00%**	**$1,090,070**
3.2	**. . . . Year 2**	**$8,793,647**	**$3,240,459**	**$6,017,053**	**50.00%**	**$18,051,159**
3.2.1	**. . . . . Facility Maintenance**	**$1,926,912**	**$710,067**	**$1,318,490**	**50.00%**	**$3,955,469**
3.2.2	**. . . . . Facility Operations**	**$6,318,355**	**$2,328,314**	**$4,323,334**	**50.00%**	**$12,970,003**
3.2.3	**. . . . . Electrical Power Usage**	**$548,380**	**$202,078**	**$375,229**	**50.00%**	**$1,125,687**
3.3	**. . . . Year 3**	**$12,851,279**	**$5,310,148**	**$9,080,714**	**50.00%**	**$27,242,141**
3.3.1	**. . . . . Facility Maintenance**	**$1,926,912**	**$796,200**	**$1,361,556**	**50.00%**	**$4,084,668**
3.3.2	**. . . . . Facility Operations**	**$6,318,355**	**$2,610,744**	**$4,464,550**	**50.00%**	**$13,393,649**
3.3.3	**. . . . . Facility Refurbishment**	**$4,057,632**	**$1,676,614**	**$2,867,123**	**50.00%**	**$8,601,368**
3.3.3	**. . . . . Electrical Power Usage**	**$548,380**	**$226,591**	**$387,485**	**50.00%**	**$1,162,456**

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.4	. . . . Year 4	$8,793,647	$4,038,922	$6,416,285	50.00%	$19,248,854
3.4.1	. . . . . Facility Maintenance	$1,926,912	$885,031	$1,405,971	50.00%	$4,217,914
3.4.2	. . . . . Facility Operations	$6,318,355	$2,902,020	$4,610,188	50.00%	$13,830,563
3.4.3	. . . . . Electrical Power Usage	$548,380	$251,871	$400,125	50.00%	$1,200,376
3.5	. . . . Year 5	$8,793,647	$4,458,379	$6,626,013	50.00%	$19,878,039
3.5.1	. . . . . Facility Maintenance	$1,926,912	$976,944	$1,451,928	50.00%	$4,355,785
3.5.2	. . . . . Facility Operations	$6,318,355	$3,203,406	$4,760,880	50.00%	$14,282,641
3.5.3	. . . . . Electrical Power Usage	$548,380	$278,029	$413,204	50.00%	$1,239,613
3.6	. . . . Year 6	$8,793,647	$4,891,026	$6,842,337	50.00%	$20,527,010
3.6.1	. . . . . Facility Maintenance	$1,926,912	$1,071,748	$1,499,330	50.00%	$4,497,991
3.6.2	. . . . . Facility Operations	$6,318,355	$3,514,269	$4,916,312	50.00%	$14,748,936
3.6.3	. . . . . Electrical Power Usage	$548,380	$305,009	$426,694	50.00%	$1,280,083
3.7	. . . . Year 7	$8,793,647	$5,338,623	$7,066,135	50.00%	$21,198,405
3.7.1	. . . . . Facility Maintenance	$1,926,912	$1,169,828	$1,548,370	50.00%	$4,645,110
3.7.2	. . . . . Facility Operations	$6,318,355	$3,835,873	$5,077,114	50.00%	$15,231,342
3.7.3	. . . . . Electrical Power Usage	$548,380	$332,921	$440,651	50.00%	$1,321,952
3.8	. . . . Year 8	$8,793,647	$5,800,290	$7,296,968	50.00%	$21,890,905
3.8.1	. . . . . Facility Maintenance	$1,926,912	$1,270,991	$1,598,952	50.00%	$4,796,855
3.8.2	. . . . . Facility Operations	$6,318,355	$4,167,587	$5,242,971	50.00%	$15,728,913
3.8.3	. . . . . Electrical Power Usage	$548,380	$361,711	$455,046	50.00%	$1,365,137
3.9	. . . . Year 9	$8,793,647	$6,276,905	$7,535,276	50.00%	$22,605,828
3.9.1	. . . . . Facility Maintenance	$1,926,912	$1,375,430	$1,651,171	50.00%	$4,953,513
3.9.2	. . . . . Facility Operations	$6,318,355	$4,510,042	$5,414,198	50.00%	$16,242,595
3.9.3	. . . . . Electrical Power Usage	$548,380	$391,434	$469,907	50.00%	$1,409,720
3.10	. . . . Year 10	$26,532,743	$20,424,906	$23,478,824	50.00%	$70,436,473
3.10.1	. . . . . Facility Maintenance	$1,926,912	$1,483,337	$1,705,124	50.00%	$5,115,373

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.10.2	. . . . . Facility Operations	$6,318,355	$4,863,870	$5,591,112	50.00%	$16,773,337
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.10.3	. . . . . Electrical Power Usage	$548,380	$422,143	$485,261	50.00%	$1,455,784
3.11	. . . . Year 11	$8,793,647	$7,277,622	$8,035,635	50.00%	$24,106,904
3.11.1	. . . . . Facility Maintenance	$1,926,912	$1,594,712	$1,760,812	50.00%	$5,282,437
3.11.2	. . . . . Facility Operations	$6,318,355	$5,229,071	$5,773,713	50.00%	$17,321,138
3.11.3	. . . . . Electrical Power Usage	$548,380	$453,839	$501,110	50.00%	$1,503,329
3.12	. . . . Year 12	$8,793,647	$7,802,603	$8,298,125	50.00%	$24,894,375
3.12.1	. . . . . Facility Maintenance	$1,926,912	$1,709,749	$1,818,331	50.00%	$5,454,992
3.12.2	. . . . . Facility Operations	$6,318,355	$5,606,276	$5,962,316	50.00%	$17,886,947
3.12.3	. . . . . Electrical Power Usage	$548,380	$486,578	$517,479	50.00%	$1,552,436
3.13	. . . . Year 13	$8,793,647	$8,344,292	$8,568,969	50.00%	$25,706,908
3.13.1	. . . . . Facility Maintenance	$1,926,912	$1,828,447	$1,877,679	50.00%	$5,633,038
3.13.2	. . . . . Facility Operations	$6,318,355	$5,995,487	$6,156,921	50.00%	$18,470,763
3.13.3	. . . . . Electrical Power Usage	$548,380	$520,358	$534,369	50.00%	$1,603,107
3.14	. . . . Year 14	$8,793,647	$8,904,447	$8,849,047	50.00%	$26,547,141
3.14.1	. . . . . Facility Maintenance	$1,926,912	$1,951,191	$1,939,052	50.00%	$5,817,155
3.14.2	. . . . . Facility Operations	$6,318,355	$6,397,966	$6,358,161	50.00%	$19,074,482
3.14.3	. . . . . Electrical Power Usage	$548,380	$555,290	$551,835	50.00%	$1,655,504
3.15	. . . . Year 15	$8,793,647	$10,079,278	$9,436,463	50.00%	$28,309,388
3.15.1	. . . . . Facility Maintenance	$1,926,912	$2,208,627	$2,067,769	50.00%	$6,203,308
3.15.2	. . . . . Facility Operations	$6,318,355	$7,242,099	$6,780,227	50.00%	$20,340,680
3.15.3	. . . . . Electrical Power Usage	$548,380	$628,553	$588,467	50.00%	$1,765,400
3.16	. . . . Year 16	$8,793,647	$10,079,278	$9,436,463	50.00%	$28,309,388
3.16.1	. . . . . Facility Maintenance	$1,926,912	$2,208,627	$2,067,769	50.00%	$6,203,308
3.16.2	. . . . . Facility Operations	$6,318,355	$7,242,099	$6,780,227	50.00%	$20,340,680

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.16.3	. . . . . Electrical Power Usage	$548,380	$628,553	$588,467	50.00%	$1,765,400
3.17	. . . . Year 17	$8,793,647	$10,695,713	$9,744,680	50.00%	$29,234,040
3.17.1	. . . . . Facility Maintenance	$1,926,912	$2,343,703	$2,135,308	50.00%	$6,405,923
3.17.2	. . . . . Facility Operations	$6,318,355	$7,685,015	$7,001,685	50.00%	$21,005,055
3.17.3	. . . . . Electrical Power Usage	$548,380	$666,995	$607,687	50.00%	$1,823,062
3.18	. . . . Year 18	$8,793,647	$11,332,373	$10,063,010	50.00%	$30,189,030
3.18.1	. . . . . Facility Maintenance	$1,926,912	$2,483,211	$2,205,062	50.00%	$6,615,185
3.18.2	. . . . . Facility Operations	$6,318,355	$8,142,464	$7,230,410	50.00%	$21,691,229
3.18.3	. . . . . Electrical Power Usage	$548,380	$706,697	$627,539	50.00%	$1,882,616
3.19	. . . . Year 19	$8,793,647	$11,990,138	$10,391,892	50.00%	$31,175,677
3.19.1	. . . . . Facility Maintenance	$1,926,912	$2,627,345	$2,277,128	50.00%	$6,831,385
3.19.2	. . . . . Facility Operations	$6,318,355	$8,615,077	$7,466,716	50.00%	$22,400,148
3.19.3	. . . . . Electrical Power Usage	$548,380	$747,716	$648,048	50.00%	$1,944,144
3.20	. . . . Year 20	$26,532,743	$38,225,723	$32,379,233	50.00%	$97,137,699
3.20.1	. . . . . Facility Maintenance	$1,926,912	$2,776,102	$2,351,507	50.00%	$7,054,521
3.20.2	. . . . . Facility Operations	$6,318,355	$9,102,854	$7,710,605	50.00%	$23,131,814
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.20.3	. . . . . Electrical Power Usage	$548,380	$790,051	$669,216	50.00%	$2,007,647
3.21	. . . . Year 21	$8,793,647	$13,369,861	$11,081,754	50.00%	$33,245,262
3.21.1	. . . . . Facility Maintenance	$1,926,912	$2,929,677	$2,428,295	50.00%	$7,284,884
3.21.2	. . . . . Facility Operations	$6,318,355	$9,606,427	$7,962,391	50.00%	$23,887,173
3.21.3	. . . . . Electrical Power Usage	$548,380	$833,757	$691,068	50.00%	$2,073,205
3.22	. . . . Year 22	$8,793,647	$14,094,457	$11,444,052	50.00%	$34,332,157
3.22.1	. . . . . Facility Maintenance	$1,926,912	$3,088,455	$2,507,683	50.00%	$7,523,050
3.22.2	. . . . . Facility Operations	$6,318,355	$10,127,059	$8,222,707	50.00%	$24,668,122
3.22.3	. . . . . Electrical Power Usage	$548,380	$878,943	$713,662	50.00%	$2,140,985

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.23	. . . . Year 23	$12,851,279	$21,690,389	$17,270,834	50.00%	$51,812,502
3.23.1	. . . . . Facility Maintenance	$1,926,912	$3,252,242	$2,589,577	50.00%	$7,768,731
3.23.2	. . . . . Facility Operations	$6,318,355	$10,664,120	$8,491,237	50.00%	$25,473,712
3.23.3	. . . . . Facility Refurbishment	$4,057,632	$6,848,471	$5,453,052	50.00%	$16,359,155
3.23.3	. . . . . Electrical Power Usage	$548,380	$925,556	$736,968	50.00%	$2,210,904
3.24	. . . . Year 24	$8,793,647	$15,614,000	$12,203,823	50.00%	$36,611,470
3.24.1	. . . . . Facility Maintenance	$1,926,912	$3,421,425	$2,674,168	50.00%	$8,022,505
3.24.2	. . . . . Facility Operations	$6,318,355	$11,218,871	$8,768,613	50.00%	$26,305,839
3.24.3	. . . . . Electrical Power Usage	$548,380	$973,704	$761,042	50.00%	$2,283,125
3.25	. . . . Year 25	$8,793,647	$16,411,583	$12,602,615	50.00%	$37,807,846
3.25.1	. . . . . Facility Maintenance	$1,926,912	$3,596,196	$2,761,554	50.00%	$8,284,662
3.25.2	. . . . . Facility Operations	$6,318,355	$11,791,946	$9,055,150	50.00%	$27,165,451
3.25.3	. . . . . Electrical Power Usage	$548,380	$1,023,442	$785,911	50.00%	$2,357,732
3.26	. . . . Year 26	$8,793,647	$17,234,669	$13,014,158	50.00%	$39,042,474
3.26.1	. . . . . Facility Maintenance	$1,926,912	$3,776,555	$2,851,733	50.00%	$8,555,200
3.26.2	. . . . . Facility Operations	$6,318,355	$12,383,344	$9,350,849	50.00%	$28,052,548
3.26.3	. . . . . Electrical Power Usage	$548,380	$1,074,770	$811,575	50.00%	$2,434,725
3.27	. . . . Year 27	$8,765,717	$18,027,574	$13,396,645	50.00%	$40,189,936
3.27.1	. . . . . Facility Maintenance	$1,926,912	$3,962,887	$2,944,900	50.00%	$8,834,699
3.27.2	. . . . . Facility Operations	$6,318,355	$12,994,329	$9,656,342	50.00%	$28,969,026
3.27.3	. . . . . Electrical Power Usage	$520,450	$1,070,357	$795,404	50.00%	$2,386,211
3.28	. . . . Year 28	$8,793,647	$18,962,620	$13,878,134	50.00%	$41,634,401
3.28.1	. . . . . Facility Maintenance	$1,926,912	$4,155,193	$3,041,053	50.00%	$9,123,158
3.28.2	. . . . . Facility Operations	$6,318,355	$13,624,901	$9,971,628	50.00%	$29,914,884
3.28.3	. . . . . Electrical Power Usage	$548,380	$1,182,527	$865,453	50.00%	$2,596,360
3.29	. . . . Year 29	$8,793,647	$19,869,245	$14,331,446	50.00%	$42,994,339

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.29.1	. . . . . Facility Maintenance	$1,926,912	$4,353,858	$3,140,385	50.00%	$9,421,154
3.29.2	. . . . . Facility Operations	$6,318,355	$14,276,323	$10,297,339	50.00%	$30,892,017
3.29.3	. . . . . Electrical Power Usage	$548,380	$1,239,065	$893,722	50.00%	$2,681,167
3.30	**. . . . Year 30**	**$26,532,743**	**$62,776,470**	**$44,654,606**	**50.00%**	**$133,963,819**
3.30.1	. . . . . Facility Maintenance	$1,926,912	$4,559,074	$3,242,993	50.00%	$9,728,979
3.30.2	. . . . . Facility Operations	$6,318,355	$14,949,228	$10,633,791	50.00%	$31,901,374
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.30.3	. . . . . Electrical Power Usage	$548,380	$1,297,467	$922,924	50.00%	$2,768,771
3.31	**. . . . Year 31**	**$8,793,647**	**$21,773,070**	**$15,283,358**	**50.00%**	**$45,850,075**
3.31.1	. . . . . Facility Maintenance	$1,926,912	$4,771,034	$3,348,973	50.00%	$10,046,919
3.31.2	. . . . . Facility Operations	$6,318,355	$15,644,247	$10,981,301	50.00%	$32,943,903
3.31.3	. . . . . Electrical Power Usage	$548,380	$1,357,789	$953,084	50.00%	$2,859,253
3.32	**. . . . Year 32**	**$8,793,647**	**$22,771,149**	**$15,782,398**	**50.00%**	**$47,347,194**
3.32.1	. . . . . Facility Maintenance	$1,926,912	$4,989,739	$3,458,325	50.00%	$10,374,976
3.32.2	. . . . . Facility Operations	$6,318,355	$16,361,380	$11,339,868	50.00%	$34,019,603
3.32.3	. . . . . Electrical Power Usage	$548,380	$1,420,030	$984,205	50.00%	$2,952,615
3.33	**. . . . Year 33**	**$8,793,647**	**$23,802,644**	**$16,298,145**	**50.00%**	**$48,894,436**
3.33.1	. . . . . Facility Maintenance	$1,926,912	$5,215,765	$3,571,339	50.00%	$10,714,016
3.33.2	. . . . . Facility Operations	$6,318,355	$17,102,523	$11,710,439	50.00%	$35,131,317
3.33.3	. . . . . Electrical Power Usage	$548,380	$1,484,355	$1,016,367	50.00%	$3,049,102
3.34	**. . . . Year 34**	**$8,793,647**	**$24,867,554**	**$16,830,601**	**50.00%**	**$50,491,802**
3.34.1	. . . . . Facility Maintenance	$1,926,912	$5,449,114	$3,688,013	50.00%	$11,064,040
3.34.2	. . . . . Facility Operations	$6,318,355	$17,867,676	$12,093,016	50.00%	$36,279,047
3.34.3	. . . . . Electrical Power Usage	$548,380	$1,550,764	$1,049,572	50.00%	$3,148,716
3.35	**. . . . Year 35**	**$8,793,647**	**$25,966,760**	**$17,380,204**	**50.00%**	**$52,140,611**
3.35.1	. . . . . Facility Maintenance	$1,926,912	$5,689,978	$3,808,445	50.00%	$11,425,336

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.35.2	. . . . . Facility Operations	$6,318,355	$18,657,470	$12,487,913	50.00%	$37,463,738
3.35.3	. . . . . Electrical Power Usage	$548,380	$1,619,311	$1,083,846	50.00%	$3,251,537
3.36	. . . . Year 36	$8,793,647	$27,102,020	$17,947,834	50.00%	$53,843,501
3.36.1	. . . . . Facility Maintenance	$1,926,912	$5,938,743	$3,932,827	50.00%	$11,798,482
3.36.2	. . . . . Facility Operations	$6,318,355	$19,473,170	$12,895,763	50.00%	$38,687,288
3.36.3	. . . . . Electrical Power Usage	$548,380	$1,690,107	$1,119,244	50.00%	$3,357,731
3.37	. . . . Year 37	$8,793,647	$28,275,093	$18,534,370	50.00%	$55,603,109
3.37.1	. . . . . Facility Maintenance	$1,926,912	$6,195,793	$4,061,352	50.00%	$12,184,057
3.37.2	. . . . . Facility Operations	$6,318,355	$20,316,039	$13,317,197	50.00%	$39,951,591
3.37.3	. . . . . Electrical Power Usage	$548,380	$1,763,261	$1,155,821	50.00%	$3,467,462
3.38	. . . . Year 38	$8,793,647	$29,485,978	$19,139,812	50.00%	$57,419,437
3.38.1	. . . . . Facility Maintenance	$1,926,912	$6,461,129	$4,194,020	50.00%	$12,582,061
3.38.2	. . . . . Facility Operations	$6,318,355	$21,186,076	$13,752,216	50.00%	$41,256,647
3.38.3	. . . . . Electrical Power Usage	$548,380	$1,838,773	$1,193,576	50.00%	$3,580,729
3.39	. . . . Year 39	$8,793,647	$30,736,434	$19,765,041	50.00%	$59,295,122
3.39.1	. . . . . Facility Maintenance	$1,926,912	$6,735,136	$4,331,024	50.00%	$12,993,071
3.39.2	. . . . . Facility Operations	$6,318,355	$22,084,546	$14,201,451	50.00%	$42,604,352
3.39.3	. . . . . Electrical Power Usage	$548,380	$1,916,753	$1,232,566	50.00%	$3,697,699
3.40	. . . . Year 40	$8,793,647	$32,027,342	$20,410,494	50.00%	$61,231,483
3.40.1	. . . . . Facility Maintenance	$1,926,912	$7,018,006	$4,472,459	50.00%	$13,417,377
3.40.2	. . . . . Facility Operations	$6,318,355	$23,012,081	$14,665,218	50.00%	$43,995,654
3.40.3	. . . . . Electrical Power Usage	$548,380	$1,997,255	$1,272,817	50.00%	$3,818,452
4	Post Irradiation Examination	$193,893,120	$321,135,480	$257,514,300	50.00%	$772,542,900
4.1	. . . . Year 1	$4,847,328	$1,576,351	$3,211,840	50.00%	$9,635,519
4.2	. . . . Year 2	$4,847,328	$1,786,240	$3,316,784	50.00%	$9,950,353

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.3	. . . . Year 3	$4,847,328	$2,002,916	$3,425,122	50.00%	$10,275,366
4.4	. . . . Year 4	$4,847,328	$2,226,378	$3,536,853	50.00%	$10,610,559
4.5	. . . . Year 5	$4,847,328	$2,457,595	$3,652,462	50.00%	$10,957,385
4.6	. . . . Year 6	$4,847,328	$2,696,084	$3,771,706	50.00%	$11,315,118
4.7	. . . . Year 7	$4,847,328	$2,942,813	$3,895,070	50.00%	$11,685,211
4.8	. . . . Year 8	$4,847,328	$3,197,298	$4,022,313	50.00%	$12,066,938
4.9	. . . . Year 9	$4,847,328	$3,460,023	$4,153,675	50.00%	$12,461,026
4.10	. . . . Year 10	$4,847,328	$3,731,473	$4,289,401	50.00%	$12,868,202
4.11	. . . . Year 11	$4,847,328	$4,011,649	$4,429,488	50.00%	$13,288,465
4.12	. . . . Year 12	$4,847,328	$4,301,034	$4,574,181	50.00%	$13,722,543
4.13	. . . . Year 13	$4,847,328	$4,599,630	$4,723,479	50.00%	$14,170,436
4.14	. . . . Year 14	$4,847,328	$4,908,404	$4,877,866	50.00%	$14,633,598
1.15	. . . . Year 15	$4,847,328	$5,556,007	$5,201,668	50.00%	$15,605,003
4.16	. . . . Year 16	$4,847,328	$5,556,007	$5,201,668	50.00%	$15,605,003
4.17	. . . . Year 17	$4,847,328	$5,895,805	$5,371,567	50.00%	$16,114,700
4.18	. . . . Year 18	$4,847,328	$6,246,752	$5,547,040	50.00%	$16,641,119
4.19	. . . . Year 19	$4,847,328	$6,609,332	$5,728,330	50.00%	$17,184,990
4.20	. . . . Year 20	$4,847,328	$6,983,545	$5,915,437	50.00%	$17,746,310
4.21	. . . . Year 21	$4,847,328	$7,369,877	$6,108,603	50.00%	$18,325,808
4.22	. . . . Year 22	$4,847,328	$7,769,297	$6,308,313	50.00%	$18,924,938
4.23	. . . . Year 23	$4,847,328	$8,181,320	$6,514,324	50.00%	$19,542,972
4.24	. . . . Year 24	$4,847,328	$8,606,916	$6,727,122	50.00%	$20,181,365
4.25	. . . . Year 25	$4,847,328	$9,046,568	$6,946,948	50.00%	$20,840,844
4.26	. . . . Year 26	$4,847,328	$9,500,278	$7,173,803	50.00%	$21,521,409

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.27	. . . . Year 27	$4,847,328	$9,969,015	$7,408,171	50.00%	$22,224,514
4.28	. . . . Year 28	$4,847,328	$10,452,778	$7,650,053	50.00%	$22,950,159
4.29	. . . . Year 29	$4,847,328	$10,952,538	$7,899,933	50.00%	$23,699,798
4.30	. . . . Year 30	$4,847,328	$11,468,778	$8,158,053	50.00%	$24,474,159
4.31	. . . . Year 31	$4,847,328	$12,001,984	$8,424,656	50.00%	$25,273,968
4.32	. . . . Year 32	$4,847,328	$12,552,156	$8,699,742	50.00%	$26,099,226
4.33	. . . . Year 33	$4,847,328	$13,120,747	$8,984,038	50.00%	$26,952,113
4.34	. . . . Year 34	$4,847,328	$13,707,759	$9,277,543	50.00%	$27,832,630
4.35	. . . . Year 35	$4,847,328	$14,313,675	$9,580,501	50.00%	$28,741,504
4.36	. . . . Year 36	$4,847,328	$14,939,465	$9,893,396	50.00%	$29,680,189
4.37	. . . . Year 37	$4,847,328	$15,586,098	$10,216,713	50.00%	$30,650,140
4.38	. . . . Year 38	$4,847,328	$16,253,576	$10,550,452	50.00%	$31,651,355
4.39	. . . . Year 39	$4,847,328	$16,942,866	$10,895,097	50.00%	$32,685,290
4.40	. . . . Year 40	$4,847,328	$17,654,453	$11,250,891	50.00%	$33,752,672
5	Transportation	$693,884,000	$1,149,245,375	$921,564,688	50.00%	$2,764,694,063
5.1	. . . . Year 1	$17,347,100	$5,641,277	$11,494,188	50.00%	$34,482,565
5.2	. . . . Year 2	$17,347,100	$6,392,406	$11,869,753	50.00%	$35,609,260
5.3	. . . . Year 3	$17,347,100	$7,167,822	$12,257,461	50.00%	$36,772,383
5.4	. . . . Year 4	$17,347,100	$7,967,523	$12,657,312	50.00%	$37,971,935
5.5	. . . . Year 5	$17,347,100	$8,794,980	$13,071,040	50.00%	$39,213,120
5.6	. . . . Year 6	$17,347,100	$9,648,457	$13,497,779	50.00%	$40,493,336
5.7	. . . . Year 7	$17,347,100	$10,531,424	$13,939,262	50.00%	$41,817,787
5.8	. . . . Year 8	$17,347,100	$11,442,147	$14,394,624	50.00%	$43,183,871
5.9	. . . . Year 9	$17,347,100	$12,382,360	$14,864,730	50.00%	$44,594,190

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.10	. . . . Year 10	$17,347,100	$13,353,798	$15,350,449	50.00%	$46,051,346
5.11	. . . . Year 11	$17,347,100	$14,356,460	$15,851,780	50.00%	$47,555,340
5.12	. . . . Year 12	$17,347,100	$15,392,082	$16,369,591	50.00%	$49,108,773
5.13	. . . . Year 13	$17,347,100	$16,460,663	$16,903,882	50.00%	$50,711,645
5.14	. . . . Year 14	$17,347,100	$17,565,673	$17,456,387	50.00%	$52,369,160
5.15	. . . . Year 15	$17,347,100	$19,883,246	$18,615,173	50.00%	$55,845,519
5.16	. . . . Year 16	$17,347,100	$19,883,246	$18,615,173	50.00%	$55,845,519
5.17	. . . . Year 17	$17,347,100	$21,099,278	$19,223,189	50.00%	$57,669,567
5.18	. . . . Year 18	$17,347,100	$22,355,208	$19,851,154	50.00%	$59,553,462
5.19	. . . . Year 19	$17,347,100	$23,652,771	$20,499,935	50.00%	$61,499,806
5.20	. . . . Year 20	$17,347,100	$24,991,967	$21,169,533	50.00%	$63,508,600
5.21	. . . . Year 21	$17,347,100	$26,374,531	$21,860,815	50.00%	$65,582,446
5.22	. . . . Year 22	$17,347,100	$27,803,932	$22,575,516	50.00%	$67,726,548
5.23	. . . . Year 23	$17,347,100	$29,278,435	$23,312,768	50.00%	$69,938,303
5.24	. . . . Year 24	$17,347,100	$30,801,511	$24,074,305	50.00%	$72,222,916
5.25	. . . . Year 25	$17,347,100	$32,374,893	$24,860,996	50.00%	$74,582,989
5.25	. . . . Year 26	$17,347,100	$33,998,581	$25,672,841	50.00%	$77,018,522
5.27	. . . . Year 27	$17,347,100	$35,676,046	$26,511,573	50.00%	$79,534,719
5.28	. . . . Year 28	$17,347,100	$37,407,286	$27,377,193	50.00%	$82,131,580
5.29	. . . . Year 29	$17,347,100	$39,195,772	$28,271,436	50.00%	$84,814,309
5.30	. . . . Year 30	$17,347,100	$41,043,239	$29,195,169	50.00%	$87,585,508
5.31	. . . . Year 31	$17,347,100	$42,951,420	$30,149,260	50.00%	$90,447,779
5.32	. . . . Year 32	$17,347,100	$44,920,315	$31,133,708	50.00%	$93,401,123
5.33	. . . . Year 33	$17,347,100	$46,955,130	$32,151,115	50.00%	$96,453,345

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3B***

Project Location: ***ORNL/LANL***
Estimate Number: ***8B26-B***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.34	. . . . Year 34	$17,347,100	$49,055,864	$33,201,482	50.00%	$99,604,446
5.35	. . . . Year 35	$17,347,100	$51,224,252	$34,285,676	50.00%	$102,857,027
5.36	. . . . Year 36	$17,347,100	$53,463,762	$35,405,431	50.00%	$106,216,293
5.37	. . . . Year 37	$17,347,100	$55,777,865	$36,562,483	50.00%	$109,687,448
5.38	. . . . Year 38	$17,347,100	$58,166,561	$37,756,831	50.00%	$113,270,492
5.39	. . . . Year 39	$17,347,100	$60,633,319	$38,990,209	50.00%	$116,970,628
5.40	. . . . Year 40	$17,347,100	$63,179,873	$40,263,486	50.00%	$120,790,459
6	Deactivation and Demolition	$13,970,112	$52,999,811	$33,484,961	50.00%	$100,454,884
Total	APIEC Consolidated - Alternate #3B	$1,504,281,551	$2,230,490,590	$1,866,630,892	49.98%	$5,601,403,032

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman, Project Engineer

From: R. D. Allen / B. W. Wallace, Cost Estimators

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #3C

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $5,600,000,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, and markup sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate and/or schedule and should be reviewed by me. If you have any questions or comments, do not

hesitate to contact Ross Allen at 526-0769 or e-mail Ross.Allen@inl.gov or Bruce Wallace at 526-5896 or email Bruce.Wallace@inl.gov.

Attachments

cc: Estimate File 8B26-C

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Project Number: ***8B26-C***

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		153.35%	*49.98%*	
Total Estimated Cost (TEC)	**$1,461,979,693**	**$2,241,989,985**	**$1,851,229,661**	**$5,555,199,339**
		153.35%	*49.98%*	
Total Cost	**$1,461,979,693**	**$2,241,989,985**	**$1,851,229,661**	**$5,555,199,339**
Rounded Total Cost (Rounded to the nearest $ 100000000)				**$5,600,000,000**

		Remarks
Type of Estimate:	Alternative Analysis - Class 5	Includes APIEC Consolidated to INL and ORNL.
Estimator:	R. D. Allen / B. W. Wallace	
Checked By:		
Approved By:		

Battelle Energy Alliance, LLC

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #3C
Estimator:	R. D. Allen / B. W. Wallace
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26-C
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**
The objective of this work is to modify existing DOE-owned facilities located at Oak Ridge National Laboratory (ORNL) and Idaho National Laboratory (INL) to support advanced post irradiation examination (PIE) activities for highly-irradiated nuclear fuels and materials.

B. **Included:**
This cost estimate includes life-cycle costs (LCC) as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs. Including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration. Includes DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Equipment procurement and modifications to the existing facilities, including the following:
   a. INL
      Equipment procurement and modifications to the Irradiated Materials Characterization Laboratory (IMCL), including the following:
      (i) Transfer cask with 8" inside diameter.
      (ii) Rough sizing, sample preparation, and waste packaging equipment.
      (iii) Specimen transfer device for transportation of source material between cells.
      (iv) Storage racks for shielded sample storage and prepared specimen storage.

(v) Post irradiation examination instrumentation.
(vi) Add metal stud wall and suspended acoustical ceiling to enclose two non-shielded examination areas.
(vii) Acoustical and electromagnetic interference (EMI) protection for examination equipment in non-shielded areas.
(viii) Miscellaneous utility modifications in non-shielded areas.
(ix) One 10'x20'x12' modular shielded enclosure (MSE) for sample preparation activities.
(x) Three 10'x10'x12' MSEs for examination activities.
(xi) Tie-in MSEs into existing facility utilities and exhaust system.
(xii) Six 6'x6'x5' inert confinement enclosures (ICE).
(xiii) Add facility infrastructure to supply inert gas to new ICEs.
(xiv) Inert gas purification system for new ICEs.
(xv) Provide temperature control for the three MSEs and two non-shielded areas containing examination equipment.
(xvi) One 6'x6'x6' shielded confinement box within the sample preparation MSE for shielded sample storage.

b. ORNL

Equipment procurement and modifications to the Radiochemical Engineering Development Center (REDC) at ORNL, including the following:

(i) Secondary facility ventilation requirements to provide a credited secondary system.
(ii) Rough sizing, sample preparation, and waste packaging equipment.
(iii) Eight pair of heavy-duty manipulators.
(iv) Nine 4'x4'x5' oiled filled shielded windows.
(v) Five 12" thick steel hot cell wall plugs.
(vi) New 12" thick steel shielding walls and concrete and steel false floor.
(vii) Storage racks for shielded sample storage and prepared specimen storage.
(viii) Post irradiation examination instrumentation.
(ix) Miscellaneous utility modifications in non-shielded areas.
(x) Add fire detection system to existing hot cells.
(xi) Add wet pipe fire suppression system to existing hot cells.
(xii) Install a new material transfer device for material transfer between existing hot cells.
(xiii) Add transport loading port from D-Cell to B-Cell.
(xiv) Seven new 6'x6'x5' ICE.
(xv) Add facility infrastructure to supply inert gas to new ICEs.
(xvi) Inert gas purification system for new ICEs.
(xvii) Tie-in new ICEs to existing facility exhaust system.
(xviii) Acoustical, vibration, and EMI protection for examination equipment in four instrument areas and two non-shielded areas.

(xix) Provide temperature control for instrumentation areas and two non-shielding areas containing examination equipment.
(xx) Seven new access ports into existing hot cells.
(xxi) Install four new access doors into existing hot cells.
(xxii) Twenty-four small hot cell penetrations for instrumentation and controls cabling.

6. Construction subcontract management costs.
7. Operational readiness costs, including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR.
8. Facility operations costs for 40 years. Includes sharing of operations staff with other resident program(s) in the facility. See estimate back-up for more details.
9. Facility maintenance costs for 40 years. Including annual facility maintenance costs, facility refurbishment costs, and equipment replacement costs. Annual maintenance and facility refurbishment costs are included only for the facility space to be used by the APIEC project.
10. Post irradiation examination activities for 40 years.
11. Off-site and on-site transportation costs for 100 experiments per year.
12. Deactivation, decommissioning, and demolition of facility (DD&D). Includes costs to DD&D the facility space to be used by the APIEC project. See estimate back-up for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Utilities upgrades exterior to the facility.
3. Physical security personnel costs.

III. **ESTIMATE METHODOLOGY:** *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of the methods are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled Low Level Waste project. Engineering and design development costs are based on the DOE

Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range. It was assumed that each of the five DOE sites requiring facility modifications will require separate design efforts, thus, increasing overall project design costs; therefore 25 percent was used.
Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

"Forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning, and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. **BASIS OF THE ESTIMATE:** *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association for the Advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012, developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th and 9th, 2012.

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. The operating contractor for each laboratory will provide resources for all project management and construction management resources.
2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by the laboratory operating contractor.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.

4. Sales tax on materials is based on an average rate of 6%.
5. Contractor markup rates are based on this estimator's judgment. The application of markups varies based on cost basis and estimate methodology used.
6. Construction and procurement costs were adjusted by geographic location based on RS Means location factors.
7. The following estimates and or projects were used as a cost basis.
   a. Modular Enclosure and Transfer Cask; BEA estimate File #1C66-B.
   b. PIE Line Item Building (LIB); BEA estimate File #1B33-D.
   c. ANL-W Lab Upgrade CDR.
   d. Advanced Test Reactor Loop 2A.
8. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.
9. Estimate allowances have been carried for specific scopes of work that have no design definition. This cost estimate includes an allowance to upgrade the secondary facility ventilation requirements to provide a credited secondary system of the ORNL REDC facility, allowance developed by the project team.

V. **ESTIMATE QUALITY ASSURANCE:** *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. **ASSUMPTIONS:** *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Per the requester:
   1. Selected facilities will be available to support the PIE program.
   2. Project will not require converting non-hazard category (HC)-2 facilities to meet HC-2 and associated seismic/performance category requirements.
   3. Facility modifications will not require wholesale replacement of existing fixed hot cells.
   4. Sixty percent of sample prep and rough sizing equipment required for the PIE LIB facility will be required for PIE examination at each facility.

5. Facility operations staffing will require a minimum of one person per facility per operations role.
6. Facility operations staffing will be shared with other resident program(s) in the facility.
7. Shipments from ATR to HFEF, HFIR to IFEL, and all APIEC off-site shipments require the use of a rental cask.
8. Shipments from other irradiators to the NDE/sizing/repackaging capability are assumed to be paid for by others. University shipments are assumed to use the existing BRR Cask and shipping paid for by other programs. Shipments from commercial and/or international entities will be at their expense.
9. On-site shipments downstream of NDE/sizing/repackaging are assumed to be performed using existing casks that are available at the site at no cost.
10. Off-site shipments will require the rental of only one cask per experiment.
11. Facility maintenance, refurbishment, and DD&D costs will be allocated to the project based on facility area usage.
12. An environmental impact statement (EIS) will not be required for this project. Costs are included for an environmental assessment (EA) and finding of no significant impact (FONSI).

VII. MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

A blanket MR rate of 50% was applied to this cost estimate. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.
2. Unknown facility upgrades not included in this cost estimate may be required.
3. Currently facilities selected for use may become unavailable.
4. The facility operations estimate is based on the assumption of sharing operations costs with other resident programs. Costs could increase if current programs are terminated.

5. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be greater than anticipated, project costs may be impacted.
6. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is greater than assumed, project costs may be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased productivity, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are assumed to be allocated based on anticipated facility area usage. If costs are allocated on a different basis or facility area usage is determined to be less than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed, project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. **OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:**

None.

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation (Spent Costs)	$1,510,356	$0	$0	0.00%	$1,510,356
2	Capital Costs (TPC)	$140,627,640	$25,659,267	$83,143,454	50.00%	$249,430,361
2.1	. . . . Idaho National Laboratory	$55,451,915	$9,784,030	$32,617,973	50.00%	$97,853,918
2.1.1	. . . . . Project Management	$5,796,120	$737,846	$3,266,983	50.00%	$9,800,948
2.1.2	. . . . . Engineering and Design Development	$7,245,150	$922,308	$4,083,729	50.00%	$12,251,186
2.1.3	. . . . . Project Integration and DOE 413 Deliverables Integration	$6,665,538	$601,231	$3,633,385	50.00%	$10,900,154
2.1.4	. . . . . Procurement	$20,380,883	$3,911,891	$12,146,387	50.00%	$36,439,161
2.1.4.1	. . . . . Civil Modifications	$7,307,126	$1,758,643	$4,532,885	50.00%	$13,598,654
2.1.4.1.1	*. . . . . Transfer Cask*	*$181,125*	*$29,831*	*$105,478*	*50.00%*	*$316,434*
2.1.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.1.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.1.4.1.4	*. . . . . Specimen Transfer Device*	*$8,569*	*$1,411*	*$4,990*	*50.00%*	*$14,971*
2.1.4.1.5	*. . . . . Examination Equipment*	*$5,285,530*	*$1,282,798*	*$3,284,164*	*50.00%*	*$9,852,492*
2.1.4.2	. . . . . Mechanical Modifications	$13,073,757	$2,153,248	$7,613,502	50.00%	$22,840,507
2.1.4.2.1	*. . . . . Shielded Confinement Box*	*$562,850*	*$92,701*	*$327,775*	*50.00%*	*$983,326*
2.1.4.2.2	*. . . . . Inert Confinement Enclosure*	*$2,427,075*	*$399,739*	*$1,413,407*	*50.00%*	*$4,240,221*
2.1.4.2.3	*. . . . . Modular Shielded Enclosures*	*$10,083,833*	*$1,660,807*	*$5,872,320*	*50.00%*	*$17,616,960*
2.1.5	. . . . . Construction	$8,599,715	$2,176,328	$5,388,022	50.00%	$16,164,065
2.1.5.1	. . . . . Civil Modifications	$6,560,040	$1,840,394	$4,200,217	50.00%	$12,600,650
2.1.5.1.1	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.1.5.1.2	*. . . . . Acoustical Isolation*	*$77,877*	*$15,832*	*$46,855*	*50.00%*	*$140,564*
2.1.5.1.3	*. . . . . EMI/RFI Protection Installation*	*$114,081*	*$23,193*	*$68,637*	*50.00%*	*$205,911*
2.1.5.1.4	*. . . . . Metal Stud Wall and Suspended Ceiling Modifications*	*$16,719*	*$3,399*	*$10,059*	*50.00%*	*$30,176*
2.1.5.1.5	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.1.5.1.6	*. . . . . Examination Equipment*	*$2,165,014*	*$613,349*	*$1,389,181*	*50.00%*	*$4,167,544*

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.1.5.2	. . . . . Mechanical Modifications	$2,039,675	$335,934	$1,187,805	50.00%	$3,563,414
2.1.5.2.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$571,794*	*$94,174*	*$332,984*	*50.00%*	*$998,953*
2.1.5.2.2	*. . . . . Modular Shielded Enclosure Utility Tie-ins*	*$187,837*	*$30,937*	*$109,387*	*50.00%*	*$328,161*
2.1.5.2.3	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$24,139*	*$85,353*	*50.00%*	*$256,059*
2.1.5.2.4	*. . . . . Inert Gas Purification System*	*$132,825*	*$21,876*	*$77,351*	*50.00%*	*$232,052*
2.1.5.2.5	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$252,757*	*$41,629*	*$147,193*	*50.00%*	*$441,580*
2.1.5.2.6	*. . . . . Temperature Control*	*$41,173*	*$6,781*	*$23,977*	*50.00%*	*$71,932*
2.1.5.2.7	*. . . . . Shielded Confinement Box Installation*	*$13,563*	*$2,234*	*$7,898*	*50.00%*	*$23,695*
2.1.5.2.8	*. . . . . Inert Confinement Enclosure Installation*	*$276,696*	*$45,572*	*$161,134*	*50.00%*	*$483,402*
2.1.5.2.9	*. . . . . Modular Shielded Enclosure Installation*	*$416,463*	*$68,592*	*$242,527*	*50.00%*	*$727,582*
2.1.6	**. . . . . Construction Management**	**$2,028,642**	**$334,117**	**$1,181,380**	**50.00%**	**$3,544,139**
2.1.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.1.8	**. . . . . General and Administrative Costs**	**$1,245,869**	**$253,285**	**$749,577**	**50.00%**	**$2,248,731**
2.2	**. . . . Oakridge National Laboratory**	**$85,175,725**	**$15,875,237**	**$50,525,481**	**50.00%**	**$151,576,443**
2.2.1	**. . . . . Project Management**	**$8,745,633**	**$1,113,319**	**$4,929,476**	**50.00%**	**$14,788,428**
2.2.2	**. . . . . Engineering and Design Development**	**$10,932,041**	**$1,391,649**	**$6,161,845**	**50.00%**	**$18,485,535**
2.2.3	**. . . . . Project Integration and DOE 413 Deliverables Integration**	**$10,057,478**	**$907,185**	**$5,482,331**	**50.00%**	**$16,446,994**
2.2.4	**. . . . . Procurement**	**$20,332,384**	**$4,713,806**	**$12,523,095**	**50.00%**	**$37,569,285**
2.2.4.1	. . . . . Civil Modifications	$17,500,797	$4,247,443	$10,874,120	50.00%	$32,622,360
2.2.4.1.1	*. . . . . Manipulators*	*$3,071,880*	*$745,545*	*$1,908,713*	*50.00%*	*$5,726,138*
2.2.4.1.2	*. . . . . Sample Preparation & Rough Sizing Equipment*	*$831,902*	*$201,903*	*$516,902*	*50.00%*	*$1,550,707*
2.2.4.1.3	*. . . . . Waste Processing Equipment*	*$1,000,000*	*$242,700*	*$621,350*	*50.00%*	*$1,864,050*
2.2.4.1.4	*. . . . . Shielded Windows*	*$6,194,475*	*$1,503,399*	*$3,848,937*	*50.00%*	*$11,546,811*
2.2.4.1.5	*. . . . . Examination Equipment*	*$6,402,540*	*$1,553,896*	*$3,978,218*	*50.00%*	*$11,934,655*
2.2.4.2	. . . . . Mechanical Modifications	$2,831,588	$466,362	$1,648,975	50.00%	$4,946,925

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.4.2.1	*. . . . . Inert Confinement Enclosure*	*$2,831,588*	*$466,362*	*$1,648,975*	*50.00%*	*$4,946,925*
2.2.5	**. . . . . Construction**	**$23,395,781**	**$5,348,794**	**$14,372,288**	**50.00%**	**$43,116,863**
2.2.5.1	. . . . . Civil Modifications	$17,118,888	$4,072,701	$10,595,794	50.00%	$31,787,383
2.2.5.1.1	*. . . . . New Internal Material Transfer Device*	*$329,853*	*$93,447*	*$211,650*	*50.00%*	*$634,950*
2.2.5.1.2	*. . . . . Manipulator Installation*	*$44,436*	*$12,589*	*$28,512*	*50.00%*	*$85,537*
2.2.5.1.3	*. . . . . Sample Preparation & Rough Sizing Equipment Installation*	*$4,169,210*	*$1,181,137*	*$2,675,174*	*50.00%*	*$8,025,521*
2.2.5.1.4	*. . . . . Vibration Isolation*	*$420,577*	*$85,503*	*$253,040*	*50.00%*	*$759,120*
2.2.5.1.5	*. . . . . Acoustical Isolation*	*$233,631*	*$47,497*	*$140,564*	*50.00%*	*$421,692*
2.2.5.1.6	*. . . . . EMI/RFI Protection Installation*	*$283,020*	*$57,538*	*$170,279*	*50.00%*	*$510,836*
2.2.5.1.7	*. . . . . Transport Loading*	*$120,750*	*$24,548*	*$72,649*	*50.00%*	*$217,948*
2.2.5.1.8	*. . . . . Specimen Storage Racks*	*$17,138*	*$3,484*	*$10,311*	*50.00%*	*$30,934*
2.2.5.1.9	*. . . . . Steel Shielding Walls*	*$5,813,890*	*$1,181,964*	*$3,497,927*	*50.00%*	*$10,493,781*
2.2.5.1.9.1	*. . . . . 12" Thick Steel Shielding Walls*	*$5,751,416*	*$1,169,263*	*$3,460,339*	*50.00%*	*$10,381,018*
2.2.5.1.9.2	*. . . . . Concrete and Steel False Floor*	*$62,474*	*$12,701*	*$37,587*	*50.00%*	*$112,762*
2.2.5.1.10	*. . . . . Shielded Windows Installation*	*$86,940*	*$17,675*	*$52,307*	*50.00%*	*$156,922*
2.2.5.1.11	*. . . . . Shielded Wall Plug*	*$271,688*	*$55,234*	*$163,461*	*50.00%*	*$490,382*
2.2.5.1.12	*. . . . . Access Ports*	*$824,119*	*$167,543*	*$495,831*	*50.00%*	*$1,487,493*
2.2.5.1.13	*. . . . . Install Access Door*	*$1,496,843*	*$304,308*	*$900,576*	*50.00%*	*$2,701,727*
2.2.5.1.13.1	*. . . . . Contractor Support*	*$302,811*	*$61,561*	*$182,186*	*50.00%*	*$546,558*
2.2.5.1.13.2	*. . . . . Subcontractor Access Door Installation*	*$1,194,033*	*$242,747*	*$718,390*	*50.00%*	*$2,155,169*
2.2.5.1.14	*. . . . . Instrument Penetrations*	*$144,900*	*$29,458*	*$87,179*	*50.00%*	*$261,537*
2.2.5.1.15	*. . . . . Examination Equipment*	*$2,861,894*	*$810,775*	*$1,836,334*	*50.00%*	*$5,509,003*
2.2.5.2	. . . . . Mechanical Modifications	$6,232,392	$1,267,045	$3,749,719	50.00%	$11,249,156
2.2.5.2.1	*. . . . . Miscellaneous Facility Modifications in Non-Shielded Area*	*$285,897*	*$58,123*	*$172,010*	*50.00%*	*$516,030*
2.2.5.2.2	*. . . . . Inert Gas Infrastructure*	*$146,566*	*$29,797*	*$88,182*	*50.00%*	*$264,545*
2.2.5.2.3	*. . . . . Inert Gas Purification System*	*$132,825*	*$27,003*	*$79,914*	*50.00%*	*$239,742*

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.5.2.4	*. . . . . Secondary Ventilation System Modifications*	*$5,000,000*	*$1,016,500*	*$3,008,250*	*50.00%*	*$9,024,750*
2.2.5.2.5	*. . . . . Tie Inert Confinement Boxes into Facility Exhaust*	*$294,883*	*$59,950*	*$177,417*	*50.00%*	*$532,250*
2.2.5.2.6	*. . . . . Temperature Control*	*$49,408*	*$10,045*	*$29,726*	*50.00%*	*$89,179*
2.2.5.2.7	*. . . . . Inert Confinement Enclosure Installation*	*$322,812*	*$65,628*	*$194,220*	*50.00%*	*$582,660*
2.2.5.3	. . . . . Fire Protection Modifications	$44,502	$9,047	$26,774	50.00%	$80,323
2.2.5.3.1	*. . . . . Fire Alarm System Upgrade*	*$23,287*	*$4,734*	*$14,011*	*50.00%*	*$42,033*
2.2.5.3.2	*. . . . . Fire Protection System Upgrade*	*$21,214*	*$4,313*	*$12,764*	*50.00%*	*$38,291*
2.2.6	**. . . . . Construction Management**	**$3,060,972**	**$504,142**	**$1,782,557**	**50.00%**	**$5,347,670**
2.2.7	**. . . . . Operational Readiness**	**$3,490,000**	**$847,023**	**$2,168,512**	**50.00%**	**$6,505,535**
2.2.8	**. . . . . General and Administrative Costs**	**$1,663,182**	**$338,125**	**$1,000,654**	**50.00%**	**$3,001,961**
2.2.9	**. . . . . Location Factor Adjustment**	**$3,498,253**	**$711,195**	**$2,104,724**	**50.00%**	**$6,314,172**
3	**Facility Operations and Maintenance**	**$436,317,443**	**$715,165,163**	**$575,741,303**	**50.00%**	**$1,727,223,909**
3.1	**. . . . Year 1**	**$9,387,590**	**$3,052,844**	**$6,220,217**	**50.00%**	**$18,660,651**
3.1.1	**. . . . . Facility Maintenance**	**$2,440,984**	**$793,808**	**$1,617,396**	**50.00%**	**$4,852,188**
3.1.2	**. . . . . Facility Operations**	**$6,125,121**	**$1,991,889**	**$4,058,505**	**50.00%**	**$12,175,516**
3.1.3	**. . . . . Electrical Power Usage**	**$821,485**	**$267,147**	**$544,316**	**50.00%**	**$1,632,948**
3.2	**. . . . Year 2**	**$9,387,590**	**$3,459,327**	**$6,423,458**	**50.00%**	**$19,270,375**
3.2.1	**. . . . . Facility Maintenance**	**$2,440,984**	**$899,503**	**$1,670,243**	**50.00%**	**$5,010,730**
3.2.2	**. . . . . Facility Operations**	**$6,125,121**	**$2,257,107**	**$4,191,114**	**50.00%**	**$12,573,342**
3.2.3	**. . . . . Electrical Power Usage**	**$821,485**	**$302,717**	**$562,101**	**50.00%**	**$1,686,303**
3.3	**. . . . Year 3**	**$11,871,926**	**$4,905,480**	**$8,388,703**	**50.00%**	**$25,166,109**
3.3.1	**. . . . . Facility Maintenance**	**$2,440,984**	**$1,008,615**	**$1,724,799**	**50.00%**	**$5,174,398**
3.3.2	**. . . . . Facility Operations**	**$6,125,121**	**$2,530,900**	**$4,328,010**	**50.00%**	**$12,984,031**
3.3.3	**. . . . . Facility Refurbishment**	**$2,484,336**	**$1,026,528**	**$1,755,432**	**50.00%**	**$5,266,295**
3.3.3	**. . . . . Electrical Power Usage**	**$821,485**	**$339,438**	**$580,461**	**50.00%**	**$1,741,384**
3.4	**. . . . Year 4**	**$9,387,590**	**$4,311,720**	**$6,849,655**	**50.00%**	**$20,548,965**

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.4.1	. . . . . Facility Maintenance	$2,440,984	$1,121,144	$1,781,064	50.00%	$5,343,192
3.4.2	. . . . . Facility Operations	$6,125,121	$2,813,268	$4,469,195	50.00%	$13,407,584
3.4.3	. . . . . Electrical Power Usage	$821,485	$377,308	$599,397	50.00%	$1,798,190
3.5	. . . . Year 5	$9,387,590	$4,759,508	$7,073,549	50.00%	$21,220,647
3.5.1	. . . . . Facility Maintenance	$2,440,984	$1,237,579	$1,839,281	50.00%	$5,517,844
3.5.2	. . . . . Facility Operations	$6,125,121	$3,105,436	$4,615,279	50.00%	$13,845,836
3.5.3	. . . . . Electrical Power Usage	$821,485	$416,493	$618,989	50.00%	$1,856,967
3.6	. . . . Year 6	$9,387,590	$5,221,378	$7,304,484	50.00%	$21,913,451
3.6.1	. . . . . Facility Maintenance	$2,440,984	$1,357,675	$1,899,330	50.00%	$5,697,989
3.6.2	. . . . . Facility Operations	$6,125,121	$3,406,792	$4,765,957	50.00%	$14,297,870
3.6.3	. . . . . Electrical Power Usage	$821,485	$456,910	$639,197	50.00%	$1,917,592
3.7	. . . . Year 7	$9,387,590	$5,699,206	$7,543,398	50.00%	$22,630,194
3.7.1	. . . . . Facility Maintenance	$2,440,984	$1,481,921	$1,961,453	50.00%	$5,884,358
3.7.2	. . . . . Facility Operations	$6,125,121	$3,718,561	$4,921,841	50.00%	$14,765,523
3.7.3	. . . . . Electrical Power Usage	$821,485	$498,724	$660,104	50.00%	$1,980,313
3.8	. . . . Year 8	$9,387,590	$6,192,054	$7,789,822	50.00%	$23,369,467
3.8.1	. . . . . Facility Maintenance	$2,440,984	$1,610,073	$2,025,529	50.00%	$6,076,586
3.8.2	. . . . . Facility Operations	$6,125,121	$4,040,130	$5,082,625	50.00%	$15,247,876
3.8.3	. . . . . Electrical Power Usage	$821,485	$541,852	$681,668	50.00%	$2,045,005
3.9	. . . . Year 9	$9,387,590	$6,700,862	$8,044,226	50.00%	$24,132,678
3.9.1	. . . . . Facility Maintenance	$2,440,984	$1,742,374	$2,091,679	50.00%	$6,275,038
3.9.2	. . . . . Facility Operations	$6,125,121	$4,372,111	$5,248,616	50.00%	$15,745,849
3.9.3	. . . . . Electrical Power Usage	$821,485	$586,376	$703,930	50.00%	$2,111,791
3.10	. . . . Year 10	$27,126,686	$20,882,123	$24,004,404	50.00%	$72,013,213
3.10.1	. . . . . Facility Maintenance	$2,440,984	$1,879,069	$2,160,027	50.00%	$6,480,080
3.10.2	. . . . . Facility Operations	$6,125,121	$4,715,118	$5,420,120	50.00%	$16,260,359

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.10.4	. . . . . Electrical Power Usage	$821,485	$632,379	$726,932	50.00%	$2,180,796
3.11	. . . . Year 11	$9,387,590	$7,769,169	$8,578,380	50.00%	$25,735,139
3.11.1	. . . . . Facility Maintenance	$2,440,984	$2,020,158	$2,230,571	50.00%	$6,691,714
3.11.2	. . . . . Facility Operations	$6,125,121	$5,069,150	$5,597,136	50.00%	$16,791,407
3.11.3	. . . . . Electrical Power Usage	$821,485	$679,861	$750,673	50.00%	$2,252,019
3.12	. . . . Year 12	$9,387,590	$8,329,609	$8,858,599	50.00%	$26,575,798
3.12.1	. . . . . Facility Maintenance	$2,440,984	$2,165,885	$2,303,435	50.00%	$6,910,304
3.12.2	. . . . . Facility Operations	$6,125,121	$5,434,820	$5,779,970	50.00%	$17,339,911
3.12.3	. . . . . Electrical Power Usage	$821,485	$728,904	$775,194	50.00%	$2,325,583
3.13	. . . . Year 13	$9,387,590	$8,907,884	$9,147,737	50.00%	$27,443,211
3.13.1	. . . . . Facility Maintenance	$2,440,984	$2,316,250	$2,378,617	50.00%	$7,135,851
3.13.2	. . . . . Facility Operations	$6,125,121	$5,812,127	$5,968,624	50.00%	$17,905,872
3.13.3	. . . . . Electrical Power Usage	$821,485	$779,507	$800,496	50.00%	$2,401,488
3.14	. . . . Year 14	$9,387,590	$9,505,874	$9,446,732	50.00%	$28,340,195
3.14.1	. . . . . Facility Maintenance	$2,440,984	$2,471,740	$2,456,362	50.00%	$7,369,087
3.14.2	. . . . . Facility Operations	$6,125,121	$6,202,298	$6,163,709	50.00%	$18,491,128
3.14.3	. . . . . Electrical Power Usage	$821,485	$831,836	$826,660	50.00%	$2,479,981
3.15	. . . . Year 15	$9,387,590	$10,760,056	$10,073,823	50.00%	$30,221,468
3.15.1	. . . . . Facility Maintenance	$2,440,984	$2,797,856	$2,619,420	50.00%	$7,858,260
3.15.2	. . . . . Facility Operations	$6,125,121	$7,020,614	$6,572,867	50.00%	$19,718,602
3.15.3	. . . . . Electrical Power Usage	$821,485	$941,586	$881,536	50.00%	$2,644,607
3.16	. . . . Year 16	$9,387,590	$10,760,056	$10,073,823	50.00%	$30,221,468
3.16.1	. . . . . Facility Maintenance	$2,440,984	$2,797,856	$2,619,420	50.00%	$7,858,260
3.16.2	. . . . . Facility Operations	$6,125,121	$7,020,614	$6,572,867	50.00%	$19,718,602
3.16.3	. . . . . Electrical Power Usage	$821,485	$941,586	$881,536	50.00%	$2,644,607

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.17	. . . . Year 17	$9,387,590	$11,418,126	$10,402,858	50.00%	$31,208,574
3.17.1	. . . . . Facility Maintenance	$2,440,984	$2,968,969	$2,704,976	50.00%	$8,114,929
3.17.2	. . . . . Facility Operations	$6,125,121	$7,449,985	$6,787,553	50.00%	$20,362,659
3.17.3	. . . . . Electrical Power Usage	$821,485	$999,172	$910,329	50.00%	$2,730,986
3.18	. . . . Year 18	$9,387,590	$12,097,787	$10,742,689	50.00%	$32,228,066
3.18.1	. . . . . Facility Maintenance	$2,440,984	$3,145,696	$2,793,340	50.00%	$8,380,020
3.18.2	. . . . . Facility Operations	$6,125,121	$7,893,443	$7,009,282	50.00%	$21,027,847
3.18.3	. . . . . Electrical Power Usage	$821,485	$1,058,648	$940,066	50.00%	$2,820,199
3.19	. . . . Year 19	$9,387,590	$12,799,979	$11,093,784	50.00%	$33,281,353
3.19.1	. . . . . Facility Maintenance	$2,440,984	$3,328,282	$2,884,633	50.00%	$8,653,899
3.19.2	. . . . . Facility Operations	$6,125,121	$8,351,602	$7,238,362	50.00%	$21,715,085
3.19.3	. . . . . Electrical Power Usage	$821,485	$1,120,095	$970,790	50.00%	$2,912,370
3.20	. . . . Year 20	$27,126,686	$39,081,416	$33,104,051	50.00%	$99,312,154
3.20.1	. . . . . Facility Maintenance	$2,440,984	$3,516,726	$2,978,855	50.00%	$8,936,564
3.20.2	. . . . . Facility Operations	$6,125,121	$8,824,462	$7,474,791	50.00%	$22,424,374
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.20.4	. . . . . Electrical Power Usage	$821,485	$1,183,513	$1,002,499	50.00%	$3,007,498
3.21	. . . . Year 21	$9,359,660	$14,230,427	$11,795,044	50.00%	$35,385,131
3.21.1	. . . . . Facility Maintenance	$2,440,984	$3,711,272	$3,076,128	50.00%	$9,228,384
3.21.2	. . . . . Facility Operations	$6,125,121	$9,312,634	$7,718,877	50.00%	$23,156,632
3.21.3	. . . . . Electrical Power Usage	$793,555	$1,206,521	$1,000,038	50.00%	$3,000,114
3.22	. . . . Year 22	$9,387,590	$15,046,429	$12,217,010	50.00%	$36,651,029
3.22.1	. . . . . Facility Maintenance	$2,440,984	$3,912,409	$3,176,697	50.00%	$9,530,090
3.22.2	. . . . . Facility Operations	$6,125,121	$9,817,344	$7,971,232	50.00%	$23,913,697
3.22.3	. . . . . Electrical Power Usage	$821,485	$1,316,676	$1,069,081	50.00%	$3,207,242
3.23	. . . . Year 23	$11,871,926	$20,037,437	$15,954,681	50.00%	$47,864,044

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.23.1	. . . . . Facility Maintenance	$2,440,984	$4,119,893	$3,280,438	50.00%	$9,841,315
3.23.2	. . . . . Facility Operations	$6,125,121	$10,337,979	$8,231,550	50.00%	$24,694,650
3.23.3	. . . . . Facility Refurbishment	$2,484,336	$4,193,062	$3,338,699	50.00%	$10,016,097
3.23.4	. . . . . Electrical Power Usage	$821,485	$1,386,502	$1,103,994	50.00%	$3,311,981
3.24	**. . . . Year 24**	**$9,387,590**	**$16,668,605**	**$13,028,097**	**50.00%**	**$39,084,292**
3.24.1	. . . . . Facility Maintenance	$2,440,984	$4,334,211	$3,387,598	50.00%	$10,162,793
3.24.2	. . . . . Facility Operations	$6,125,121	$10,875,765	$8,500,443	50.00%	$25,501,329
3.24.3	. . . . . Electrical Power Usage	$821,485	$1,458,629	$1,140,057	50.00%	$3,420,171
3.25	**. . . . Year 25**	**$9,387,590**	**$17,520,059**	**$13,453,825**	**50.00%**	**$40,361,474**
3.25.1	. . . . . Facility Maintenance	$2,440,984	$4,555,608	$3,498,296	50.00%	$10,494,889
3.25.2	. . . . . Facility Operations	$6,125,121	$11,431,313	$8,778,217	50.00%	$26,334,651
3.25.3	. . . . . Electrical Power Usage	$821,485	$1,533,137	$1,177,311	50.00%	$3,531,934
3.26	**. . . . Year 26**	**$9,387,590**	**$18,398,738**	**$13,893,164**	**50.00%**	**$41,679,491**
3.26.1	. . . . . Facility Maintenance	$2,440,984	$4,784,085	$3,612,534	50.00%	$10,837,603
3.26.2	. . . . . Facility Operations	$6,125,121	$12,004,625	$9,064,873	50.00%	$27,194,618
3.26.3	. . . . . Electrical Power Usage	$821,485	$1,610,028	$1,215,757	50.00%	$3,647,270
3.27	**. . . . Year 27**	**$9,387,590**	**$19,306,518**	**$14,347,054**	**50.00%**	**$43,041,161**
3.27.1	. . . . . Facility Maintenance	$2,440,984	$5,020,128	$3,730,556	50.00%	$11,191,668
3.27.2	. . . . . Facility Operations	$6,125,121	$12,596,924	$9,361,022	50.00%	$28,083,067
3.27.3	. . . . . Electrical Power Usage	$821,485	$1,689,466	$1,255,476	50.00%	$3,766,427
3.28	**. . . . Year 28**	**$9,387,590**	**$20,243,399**	**$14,815,495**	**50.00%**	**$44,446,484**
3.28.1	. . . . . Facility Maintenance	$2,440,984	$5,263,738	$3,852,361	50.00%	$11,557,083
3.28.2	. . . . . Facility Operations	$6,125,121	$13,208,211	$9,666,666	50.00%	$28,999,998
3.28.3	. . . . . Electrical Power Usage	$821,485	$1,771,450	$1,296,468	50.00%	$3,889,403
3.29	**. . . . Year 29**	**$9,387,590**	**$21,211,260**	**$15,299,425**	**50.00%**	**$45,898,274**
3.29.1	. . . . . Facility Maintenance	$2,440,984	$5,515,403	$3,978,194	50.00%	$11,934,581

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.29.2	. . . . . Facility Operations	$6,125,121	$13,839,711	$9,982,416	50.00%	$29,947,248
3.29.3	. . . . . Electrical Power Usage	$821,485	$1,856,145	$1,338,815	50.00%	$4,016,446
3.30	**. . . . Year 30**	**$27,126,686**	**$64,181,739**	**$45,654,213**	**50.00%**	**$136,962,638**
3.30.1	. . . . . Facility Maintenance	$2,440,984	$5,775,368	$4,108,176	50.00%	$12,324,528
3.30.2	. . . . . Facility Operations	$6,125,121	$14,492,036	$10,308,579	50.00%	$30,925,736
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.30.4	. . . . . Electrical Power Usage	$821,485	$1,943,634	$1,382,559	50.00%	$4,147,678
3.31	**. . . . Year 31**	**$9,387,590**	**$23,243,673**	**$16,315,631**	**50.00%**	**$48,946,894**
3.31.1	. . . . . Facility Maintenance	$2,440,984	$6,043,876	$4,242,430	50.00%	$12,727,291
3.31.2	. . . . . Facility Operations	$6,125,121	$15,165,800	$10,645,460	50.00%	$31,936,381
3.31.3	. . . . . Electrical Power Usage	$821,485	$2,033,997	$1,427,741	50.00%	$4,283,223
3.32	**. . . . Year 32**	**$12,043,403**	**$31,186,392**	**$21,614,898**	**50.00%**	**$64,844,693**
3.32.1	. . . . . Facility Maintenance	$2,440,984	$6,320,928	$4,380,956	50.00%	$13,142,868
3.32.2	. . . . . Facility Operations	$6,125,121	$15,861,001	$10,993,061	50.00%	$32,979,183
3.32.3	. . . . . Facility Refurbishment	$2,655,813	$6,877,228	$4,766,520	50.00%	$14,299,561
3.32.4	. . . . . Electrical Power Usage	$821,485	$2,127,235	$1,474,360	50.00%	$4,423,081
3.33	**. . . . Year 33**	**$9,387,590**	**$25,410,329**	**$17,398,959**	**50.00%**	**$52,196,878**
3.33.1	. . . . . Facility Maintenance	$2,440,984	$6,607,255	$4,524,120	50.00%	$13,572,359
3.33.2	. . . . . Facility Operations	$6,125,121	$16,579,478	$11,352,299	50.00%	$34,056,898
3.33.3	. . . . . Electrical Power Usage	$821,485	$2,223,596	$1,522,540	50.00%	$4,567,621
3.34	**. . . . Year 34**	**$9,387,590**	**$26,547,166**	**$17,967,378**	**50.00%**	**$53,902,134**
3.34.1	. . . . . Facility Maintenance	$2,440,984	$6,902,859	$4,671,921	50.00%	$14,015,764
3.34.2	. . . . . Facility Operations	$6,125,121	$17,321,230	$11,723,175	50.00%	$35,169,526
3.34.3	. . . . . Electrical Power Usage	$821,485	$2,323,077	$1,572,281	50.00%	$4,716,844
3.35	**. . . . Year 35**	**$9,387,590**	**$27,720,615**	**$18,554,102**	**50.00%**	**$55,662,307**
3.35.1	. . . . . Facility Maintenance	$2,440,984	$7,207,982	$4,824,483	50.00%	$14,473,448

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.35.2	. . . . . Facility Operations	$6,125,121	$18,086,870	$12,105,995	50.00%	$36,317,986
3.35.3	. . . . . Electrical Power Usage	$821,485	$2,425,763	$1,623,624	50.00%	$4,870,872
3.36	. . . . Year 36	$9,387,590	$28,932,552	$19,160,071	50.00%	$57,480,214
3.36.1	. . . . . Facility Maintenance	$2,440,984	$7,523,113	$4,982,048	50.00%	$14,946,145
3.36.2	. . . . . Facility Operations	$6,125,121	$18,877,623	$12,501,372	50.00%	$37,504,116
3.36.3	. . . . . Electrical Power Usage	$821,485	$2,531,817	$1,676,651	50.00%	$5,029,953
3.37	. . . . Year 37	$9,387,590	$30,184,857	$19,786,223	50.00%	$59,358,670
3.37.1	. . . . . Facility Maintenance	$2,440,984	$7,848,740	$5,144,862	50.00%	$15,434,586
3.37.2	. . . . . Facility Operations	$6,125,121	$19,694,714	$12,909,918	50.00%	$38,729,753
3.37.3	. . . . . Electrical Power Usage	$821,485	$2,641,403	$1,731,444	50.00%	$5,194,332
3.38	. . . . Year 38	$9,387,590	$31,477,528	$20,432,559	50.00%	$61,297,677
3.38.1	. . . . . Facility Maintenance	$2,440,984	$8,184,863	$5,312,924	50.00%	$15,938,771
3.38.2	. . . . . Facility Operations	$6,125,121	$20,538,143	$13,331,632	50.00%	$39,994,896
3.38.3	. . . . . Electrical Power Usage	$821,485	$2,754,521	$1,788,003	50.00%	$5,364,010
3.39	. . . . Year 39	$9,387,590	$32,812,443	$21,100,017	50.00%	$63,300,050
3.39.1	. . . . . Facility Maintenance	$2,440,984	$8,531,971	$5,486,478	50.00%	$16,459,433
3.39.2	. . . . . Facility Operations	$6,125,121	$21,409,135	$13,767,128	50.00%	$41,301,385
3.39.3	. . . . . Electrical Power Usage	$821,485	$2,871,337	$1,846,411	50.00%	$5,539,232
3.40	. . . . Year 40	$9,387,590	$34,190,542	$21,789,066	50.00%	$65,367,197
3.41.1	. . . . . Facility Maintenance	$2,440,984	$8,890,308	$5,665,646	50.00%	$16,996,938
3.40.2	. . . . . Facility Operations	$6,125,121	$22,308,303	$14,216,712	50.00%	$42,650,136
3.40.3	. . . . . Electrical Power Usage	$821,485	$2,991,931	$1,906,708	50.00%	$5,720,123
4	Post Irradiation Examination	$193,893,120	$321,135,480	$257,514,300	50.00%	$772,542,900
4.1	. . . . Year 1	$4,847,328	$1,576,351	$3,211,840	50.00%	$9,635,519
4.2	. . . . Year 2	$4,847,328	$1,786,240	$3,316,784	50.00%	$9,950,353

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.3	. . . . Year 3	$4,847,328	$2,002,916	$3,425,122	50.00%	$10,275,366
4.4	. . . . Year 4	$4,847,328	$2,226,378	$3,536,853	50.00%	$10,610,559
4.5	. . . . Year 5	$4,847,328	$2,457,595	$3,652,462	50.00%	$10,957,385
4.6	. . . . Year 6	$4,847,328	$2,696,084	$3,771,706	50.00%	$11,315,118
4.7	. . . . Year 7	$4,847,328	$2,942,813	$3,895,070	50.00%	$11,685,211
4.8	. . . . Year 8	$4,847,328	$3,197,298	$4,022,313	50.00%	$12,066,938
4.9	. . . . Year 9	$4,847,328	$3,460,023	$4,153,675	50.00%	$12,461,026
4.10	. . . . Year 10	$4,847,328	$3,731,473	$4,289,401	50.00%	$12,868,202
4.11	. . . . Year 11	$4,847,328	$4,011,649	$4,429,488	50.00%	$13,288,465
4.12	. . . . Year 12	$4,847,328	$4,301,034	$4,574,181	50.00%	$13,722,543
4.13	. . . . Year 13	$4,847,328	$4,599,630	$4,723,479	50.00%	$14,170,436
4.14	. . . . Year 14	$4,847,328	$4,908,404	$4,877,866	50.00%	$14,633,598
1.15	. . . . Year 15	$4,847,328	$5,556,007	$5,201,668	50.00%	$15,605,003
4.16	. . . . Year 16	$4,847,328	$5,556,007	$5,201,668	50.00%	$15,605,003
4.17	. . . . Year 17	$4,847,328	$5,895,805	$5,371,567	50.00%	$16,114,700
4.18	. . . . Year 18	$4,847,328	$6,246,752	$5,547,040	50.00%	$16,641,119
4.19	. . . . Year 19	$4,847,328	$6,609,332	$5,728,330	50.00%	$17,184,990
4.20	. . . . Year 20	$4,847,328	$6,983,545	$5,915,437	50.00%	$17,746,310
4.21	. . . . Year 21	$4,847,328	$7,369,877	$6,108,603	50.00%	$18,325,808
4.22	. . . . Year 22	$4,847,328	$7,769,297	$6,308,313	50.00%	$18,924,938
4.23	. . . . Year 23	$4,847,328	$8,181,320	$6,514,324	50.00%	$19,542,972
4.24	. . . . Year 24	$4,847,328	$8,606,916	$6,727,122	50.00%	$20,181,365
4.25	. . . . Year 25	$4,847,328	$9,046,568	$6,946,948	50.00%	$20,840,844
4.26	. . . . Year 26	$4,847,328	$9,500,278	$7,173,803	50.00%	$21,521,409

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.27	. . . . Year 27	$4,847,328	$9,969,015	$7,408,171	50.00%	$22,224,514
4.28	. . . . Year 28	$4,847,328	$10,452,778	$7,650,053	50.00%	$22,950,159
4.29	. . . . Year 29	$4,847,328	$10,952,538	$7,899,933	50.00%	$23,699,798
4.30	. . . . Year 30	$4,847,328	$11,468,778	$8,158,053	50.00%	$24,474,159
4.31	. . . . Year 31	$4,847,328	$12,001,984	$8,424,656	50.00%	$25,273,968
4.32	. . . . Year 32	$4,847,328	$12,552,156	$8,699,742	50.00%	$26,099,226
4.33	. . . . Year 33	$4,847,328	$13,120,747	$8,984,038	50.00%	$26,952,113
4.34	. . . . Year 34	$4,847,328	$13,707,759	$9,277,543	50.00%	$27,832,630
4.35	. . . . Year 35	$4,847,328	$14,313,675	$9,580,501	50.00%	$28,741,504
4.36	. . . . Year 36	$4,847,328	$14,939,465	$9,893,396	50.00%	$29,680,189
4.37	. . . . Year 37	$4,847,328	$15,586,098	$10,216,713	50.00%	$30,650,140
4.38	. . . . Year 38	$4,847,328	$16,253,576	$10,550,452	50.00%	$31,651,355
4.39	. . . . Year 39	$4,847,328	$16,942,866	$10,895,097	50.00%	$32,685,290
4.40	. . . . Year 40	$4,847,328	$17,654,453	$11,250,891	50.00%	$33,752,672
5	Transportation	$671,934,000	$1,112,890,688	$892,412,344	50.00%	$2,677,237,031
5.1	. . . . Year 1	$16,798,350	$5,462,823	$11,130,587	50.00%	$33,391,760
5.2	. . . . Year 2	$16,798,350	$6,190,192	$11,494,271	50.00%	$34,482,813
5.3	. . . . Year 3	$16,798,350	$6,941,078	$11,869,714	50.00%	$35,609,142
5.4	. . . . Year 4	$16,798,350	$7,715,482	$12,256,916	50.00%	$36,770,748
5.5	. . . . Year 5	$16,798,350	$8,516,763	$12,657,557	50.00%	$37,972,670
5.6	. . . . Year 6	$16,798,350	$9,343,242	$13,070,796	50.00%	$39,212,388
5.7	. . . . Year 7	$16,798,350	$10,198,278	$13,498,314	50.00%	$40,494,942
5.8	. . . . Year 8	$16,798,350	$11,080,192	$13,939,271	50.00%	$41,817,812
5.9	. . . . Year 9	$16,798,350	$11,990,662	$14,394,506	50.00%	$43,183,518

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.10	. . . . Year 10	$16,798,350	$12,931,370	$14,864,860	50.00%	$44,594,580
5.11	. . . . Year 11	$16,798,350	$13,902,314	$15,350,332	50.00%	$46,050,997
5.12	. . . . Year 12	$16,798,350	$14,905,176	$15,851,763	50.00%	$47,555,289
5.13	. . . . Year 13	$16,798,350	$15,939,954	$16,369,152	50.00%	$49,107,456
5.14	. . . . Year 14	$16,798,350	$17,010,009	$16,904,180	50.00%	$50,712,539
5.15	. . . . Year 15	$16,798,350	$19,254,269	$18,026,309	50.00%	$54,078,928
5.16	. . . . Year 16	$16,798,350	$19,254,269	$18,026,309	50.00%	$54,078,928
5.17	. . . . Year 17	$16,798,350	$20,431,833	$18,615,092	50.00%	$55,845,275
5.18	. . . . Year 18	$16,798,350	$21,648,034	$19,223,192	50.00%	$57,669,575
5.19	. . . . Year 19	$16,798,350	$22,904,550	$19,851,450	50.00%	$59,554,350
5.20	. . . . Year 20	$16,798,350	$24,201,383	$20,499,866	50.00%	$61,499,599
5.21	. . . . Year 21	$16,798,350	$25,540,211	$21,169,281	50.00%	$63,507,842
5.22	. . . . Year 22	$16,798,350	$26,924,395	$21,861,373	50.00%	$65,584,118
5.23	. . . . Year 23	$16,798,350	$28,352,255	$22,575,303	50.00%	$67,725,908
5.24	. . . . Year 24	$16,798,350	$29,827,150	$23,312,750	50.00%	$69,938,250
5.25	. . . . Year 25	$16,798,350	$31,350,761	$24,074,555	50.00%	$72,223,666
5.25	. . . . Year 26	$16,798,350	$32,923,086	$24,860,718	50.00%	$74,582,154
5.27	. . . . Year 27	$16,798,350	$34,547,487	$25,672,918	50.00%	$77,018,755
5.28	. . . . Year 28	$16,798,350	$36,223,962	$26,511,156	50.00%	$79,533,468
5.29	. . . . Year 29	$16,798,350	$37,955,872	$27,377,111	50.00%	$82,131,333
5.30	. . . . Year 30	$16,798,350	$39,744,896	$28,271,623	50.00%	$84,814,869
5.31	. . . . Year 31	$16,798,350	$41,592,715	$29,195,532	50.00%	$87,586,597
5.32	. . . . Year 32	$16,798,350	$43,499,327	$30,148,839	50.00%	$90,446,516
5.33	. . . . Year 33	$16,798,350	$45,469,774	$31,134,062	50.00%	$93,402,186

Project Summary Report

Project Name: ***APIEC Consolidated - Alternative #3C***

Project Location: ***INL/ORNL***
Estimate Number: ***8B26-C***

Client: ***B. Landman***
Prepared By: ***R. D. Allen / B. W. Wallace***
Estimate Type: ***Alternative Analysis - Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.34	. . . . Year 34	$16,798,350	$47,504,054	$32,151,202	50.00%	$96,453,606
5.35	. . . . Year 35	$16,798,350	$49,603,848	$33,201,099	50.00%	$99,603,297
5.36	. . . . Year 36	$16,798,350	$51,772,515	$34,285,432	50.00%	$102,856,297
5.37	. . . . Year 37	$16,798,350	$54,013,415	$35,405,882	50.00%	$106,217,647
5.38	. . . . Year 38	$16,798,350	$56,326,547	$36,562,449	50.00%	$109,687,346
5.39	. . . . Year 39	$16,798,350	$58,715,273	$37,756,811	50.00%	$113,270,434
5.40	. . . . Year 40	$16,798,350	$61,181,271	$38,989,810	50.00%	$116,969,431
6	Deactivation and Demolition	$17,697,134	$67,139,387	$42,418,260	50.00%	$127,254,781
Total	APIEC Consolidated - Alternate #3C	$1,461,979,693	$2,241,989,985	$1,851,229,661	49.98%	$5,555,199,339

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman

From: D. J. Radford / R. D. Allen, Cost Estimators

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #4A Idaho National Laboratory

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $3,600,000,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, markup, and labor sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate

and/or schedule and should be reviewed by me. If you have any questions or comments, do not hesitate to contact me at 419-4165 or e-mail dradford@portageinc.com or Ross Allen at 526-0769 or e-mail ross.allen@inl.gov.

Attachments

cc: Estimate File 8B26-D

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Project Name: *Lifecycle INL Estimate for Advanced PIE Alternate 4A*
Project Location: *MFC*
Project Number: *8B26-D*

Summary Report

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		149.75%	*48.60%*	
Total Estimated Cost (TEC)	$974,117,525	$1,458,756,520	$1,182,292,502	$3,615,166,547
		149.75%	*48.60%*	
Total Cost	$974,117,525	$1,458,756,520	$1,182,292,502	$3,615,166,547
Rounded Total Cost (Rounded to the nearest $ 100000000)				$3,600,000,000

	Remarks
Type of Estimate: Class 5	
Estimator: D. Radford	
Checked By:	
Approved By:	

Battelle Energy Alliance, LLC

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #4A
Estimator:	D. J. Radford / R. D. Allen
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26-D
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**
The objective of this work is provide a lifecycle cost for a scaled down version of the Post Irradiation Examination Facility proposed to be located at Idaho National Laboratory (INL) to support advanced post irradiation examination (PIE) activities for highly-irradiated nuclear fuels and materials. The scaled down version removes the space that was allocated for future expansion.

B. **Included:**
This cost estimate includes life-cycle costs (LCC) as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs, including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration. Includes DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Construction of a new facility at INL.
6. Construction subcontract management costs.
7. Operational readiness costs. Including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR.
8. Facility operations costs for 40 years. See estimate back-up for more details.
9. Facility maintenance costs for 40 years, including annual facility maintenance costs, and equipment replacement costs.
10. Post irradiation examination for 40 years.
11. Transportation costs for 100 experiments per year.

12. Deactivation, decommissioning, and demolition (DD&D) of facility. Includes costs to DD&D the facility space to be used by the APIEC project. See estimate back-up for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Physical security personnel costs.
3. Additional utility upgrades outside of the facility.

III. **ESTIMATE METHODOLOGY:** *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of them are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled Low Level Waste project. Engineering and design development costs are based on the DOE Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range.

Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

A "forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. **BASIS OF THE ESTIMATE:** *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association of the advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012, developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th , 9th and 29th 2012. On August 17, 2012 B. Landman provided information regarding the scaling of the original PIE estimate (1D03-A).

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. BEA will provide resources for all project management and construction management resources.

2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by BEA.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Sales tax for materials in construction items is included as part of the contractor mark-ups.
4. Sales tax for equipment replacement has been included in the equipment purchase cost.
5. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.
6. Contractor markup rates are based information developed by BEA estimating. The application of markups varies based on cost basis and estimate methodology used.
7. Capital costs were adjusted by geographic location based on RS Means location factors.
8. The Post Irradiation Examination Facility; estimate File #1D03-A was used as a cost basis.
9. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.

V. **ESTIMATE QUALITY ASSURANCE:** *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. **ASSUMPTIONS:** *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Mock-up space will be available at an INL facility and will not require space rental charges to the project.
B. Project Management and Project Integration are each 6% of all direct costs included in WBS element 35 and higher, not including design.
C. Procurement is included in the 6% project management adder.
D. Construction Management is 4% of all direct costs included in WBS element 35 and higher not including design, process equipment, or characterization equipment.
E. The effort to mock-up / install the three pieces that do not require being remote (TEM, APM, and SIMS) are equivalent to a low complexity piece of process equipment.
F. The testing verification effort is 20% of the remotize /mock-up /install effort.

VII. **MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:**

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

Due to the preliminary nature of the design a detailed risk assessment has not been performed. With the exception of conceptual design a management reserve of 30% applied to the work through the completion of facility construction was included in the original estimate. As agreed to by the project team this has not been changed. Management reserve for conceptual design was included at the rates identified in the source estimate (1B33-A) by S. Wasley.

A blanket MR rate of 50% was applied to this cost estimate for all out year lifecycle costs. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.
2. Facility maintenance, refurbishment, and DD&D costs are based on anticipated facility area. If the facility area usage is determined to be greater than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is great than assumed, project costs may be impacted.
4. Based on the assumed life of the building no major refurbishments are anticipated. If major refurbishments are required due to environmental or other unforeseen impacts, project lifecycle costs will be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased production, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are based on anticipated facility area. If the facility area usage is determined to be less than anticipated project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. **OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:**

The construction portion of this estimate has been derived from an estimate developed by an outside source. While the estimate does include mark-ups they are incorporated in a manner incompatible with the standard BEA contractor mark-up report. As a result this report is not included in the estimate package.

Standard AACEI guidance for a Class 5 estimate indicates that the expected estimate at completion accuracy range of the estimate is -50% to +100% of the estimated costs including MR.

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation (Spent Cost)	$1,510,356	$0	$0	0.00%	$1,510,356
2	Advanced Post Irradiation (APEX) (PIE) Capabilities (TPC)	$134,608,845	$28,374,515	$48,102,337	29.51%	$211,085,698
2.1	. . . . Project Management	$5,726,514	$1,005,789	$1,898,335	28.20%	$8,630,637
2.1.1	. . . . . PM Definition Phase	$517,743	$9,889	$36,934	7.00%	$564,566
2.1.1.1	. . . . . Project Management	$517,743	$9,889	$36,934	7.00%	$564,566
2.1.1.1.1	*. . . . . CD -1 PM Oversight - Level of Effort (LOE)*	*$517,743*	*$9,889*	*$36,934*	*7.00%*	*$564,566*
2.1.2	. . . . . PM Execution Phase	$4,948,332	$926,021	$1,762,306	30.00%	$7,636,659
2.1.2.1	. . . . . PM Execution Phase	$4,948,332	$926,021	$1,762,306	30.00%	$7,636,659
2.1.2.1.1	*. . . . . Project Management CD2 through CD4*	*$4,948,332*	*$926,021*	*$1,762,306*	*30.00%*	*$7,636,659*
2.1.3	. . . . . PM Closeout Phase	$260,439	$69,878	$99,095	30.00%	$429,412
2.1.3.1	. . . . . PM Closeout Phase	$260,439	$69,878	$99,095	30.00%	$429,412
2.2	. . . . Conceptual Design of APEX Capability Studies	$2,486,644	$54,969	$381,242	15.00%	$2,922,855
2.2.1	. . . . . Alternatives Analysis	$443,530	$1,904	$66,815	15.00%	$512,249
2.2.1.1	. . . . . Alternative Definition and Selection	$288,554	$1,265	$43,473	15.00%	$333,291
2.2.1.1.1	*. . . . . Project Engineering - Alternatives Definition*	*$288,554*	*$1,265*	*$43,473*	*15.00%*	*$333,291*
2.2.1.1.1.1	*. . . . . General Studies*	*$147,090*	*$954*	*$22,206*	*15.00%*	*$170,250*
2.2.1.1.1.1.1	*. . . . . Existing U. S. Capabilities*	*$42,088*	*$848*	*$6,440*	*15.00%*	*$49,376*
2.2.1.1.1.1.2	*. . . . . Shipping Costs*	*$18,728*	*$35*	*$2,814*	*15.00%*	*$21,578*
2.2.1.1.1.1.3	*. . . . . Comparison Basis*	*$16,873*	*$18*	*$2,534*	*15.00%*	*$19,424*
2.2.1.1.1.1.4	*. . . . . Path Forward*	*$18,760*	*$35*	*$2,819*	*15.00%*	*$21,615*
2.2.1.1.1.1.5	*. . . . . Review Alternative Analysis*	*$40,876*	*$0*	*$6,131*	*15.00%*	*$47,008*
2.2.1.1.1.1.6	*. . . . . Incorporate Comments*	*$9,764*	*$18*	*$1,467*	*15.00%*	*$11,249*
2.2.1.1.1.2	*. . . . . No Action Alternative - Write Report*	*$14,054*	*$35*	*$2,113*	*15.00%*	*$16,203*
2.2.1.1.1.3	*. . . . . Complex Wide Distributed Capability - Identify, Estimate, Write Report*	*$62,411*	*$133*	*$9,382*	*15.00%*	*$71,926*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.1.1.1.4	*. . . . . MFC Wide Distributed Capacity - Identify, Estimate, Write Report*	*$39,129*	*$108*	*$5,886*	*15.00%*	*$45,122*
2.2.1.1.1.5	*. . . . . PIE LIB - Write Report*	*$25,870*	*$35*	*$3,886*	*15.00%*	*$29,791*
2.2.1.2	. . . . . Tradeoff Studies	$154,976	$639	$23,342	15.00%	$178,958
2.2.1.2.1	*. . . . . Trade-off Studies*	*$154,976*	*$639*	*$23,342*	*15.00%*	*$178,958*
2.2.1.2.1.1	*. . . . . Site Location Trade-Off - Footprint Determination and Utilities*	*$111,076*	*$639*	*$16,757*	*15.00%*	*$128,473*
2.2.1.2.1.2	*. . . . . Electrical Capacity Study*	*$28,690*	*$0*	*$4,303*	*15.00%*	*$32,993*
2.2.1.2.1.3	*. . . . . Fire Water Availability Study*	*$6,821*	*$0*	*$1,023*	*15.00%*	*$7,844*
2.2.1.2.1.4	*. . . . . Sewer Water Availability Study*	*$8,389*	*$0*	*$1,258*	*15.00%*	*$9,648*
2.2.2	**. . . . . Conceptual Design of Preferred Alternative**	**$2,043,114**	**$53,065**	**$314,427**	**15.00%**	**$2,410,606**
2.2.2.1	. . . . . Engineering Supervision	$246,633	$4,711	$37,701	15.00%	$289,045
2.2.2.1.1	*. . . . . Engineering Supervision and Support*	*$246,633*	*$4,711*	*$37,701*	*15.00%*	*$289,045*
2.2.2.2	. . . . . Site D&D and Development	$192,232	$7,756	$29,998	15.00%	$229,987
2.2.2.2.1	*. . . . . Civil*	*$192,232*	*$7,756*	*$29,998*	*15.00%*	*$229,987*
2.2.2.3	. . . . . Facilities and Ancillary Support Systems	$863,003	$26,440	$133,417	15.00%	$1,022,860
2.2.2.3.1	*. . . . . Architectural*	*$84,243*	*$5,184*	*$13,414*	*15.00%*	*$102,841*
2.2.2.3.3	*. . . . . Electrical*	*$164,735*	*$5,699*	*$25,565*	*15.00%*	*$195,999*
2.2.2.3.4	*. . . . . Fire Protection*	*$25,237*	*$482*	*$3,858*	*15.00%*	*$29,577*
2.2.2.3.5.5	*. . . . . H&V*	*$100,370*	*$1,917*	*$15,343*	*15.00%*	*$117,630*
2.2.2.3.6	*. . . . . I&C*	*$76,005*	*$1,452*	*$11,618*	*15.00%*	*$89,075*
2.2.2.3.7	*. . . . . Mechanical*	*$185,066*	*$7,364*	*$28,864*	*15.00%*	*$221,294*
2.2.2.3.8	*. . . . . Structural*	*$227,348*	*$4,342*	*$34,754*	*15.00%*	*$266,444*
2.2.2.4	. . . . . Process Cell Equipment Design	$453,226	$8,657	$69,282	15.00%	$531,165
2.2.2.4.1	*. . . . . Sample Process Cell Equipment Design*	*$453,226*	*$8,657*	*$69,282*	*15.00%*	*$531,165*
2.2.2.5	. . . . . Exam Equipment and Modular Cells	$288,020	$5,501	$44,028	15.00%	$337,550
2.2.2.5.1	*. . . . . Examination Equipment Design*	*$288,020*	*$5,501*	*$44,028*	*15.00%*	*$337,550*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3	**. . . . Project Integration and DOE 413 Deliverables Integration**	**$11,157,027**	**$1,962,976**	**$3,645,927**	**27.79%**	**$16,765,930**
2.3.1	**. . . . . Critical Decision 1 Evaluations**	**$790,524**	**$16,695**	**$111,665**	**13.83%**	**$918,883**
2.3.1.1	. . . . . Nuclear Safety	$346,286	$6,614	$52,935	15.00%	$405,836
2.3.1.1.1	*. . . . . Nuclear Safety Work Package*	*$346,286*	*$6,614*	*$52,935*	*15.00%*	*$405,836*
2.3.1.1.1.1	*. . . . . Safety Design Strategy*	*$95,228*	*$1,819*	*$14,557*	*15.00%*	*$111,604*
2.3.1.1.1.2	*. . . . . Preliminary Hazard Analysis Report*	*$43,817*	*$837*	*$6,698*	*15.00%*	*$51,352*
2.3.1.1.1.3	*. . . . . Conceptual Safety Design Report*	*$78,489*	*$1,499*	*$11,998*	*15.00%*	*$91,987*
2.3.1.1.1.4	*. . . . . Nuclear Safety Support*	*$128,752*	*$2,459*	*$19,682*	*15.00%*	*$150,893*
2.3.1.2	. . . . . Risk Management	$102,074	$1,950	$15,603	15.00%	$119,627
2.3.1.2.1	*. . . . . Risk Management Plan*	*$33,810*	*$646*	*$5,168*	*15.00%*	*$39,624*
2.3.1.2.2	*. . . . . Initial Risk Assessment Report*	*$47,261*	*$903*	*$7,225*	*15.00%*	*$55,388*
2.3.1.2.3	*. . . . . Support Risk Assessment*	*$21,003*	*$401*	*$3,211*	*15.00%*	*$24,614*
2.3.1.3	. . . . . DOE 413.3B Documents	$193,359	$5,289	$21,067	10.61%	$219,715
2.3.1.3.1	*. . . . . Project Management*	*$45,436*	*$868*	*$6,946*	*15.00%*	*$53,249*
2.3.1.3.1.1	*. . . . . Acquisition Strategy*	*$18,174*	*$347*	*$2,778*	*15.00%*	*$21,300*
2.3.1.3.1.2	*. . . . . Develop Project Execution Plan*	*$27,262*	*$521*	*$4,167*	*15.00%*	*$31,950*
2.3.1.3.2	*. . . . . Systems Engineering Work Package*	*$42,153*	*$1,064*	*$6,483*	*15.00%*	*$49,700*
2.3.1.3.2.1	*. . . . . Compile CD-1 Work Package*	*$42,153*	*$1,064*	*$6,483*	*15.00%*	*$49,700*
2.3.1.3.3	*. . . . . Cost Estimating and Scheduling CD1*	*$105,770*	*$3,357*	*$7,639*	*7.00%*	*$116,766*
2.3.1.3.3.1	*. . . . . Develop Project Cost Estimate (Baseline)*	*$48,699*	*$1,674*	*$3,526*	*7.00%*	*$53,899*
2.3.1.3.3.2	*. . . . . Develop Prelim Design Cost Estimate*	*$21,262*	*$639*	*$1,533*	*7.00%*	*$23,435*
2.3.1.3.3.3	*. . . . . Develop Project Schedule*	*$22,223*	*$581*	*$1,596*	*7.00%*	*$24,400*
2.3.1.3.3.4	*. . . . . Develop Prelim Design Schedule*	*$13,586*	*$463*	*$983*	*7.00%*	*$15,032*
2.3.1.4	. . . . . ESHQ&SS	$49,782	$951	$6,922	13.64%	$57,655
2.3.1.4.1	*. . . . . ES&H Plan*	*$23,606*	*$451*	*$3,608*	*15.00%*	*$27,665*
2.3.1.4.1.1	*. . . . . Prepare Preliminary ES&H Plan*	*$23,606*	*$451*	*$3,608*	*15.00%*	*$27,665*
2.3.1.4.2	*. . . . . Environmental Compliance*	*$17,739*	*$339*	*$2,712*	*15.00%*	*$20,789*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.1.4.2.1	*. . . . . NEPA Documents*	*$17,739*	*$339*	*$2,712*	*15.00%*	*$20,789*
2.3.1.4.3	*. . . . . Quality Assurance*	*$8,437*	*$161*	*$602*	*7.00%*	*$9,200*
2.3.1.4.3.1	*. . . . . Quality Assurance Program Plan*	*$8,437*	*$161*	*$602*	*7.00%*	*$9,200*
2.3.1.5	. . . . . CD-1 Reviews	$99,023	$1,891	$15,137	15.00%	$116,051
2.3.1.5.1	*. . . . . Reviewers (Internal)*	*$43,384*	*$829*	*$6,632*	*15.00%*	*$50,844*
2.3.1.5.1.1	*. . . . . Conduct Conceptual Design Review*	*$43,384*	*$829*	*$6,632*	*15.00%*	*$50,844*
2.3.1.5.2	*. . . . . Reviewers (Independent/External)*	*$19,158*	*$366*	*$2,929*	*15.00%*	*$22,452*
2.3.1.5.2.1	*. . . . . Support DOE Technical Independent Project Review*	*$19,158*	*$366*	*$2,929*	*15.00%*	*$22,452*
2.3.1.5.3	*. . . . . Safeguards and Security*	*$36,482*	*$697*	*$5,577*	*15.00%*	*$42,755*
2.3.1.5.3.1	*. . . . . Preliminary Security Vulnerability Assessment Report*	*$36,482*	*$697*	*$5,577*	*15.00%*	*$42,755*
2.3.2	**. . . . . Critical Decision 2 Evaluations**	**$976,811**	**$144,025**	**$336,251**	**30.00%**	**$1,457,087**
2.3.2.1	. . . . . Critical Decision 2	$976,811	$144,025	$336,251	30.00%	$1,457,087
2.3.2.1.1	*. . . . . Nuclear Safety*	*$726,811*	*$107,164*	*$250,192*	*30.00%*	*$1,084,167*
2.3.2.1.2	*. . . . . Nuclear Safety Support*	*$250,000*	*$36,861*	*$86,058*	*30.00%*	*$372,919*
2.3.3	**. . . . . Critical Decision 3 Evaluations**	**$970,123**	**$181,547**	**$345,501**	**30.00%**	**$1,497,171**
2.3.3.1	. . . . . Critical Decision 3	$970,123	$181,547	$345,501	30.00%	$1,497,171
2.3.3.1.1	*. . . . . Nuclear Safety*	*$970,123*	*$181,547*	*$345,501*	*30.00%*	*$1,497,171*
2.3.4	**. . . . . Critical Decision 4 Evaluations**	**$208,351**	**$73,734**	**$84,625**	**30.00%**	**$366,710**
2.3.5	**. . . . . Post Critical Decision 4**	**$52,088**	**$18,434**	**$21,156**	**30.00%**	**$91,678**
2.3.6	**. . . . . Project Integration (Definition Phase)**	**$773,398**	**$14,948**	**$76,931**	**9.76%**	**$865,278**
2.3.6.1	. . . . . System Engineering Evaluations	$773,398	$14,948	$76,931	9.76%	$865,278
2.3.6.1.1	*. . . . . Project Integration CD1*	*$773,398*	*$14,948*	*$76,931*	*9.76%*	*$865,278*
2.3.6.1.1.1	*. . . . . Project Engineering and Support*	*$506,655*	*$9,853*	*$36,156*	*7.00%*	*$552,664*
2.3.6.1.1.2	*. . . . . DR - Systems Engineering*	*$266,744*	*$5,095*	*$40,776*	*15.00%*	*$312,614*
2.3.6.1.1.2.1	*. . . . . Systems Engineering Managment Plan (SEMP)*	*$42,455*	*$811*	*$6,490*	*15.00%*	*$49,755*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.6.1.1.2.2	*. . . . . Systems Engineering -T&FRs*	*$106,137*	*$2,027*	*$16,225*	*15.00%*	*$124,389*
2.3.6.1.1.2.3	*. . . . . Systems Engineering -Action Tracking*	*$39,384*	*$752*	*$6,020*	*15.00%*	*$46,157*
2.3.6.1.1.2.4	*. . . . . Systems Engineering -Trade Study Support*	*$78,768*	*$1,504*	*$12,041*	*15.00%*	*$92,313*
2.3.7	**. . . . . Project Integration-Execution Phase**	**$4,948,332**	**$926,021**	**$1,762,306**	**30.00%**	**$7,636,659**
2.3.7.1	. . . . . Project Integration	$4,948,332	$926,021	$1,762,306	30.00%	$7,636,659
2.3.8	**. . . . . Project Integration-Closeout Phase**	**$260,439**	**$92,168**	**$105,782**	**30.00%**	**$458,388**
2.3.8.1	. . . . . Project Integration	$260,439	$92,168	$105,782	30.00%	$458,388
2.3.9	**. . . . . PM-Construction Management**	**$2,176,962**	**$495,404**	**$801,710**	**30.00%**	**$3,474,076**
2.3.9.1	. . . . . Construction Management	$2,176,962	$495,404	$801,710	30.00%	$3,474,076
2.4	**. . . . Preliminary Design**	**$10,385,117**	**$1,126,635**	**$3,453,526**	**30.00%**	**$14,965,278**
2.4.1	**. . . . . Preliminary Design**	**$10,385,117**	**$1,126,635**	**$3,453,526**	**30.00%**	**$14,965,278**
2.4.1.1	. . . . . Preliminary Design	$10,385,117	$1,126,635	$3,453,526	30.00%	$14,965,278
2.4.1.1.1	*. . . . . Site Development Preliminary Design (Title I)*	*$863,557*	*$93,683*	*$287,172*	*30.00%*	*$1,244,412*
2.4.1.1.2	*. . . . . Facility Structure & Ancillary Supt. Sys. Preliminary Design (Title I)*	*$4,526,221*	*$491,030*	*$1,505,175*	*30.00%*	*$6,522,425*
2.4.1.1.3	*. . . . . Modular Hot Cells Preliminary Design (Title I)*	*$4,995,339*	*$541,922*	*$1,661,178*	*30.00%*	*$7,198,440*
2.5	**. . . . Final Design**	**$151,582**	**$28,367**	**$53,984**	**30.00%**	**$233,933**
2.5.1	**. . . . . Final Design**	**$151,582**	**$28,367**	**$53,984**	**30.00%**	**$233,933**
2.5.1.1	. . . . . Final Design	$151,582	$28,367	$53,984	30.00%	$233,933
2.5.1.1.1	*. . . . . Site D&D Preliminary & Final Design (Title I)*	*$151,582*	*$28,367*	*$53,984*	*30.00%*	*$233,933*
2.6	**. . . . Procurement**	**$40,140,696**	**$9,134,694**	**$14,782,617**	**30.00%**	**$64,058,006**
2.6.1	**. . . . . Procurement**	**$40,140,696**	**$9,134,694**	**$14,782,617**	**30.00%**	**$64,058,006**
2.6.1.1	. . . . . Procurement	$40,140,696	$9,134,694	$14,782,617	30.00%	$64,058,006
2.6.1.1.1	*. . . . . Facility Structure & Ancillary Supt. Sys. Procurement/Fabrication*	*$3,240,803*	*$737,500*	*$1,193,491*	*30.00%*	*$5,171,794*
2.6.1.1.1.1	*. . . . . Miscellaneous Equipment*	*$779,986*	*$177,499*	*$287,245*	*30.00%*	*$1,244,730*
2.6.1.1.1.2	*. . . . . Mechanical Equipment*	*$2,460,817*	*$560,001*	*$906,245*	*30.00%*	*$3,927,063*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.6.1.1.2.1	*. . . . . Exhaust Stack*	*$109,999*	*$25,032*	*$40,509*	*30.00%*	*$175,540*
2.6.1.1.2.2	*. . . . . Building HVAC Equipment*	*$210,671*	*$47,942*	*$77,584*	*30.00%*	*$336,197*
80.15.50.10.10.4.2.3	*. . . . . Exhaust System Equipment*	*$2,140,147*	*$487,027*	*$788,152*	*30.00%*	*$3,415,326*
2.6.1.1.2	*. . . . . Facility Process Equipment Procurement/Fabrication*	*$1,233,983*	*$280,814*	*$454,439*	*30.00%*	*$1,969,236*
2.6.1.1.3	*. . . . . Modular Hot Cells Procurement/Fabrication*	*$24,639,425*	*$5,607,118*	*$9,073,963*	*30.00%*	*$39,320,506*
2.6.1.1.4	*. . . . . Characterization Specialty Equipment Procurement/Fabrication*	*$11,026,484*	*$2,509,263*	*$4,060,724*	*30.00%*	*$17,596,471*
2.6.1.1.4.1	*. . . . . Thermal Examination*	*$860,000*	*$195,708*	*$316,712*	*30.00%*	*$1,372,420*
2.6.1.1.4.2	*. . . . . Microstructure Examination*	*$10,166,484*	*$2,313,555*	*$3,744,012*	*30.00%*	*$16,224,051*
2.7	**. . . . Construction**	**$59,586,868**	**$13,635,536**	**$21,966,721**	**30.00%**	**$95,189,125**
2.7.1	**. . . . . Construction**	**$59,586,868**	**$13,635,536**	**$21,966,721**	**30.00%**	**$95,189,125**
2.7.1.1	. . . . . Construction	$59,586,868	$13,635,536	$21,966,721	30.00%	$95,189,125
2.7.1.1.1	*. . . . . Title 3 Design*	*$936,094*	*$251,164*	*$356,177*	*30.00%*	*$1,543,435*
2.7.1.1.2	*. . . . . Site D&D Construction/Installation*	*$778,417*	*$208,858*	*$296,182*	*30.00%*	*$1,283,457*
2.7.1.1.2.1	*. . . . . Building Deactivation & Demolition*	*$778,417*	*$208,858*	*$296,182*	*30.00%*	*$1,283,457*
2.7.1.1.3	*. . . . . Site Development Construction/Installation*	*$5,115,282*	*$1,330,029*	*$1,933,593*	*30.00%*	*$8,378,904*
2.7.1.1.3.1	*. . . . . Civil*	*$3,664,162*	*$977,761*	*$1,392,577*	*30.00%*	*$6,034,500*
2.7.1.1.3.1.1	*. . . . . Site Preparation*	*$2,580,000*	*$692,242*	*$981,673*	*30.00%*	*$4,253,914*
2.7.1.1.3.1.2	*. . . . . Landscaping*	*$860,000*	*$230,747*	*$327,224*	*30.00%*	*$1,417,971*
2.7.1.1.3.1.3	*. . . . . Asphalt Paving*	*$114,624*	*$29,333*	*$43,187*	*30.00%*	*$187,145*
2.7.1.1.3.1.4	*. . . . . Concrete Paving*	*$109,538*	*$25,438*	*$40,493*	*30.00%*	*$175,469*
2.7.1.1.3.2	*. . . . . Electrical*	*$1,258,803*	*$312,305*	*$471,332*	*30.00%*	*$2,042,439*
2.7.1.1.3.2.1	*. . . . . Equipment*	*$722,004*	*$190,368*	*$273,711*	*30.00%*	*$1,186,083*
2.7.1.1.3.2.2	*. . . . . Raceway*	*$318,506*	*$70,662*	*$116,750*	*30.00%*	*$505,919*
2.7.1.1.3.2.3	*. . . . . Cable*	*$169,057*	*$40,181*	*$62,772*	*30.00%*	*$272,011*
2.7.1.1.3.2.4	*. . . . . Demo*	*$49,235*	*$11,094*	*$18,099*	*30.00%*	*$78,427*
2.7.1.1.3.3	*. . . . . Overtime (Distributed)*	*$192,317*	*$39,964*	*$69,684*	*30.00%*	*$301,965*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4	. . . . . Facility Structure & Ancillary Supt. Sys. Construction/Installation	$24,476,146	$5,724,082	$9,060,069	30.00%	$39,260,298
2.7.1.1.4.1	. . . . . Main Facility	$16,457,637	$3,882,776	$6,102,124	30.00%	$26,442,538
2.7.1.1.4.1.1	 Civil	$8,222,470	$1,900,253	$3,036,817	30.00%	$13,159,540
2.7.1.1.4.1.1.1	. . . . . Concrete	$3,764,089	$837,831	$1,380,576	30.00%	$5,982,496
2.7.1.1.4.1.1.2	. . . . . Masonry	$518,386	$112,112	$189,149	30.00%	$819,647
2.7.1.1.4.1.1.3	. . . . . Metals	$1,607,424	$384,376	$597,540	30.00%	$2,589,341
2.7.1.1.4.1.1.4	. . . . . Openings	$201,216	$49,139	$75,106	30.00%	$325,461
2.7.1.1.4.1.1.5	. . . . . Thermal & Moisture Protection	$494,218	$114,479	$182,609	30.00%	$791,306
2.7.1.1.4.1.1.6	. . . . . Finishes	$1,529,183	$379,138	$572,496	30.00%	$2,480,818
2.7.1.1.4.1.1.7	. . . . . Miscellaneous Equipment	$107,954	$23,178	$39,340	30.00%	$170,472
2.7.1.1.4.1.2	. . . . . Mechanical	$7,481,108	$1,806,985	$2,786,428	30.00%	$12,074,520
2.7.1.1.4.1.2.1	. . . . . HVAC, Entire Bldg.	$4,920,048	$1,192,067	$1,833,635	30.00%	$7,945,750
2.7.1.1.4.1.2.1.1	. . . . . Heating, AC & Air Supply	$977,722	$240,159	$365,364	30.00%	$1,583,244
2.7.1.1.4.1.2.1.2	. . . . . Primary Exhaust System & Stack	$2,734,297	$664,885	$1,019,755	30.00%	$4,418,938
2.7.1.1.4.1.2.1.3	. . . . . Suspect Exhaust System	$1,208,029	$287,023	$448,516	30.00%	$1,943,568
2.7.1.1.4.1.2.2	. . . . . Piping, Entire Bldg.	$2,298,051	$550,050	$854,430	30.00%	$3,702,531
2.7.1.1.4.1.2.2.01	. . . . . Sanitary Waste System	$123,614	$27,271	$45,266	30.00%	$196,152
2.7.1.1.4.1.2.2.01.1	 Civil	$9,399	$2,199	$3,479	30.00%	$15,077
2.7.1.1.4.1.2.2.01.2	. . . . . Mechanical	$114,215	$25,073	$41,786	30.00%	$181,074
2.7.1.1.4.1.2.2.01.1	. . . . . Equipment	$12,865	$3,147	$4,804	30.00%	$20,815
2.7.1.1.4.1.2.2.01.2	. . . . . Piping	$101,350	$21,926	$36,983	30.00%	$160,259
2.7.1.1.4.1.2.2.02	. . . . . Safety Shower System	$35,157	$8,065	$12,966	30.00%	$56,187
2.7.1.1.4.1.2.2.02.1	. . . . . Equipment	$6,939	$1,717	$2,597	30.00%	$11,253
2.7.1.1.4.1.2.2.02.2	. . . . . Piping	$25,476	$5,739	$9,364	30.00%	$40,579
2.7.1.1.4.1.2.2.02.3	. . . . . Insulation	$2,741	$609	$1,005	30.00%	$4,356

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.1.2.2.03	Clear Water Drain System	$51,324	$11,698	$18,907	30.00%	$81,929
2.7.1.1.4.1.2.2.03.1	Equipment	$19,287	$4,783	$7,221	30.00%	$31,291
2.7.1.1.4.1.2.2.03.2	Piping & Valves	$32,037	$6,916	$11,686	30.00%	$50,638
2.7.1.1.4.1.2.2.04	Cooling Water System	$361,339	$81,562	$132,870	30.00%	$575,771
2.7.1.1.4.1.2.2.04.1	Equipment	$84,501	$21,269	$31,731	30.00%	$137,501
2.7.1.1.4.1.2.2.04.2	Piping	$244,590	$53,267	$89,357	30.00%	$387,214
2.7.1.1.4.1.2.2.04.3	Fiberglass Insul,ASJ/SSL,1"	$19,833	$4,336	$7,251	30.00%	$31,419
2.7.1.1.4.1.2.2.04.4	1" Fiberglass w/0.016" Alum. Jacket, 2" dia.	$10,190	$2,203	$3,718	30.00%	$16,112
2.7.1.1.4.1.2.2.04.5	1" Fiberglass w/0.016" Alum. Jacket, 5" dia.	$2,225	$486	$813	30.00%	$3,525
2.7.1.1.4.1.2.2.05	Facility DP Monitoring System	$92,203	$22,038	$34,272	30.00%	$148,514
2.7.1.1.4.1.2.2.05.1	Equipment	$71,002	$17,392	$26,518	30.00%	$114,913
2.7.1.1.4.1.2.2.05.2	Piping	$21,201	$4,646	$7,754	30.00%	$33,601
2.7.1.1.4.1.2.2.06	Nitrogen Liquid & Gas System	$179,873	$44,276	$67,245	30.00%	$291,395
2.7.1.1.4.1.2.2.06.1	Civil	$5,641	$1,258	$2,070	30.00%	$8,969
2.7.1.1.4.1.2.2.06.2	Instrumentation & Controls	$11,270	$2,724	$4,198	30.00%	$18,192
2.7.1.1.4.1.2.2.06.3	Equipment	$68,364	$17,682	$25,814	30.00%	$111,859
2.7.1.1.4.1.2.2.06.4	Piping/Valves	$81,456	$19,738	$30,358	30.00%	$131,552
2.7.1.1.4.1.2.2.06.5	1.5" Cal-Sil. w/0.016" Alum. Jacket, 1" dia. & dn.	$6,132	$1,339	$2,241	30.00%	$9,712
2.7.1.1.4.1.2.2.06.6	1.5" Cal-Sil. w/0.016" Alum. Jacket, 1.25" & 1.5" dia.	$7,011	$1,535	$2,564	30.00%	$11,110
2.7.1.1.4.1.2.2.07	Leak Monitoring System	$124,678	$30,516	$46,558	30.00%	$201,752
2.7.1.1.4.1.2.2.07.1	Equipment	$29,690	$7,760	$11,235	30.00%	$48,685

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.1.2.2.07.2	Piping	$94,988	$22,756	$35,323	30.00%	$153,067
2.7.1.1.4.1.2.2.08	Pneumatic Transfer System	$390,046	$96,373	$145,926	30.00%	$632,344
2.7.1.1.4.1.2.2.08.1	Civil/Structural	$48,219	$11,110	$17,799	30.00%	$77,127
2.7.1.1.4.1.2.2.08.2	Equipment	$117,839	$29,749	$44,276	30.00%	$191,864
2.7.1.1.4.1.2.2.08.3	Piping/Valves	$223,989	$55,514	$83,851	30.00%	$363,353
2.7.1.1.4.1.2.2.09	Fixed Air Sampling System	$125,070	$27,004	$45,622	30.00%	$197,697
2.7.1.1.4.1.2.2.10	Plant Air System	$249,871	$65,229	$94,530	30.00%	$409,630
2.7.1.1.4.1.2.2.11	Breathing Air System	$275,523	$65,920	$102,433	30.00%	$443,876
2.7.1.1.4.1.2.2.12	Nitrogen Gas System	$29,915	$6,783	$11,009	30.00%	$47,707
2.7.1.1.4.1.2.2.13	P-10 Gas System	$29,915	$6,783	$11,009	30.00%	$47,707
2.7.1.1.4.1.2.2.14	Specialty No. 1 Gas System	$29,915	$6,783	$11,009	30.00%	$47,707
2.7.1.1.4.1.2.2.15	Specialty No. 2 Gas System	$29,915	$6,783	$11,009	30.00%	$47,707
2.7.1.1.4.1.2.2.16	Deionized Water	$169,693	$42,965	$63,798	30.00%	$276,456
2.7.1.1.4.1.2.3	Fire Protection, Entire Bldg.	$263,009	$64,868	$98,363	30.00%	$426,239
2.7.1.1.4.1.3	Electrical	$754,059	$175,539	$278,879	30.00%	$1,208,477
2.7.1.1.4.1.3.1	Gallery	$506,112	$117,440	$187,066	30.00%	$810,618
2.7.1.1.4.1.3.2	Office	$217,205	$50,935	$80,442	30.00%	$348,581
2.7.1.1.4.1.3.3	Grounding and Lightning Protection	$30,742	$7,164	$11,372	30.00%	$49,277
2.7.1.1.4.2	Storage Annex	$3,443,499	$788,455	$1,269,586	30.00%	$5,501,540
2.7.1.1.4.2.1	Civil	$3,082,109	$704,659	$1,136,030	30.00%	$4,922,798
2.7.1.1.4.2.1.1	Concrete	$1,623,901	$359,773	$595,102	30.00%	$2,578,776
2.7.1.1.4.2.1.2	Masonry	$117,674	$25,450	$42,937	30.00%	$186,061
2.7.1.1.4.2.1.3	Metals	$730,932	$176,572	$272,251	30.00%	$1,179,756
2.7.1.1.4.2.1.4	Openings	$99,209	$24,862	$37,221	30.00%	$161,291

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.2.1.5	Thermal & Moisture Protection	$248,787	$57,766	$91,966	30.00%	$398,518
2.7.1.1.4.2.1.6	Finishes	$261,606	$60,237	$96,553	30.00%	$418,397
2.7.1.1.4.2.2	Electrical	$361,390	$83,796	$133,556	30.00%	$578,742
2.7.1.1.4.3	HVAC & Mechanical Room	$3,398,520	$795,454	$1,258,192	30.00%	$5,452,166
2.7.1.1.4.3.1	Civil	$2,819,127	$655,585	$1,042,414	30.00%	$4,517,126
2.7.1.1.4.3.1.1	Concrete	$413,976	$88,856	$150,850	30.00%	$653,682
2.7.1.1.4.3.1.2	Masonry	$247,735	$53,578	$90,394	30.00%	$391,707
2.7.1.1.4.3.1.3	Metals	$1,153,341	$280,312	$430,096	30.00%	$1,863,749
2.7.1.1.4.3.1.4	Openings	$79,324	$20,271	$29,879	30.00%	$129,474
2.7.1.1.4.3.1.5	Thermal & Moisture Protection	$592,179	$137,272	$218,835	30.00%	$948,287
2.7.1.1.4.3.1.6	Finishes	$332,571	$75,296	$122,360	30.00%	$530,226
2.7.1.1.4.3.2	Mechanical	$295,555	$73,055	$110,583	30.00%	$479,193
2.7.1.1.4.3.2.1	HVAC	$159,846	$39,263	$59,733	30.00%	$258,841
2.7.1.1.4.3.2.2	Piping	$93,111	$22,362	$34,642	30.00%	$150,115
2.7.1.1.4.3.2.2.1	Cooling Water System	$55,046	$12,425	$20,241	30.00%	$87,713
2.7.1.1.4.3.2.2.1.1	Equipment	$12,873	$3,240	$4,834	30.00%	$20,947
2.7.1.1.4.3.2.2.1.2	Piping	$37,261	$8,115	$13,613	30.00%	$58,988
2.7.1.1.4.3.2.2.1.3	Insulation	$4,913	$1,070	$1,795	30.00%	$7,778
2.7.1.1.4.3.2.2.1.31	Fiberglass Insul,ASJ/SSL,1", 2006	$3,021	$661	$1,105	30.00%	$4,786
2.7.1.1.4.3.2.2.1.32	1" Fiberglass w/0.016" Alum. Jacket, 2" dia.	$1,552	$336	$566	30.00%	$2,454
2.7.1.1.4.3.2.2.1.33	1" Fiberglass w/0.016" Alum. Jacket, 5" dia.	$339	$74	$124	30.00%	$537
2.7.1.1.4.3.2.2.2	Plant Air System	$38,065	$9,937	$14,401	30.00%	$62,403
2.7.1.1.4.3.2.3	Fire Protection	$42,598	$11,430	$16,208	30.00%	$70,237
2.7.1.1.4.3.3	Electrical	$283,838	$66,814	$105,196	30.00%	$455,847
2.7.1.1.4.4	Earthwork	$279,894	$71,084	$105,293	30.00%	$456,271

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.4.1	*. . . . . Building Excavation*	*$279,894*	*$71,084*	*$105,293*	*30.00%*	*$456,271*
2.7.1.1.4.5	*. . . . . Overtime (Distributed)*	*$896,597*	*$186,313*	*$324,873*	*30.00%*	*$1,407,782*
2.7.1.1.5	*. . . . . Facility Process Equipment Construction/Installation*	*$8,933,172*	*$1,984,802*	*$3,275,392*	*30.00%*	*$14,193,365*
2.7.1.1.5.1	*. . . . . Remotize/ Mockup/ Install Process Equipment*	*$6,933,172*	*$1,448,180*	*$2,514,406*	*30.00%*	*$10,895,757*
2.7.1.1.5.2	*. . . . . Waste Packaging Cell*	*$1,000,000*	*$268,311*	*$380,493*	*30.00%*	*$1,648,804*
2.7.1.1.5.3	*. . . . . Sample Storage Cell*	*$1,000,000*	*$268,311*	*$380,493*	*30.00%*	*$1,648,804*
2.7.1.1.6	*. . . . . Modular Hot Cells Construction/Installation*	*$10,251,258*	*$2,203,722*	*$3,736,494*	*30.00%*	*$16,191,475*
2.7.1.1.6.1	*. . . . . Civil*	*$9,162,467*	*$1,962,358*	*$3,337,448*	*30.00%*	*$14,462,273*
2.7.1.1.6.1.1	*. . . . . Concrete*	*$1,741,105*	*$380,066*	*$636,351*	*30.00%*	*$2,757,523*
2.7.1.1.6.1.2	*. . . . . Metals*	*$6,716,556*	*$1,432,263*	*$2,444,646*	*30.00%*	*$10,593,465*
2.7.1.1.6.1.3	*. . . . . Openings*	*$655,889*	*$139,864*	*$238,726*	*30.00%*	*$1,034,479*
2.7.1.1.6.1.4	*. . . . . Penetrations*	*$48,917*	*$10,165*	*$17,725*	*30.00%*	*$76,807*
2.7.1.1.6.2	*. . . . . Mechanical*	*$289,123*	*$62,768*	*$105,567*	*30.00%*	*$457,458*
2.7.1.1.6.3	*. . . . . Electrical*	*$215,160*	*$57,135*	*$81,688*	*30.00%*	*$353,983*
2.7.1.1.6.4	*. . . . . Overtime (Distributed)*	*$584,509*	*$121,461*	*$211,791*	*30.00%*	*$917,761*
2.7.1.1.7	*. . . . . Characterization Specialty Equipment Construction/Installation*	*$9,096,499*	*$1,932,879*	*$3,308,813*	*30.00%*	*$14,338,192*
2.7.1.1.7.1	*. . . . . Remotize/ Mockup/ Instal Thermal Examination*	*$4,207,408*	*$879,503*	*$1,526,074*	*30.00%*	*$6,612,985*
2.7.1.1.7.2	*. . . . . Remotize/ Mockup/ Instal Microstructure Examination*	*$4,889,091*	*$1,053,376*	*$1,782,740*	*30.00%*	*$7,725,206*
2.8	**. . . . Startup**	**$3,167,693**	**$786,169**	**$1,186,159**	**30.00%**	**$5,140,020**
2.8.1	**. . . . . Startup**	**$3,167,693**	**$786,169**	**$1,186,159**	**30.00%**	**$5,140,020**
2.8.1.1	. . . . . Startup	$3,167,693	$786,169	$1,186,159	30.00%	$5,140,020
2.8.1.1.1	*. . . . . Facility Process Equipment Testing & Verification*	*$1,464,491*	*$363,047*	*$548,261*	*30.00%*	*$2,375,799*
2.8.1.1.2	*. . . . . Characterization Specialty Equipment Testing & Verification*	*$1,703,203*	*$423,121*	*$637,897*	*30.00%*	*$2,764,221*
2.8.1.1.2.1	*. . . . . Testing & Verification Thermal Examination*	*$824,282*	*$204,339*	*$308,586*	*30.00%*	*$1,337,207*

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.8.1.1.2.2	*. . . . . Testing & Verification Microstructure Examination*	*$878,921*	*$218,782*	*$329,311*	*30.00%*	*$1,427,014*
2.9	**. . . . Closeout**	**$1,806,705**	**$639,382**	**$733,826**	**30.00%**	**$3,179,912**
2.9.1	**. . . . . Closeout**	**$1,806,705**	**$639,382**	**$733,826**	**30.00%**	**$3,179,912**
2.9.1.2	. . . . . Closeout	$1,806,705	$639,382	$733,826	30.00%	$3,179,912
2.9.1.2.1	*. . . . . Site D&D Operations Readiness & Turnover*	*$25,992*	*$9,198*	*$10,557*	*30.00%*	*$45,747*
2.9.1.2.2	*. . . . . Site Development Operations Readiness & Turnover*	*$148,072*	*$52,402*	*$60,142*	*30.00%*	*$260,616*
2.9.1.2.3	*. . . . . Facility Structure & Ancillary Supt. Sys.Operations Readiness & Turnover*	*$776,101*	*$274,657*	*$315,227*	*30.00%*	*$1,365,986*
2.9.1.2.4	*. . . . . Modular Hot Cells Operations Readiness & Turnover*	*$856,540*	*$303,124*	*$347,899*	*30.00%*	*$1,507,564*
3	**Facility Operations and Maintenance**	**$424,392,808**	**$695,942,428**	**$560,167,618**	**50.00%**	**$1,680,502,854**
3.1	**. . . . Year 1**	**$9,279,388**	**$3,017,657**	**$6,148,522**	**50.00%**	**$18,445,567**
3.1.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,036,743**	**$2,112,379**	**50.00%**	**$6,337,138**
3.1.2	**. . . . . Facility Operations**	**$6,091,372**	**$1,980,914**	**$4,036,143**	**50.00%**	**$12,108,429**
3.2	**. . . . Year 2**	**$9,279,388**	**$3,419,454**	**$6,349,421**	**50.00%**	**$19,048,264**
3.2.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,174,784**	**$2,181,400**	**50.00%**	**$6,544,200**
3.2.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,244,671**	**$4,168,021**	**50.00%**	**$12,504,064**
3.3	**. . . . Year 3**	**$9,279,388**	**$3,834,243**	**$6,556,816**	**50.00%**	**$19,670,447**
3.3.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,317,288**	**$2,252,652**	**50.00%**	**$6,757,956**
3.3.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,516,955**	**$4,304,163**	**50.00%**	**$12,912,490**
3.4	**. . . . Year 4**	**$9,279,388**	**$4,262,023**	**$6,770,705**	**50.00%**	**$20,312,116**
3.4.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,464,256**	**$2,326,136**	**50.00%**	**$6,978,408**
3.4.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,797,767**	**$4,444,570**	**50.00%**	**$13,333,709**
3.5	**. . . . Year 5**	**$9,279,388**	**$4,704,650**	**$6,992,019**	**50.00%**	**$20,976,057**
3.5.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,616,324**	**$2,402,170**	**50.00%**	**$7,206,510**
3.5.2	**. . . . . Facility Operations**	**$6,091,372**	**$3,088,326**	**$4,589,849**	**50.00%**	**$13,769,546**
3.6	**. . . . Year 6**	**$9,279,388**	**$5,161,196**	**$7,220,292**	**50.00%**	**$21,660,875**

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.6.1	. . . . . Facility Maintenance	$3,188,016	$1,773,174	$2,480,595	50.00%	$7,441,786
3.6.2	. . . . . Facility Operations	$6,091,372	$3,388,021	$4,739,697	50.00%	$14,219,090
3.7	. . . . Year 7	$9,279,388	$5,633,516	$7,456,452	50.00%	$22,369,357
3.7.1	. . . . . Facility Maintenance	$3,188,016	$1,935,445	$2,561,730	50.00%	$7,685,191
3.7.2	. . . . . Facility Operations	$6,091,372	$3,698,072	$4,894,722	50.00%	$14,684,166
3.8	. . . . Year 8	$9,279,388	$6,120,684	$7,700,036	50.00%	$23,100,108
3.8.1	. . . . . Facility Maintenance	$3,188,016	$2,102,815	$2,645,416	50.00%	$7,936,247
3.8.2	. . . . . Facility Operations	$6,091,372	$4,017,869	$5,054,620	50.00%	$15,163,861
3.9	. . . . Year 9	$9,279,388	$6,623,627	$7,951,508	50.00%	$23,854,523
3.9.1	. . . . . Facility Maintenance	$3,188,016	$2,275,606	$2,731,811	50.00%	$8,195,433
3.9.2	. . . . . Facility Operations	$6,091,372	$4,348,021	$5,219,697	50.00%	$15,659,090
3.10	. . . . Year 10	$27,018,484	$20,798,829	$23,908,656	50.00%	$71,725,969
3.10.1	. . . . . Facility Maintenance	$3,188,016	$2,454,135	$2,821,075	50.00%	$8,463,226
3.10.2	. . . . . Facility Operations	$6,091,372	$4,689,138	$5,390,255	50.00%	$16,170,765
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.11	. . . . Year 11	$9,279,388	$7,679,622	$8,479,505	50.00%	$25,438,514
3.11.1	. . . . . Facility Maintenance	$3,188,016	$2,638,402	$2,913,209	50.00%	$8,739,627
3.11.2	. . . . . Facility Operations	$6,091,372	$5,041,219	$5,566,296	50.00%	$16,698,887
3.12	. . . . Year 12	$9,279,388	$8,233,601	$8,756,494	50.00%	$26,269,483
3.12.1	. . . . . Facility Maintenance	$3,188,016	$2,828,727	$3,008,371	50.00%	$9,025,114
3.12.2	. . . . . Facility Operations	$6,091,372	$5,404,874	$5,748,123	50.00%	$17,244,370
3.13	. . . . Year 13	$9,279,388	$8,805,211	$9,042,300	50.00%	$27,126,899
3.13.1	. . . . . Facility Maintenance	$3,188,016	$3,025,108	$3,106,562	50.00%	$9,319,687
3.13.2	. . . . . Facility Operations	$6,091,372	$5,780,103	$5,935,737	50.00%	$17,807,212
3.14	. . . . Year 14	$9,279,388	$9,396,308	$9,337,848	50.00%	$28,013,544
3.14.1	. . . . . Facility Maintenance	$3,188,016	$3,228,185	$3,208,101	50.00%	$9,624,302

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.14.2	. . . . . Facility Operations	$6,091,372	$6,168,123	$6,129,748	50.00%	$18,389,243
3.15	. . . . Year 15	$9,279,388	$10,636,035	$9,957,711	50.00%	$29,873,134
3.15.1	. . . . . Facility Maintenance	$3,188,016	$3,654,104	$3,421,060	50.00%	$10,263,180
3.15.2	. . . . . Facility Operations	$6,091,372	$6,981,931	$6,536,651	50.00%	$19,609,954
3.16	. . . . Year 16	$9,279,388	$10,636,035	$9,957,711	50.00%	$29,873,134
3.16.1	. . . . . Facility Maintenance	$3,188,016	$3,654,104	$3,421,060	50.00%	$10,263,180
3.16.2	. . . . . Facility Operations	$6,091,372	$6,981,931	$6,536,651	50.00%	$19,609,954
3.17	. . . . Year 17	$9,279,388	$11,286,520	$10,282,954	50.00%	$30,848,861
3.17.1	. . . . . Facility Maintenance	$3,188,016	$3,877,584	$3,532,800	50.00%	$10,598,400
3.17.2	. . . . . Facility Operations	$6,091,372	$7,408,936	$6,750,154	50.00%	$20,250,462
3.18	. . . . Year 18	$9,279,388	$11,958,347	$10,618,868	50.00%	$31,856,603
3.18.1	. . . . . Facility Maintenance	$3,188,016	$4,108,396	$3,648,206	50.00%	$10,944,618
3.18.2	. . . . . Facility Operations	$6,091,372	$7,849,951	$6,970,662	50.00%	$20,911,985
3.19	. . . . Year 19	$9,279,388	$12,652,446	$10,965,917	50.00%	$32,897,750
3.19.1	. . . . . Facility Maintenance	$3,188,016	$4,346,860	$3,767,438	50.00%	$11,302,314
3.19.2	. . . . . Facility Operations	$6,091,372	$8,305,586	$7,198,479	50.00%	$21,595,437
3.20	. . . . Year 20	$27,018,484	$38,925,530	$32,972,007	50.00%	$98,916,021
3.20.1	. . . . . Facility Maintenance	$3,188,016	$4,592,975	$3,890,495	50.00%	$11,671,486
3.20.2	. . . . . Facility Operations	$6,091,372	$8,775,840	$7,433,606	50.00%	$22,300,817
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.21	. . . . Year 21	$9,279,388	$14,108,382	$11,693,885	50.00%	$35,081,654
3.21.1	. . . . . Facility Maintenance	$3,188,016	$4,847,060	$4,017,538	50.00%	$12,052,613
3.21.2	. . . . . Facility Operations	$6,091,372	$9,261,322	$7,676,347	50.00%	$23,029,041
3.22	. . . . Year 22	$9,279,388	$14,873,003	$12,076,196	50.00%	$36,228,587
3.22.1	. . . . . Facility Maintenance	$3,188,016	$5,109,752	$4,148,884	50.00%	$12,446,652
3.22.2	. . . . . Facility Operations	$6,091,372	$9,763,251	$7,927,312	50.00%	$23,781,935

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.23	. . . . Year 23	$9,279,388	$15,661,751	$12,470,570	50.00%	$37,411,709
3.23.1	. . . . . Facility Maintenance	$3,188,016	$5,380,733	$4,284,375	50.00%	$12,853,124
3.23.2	. . . . . Facility Operations	$6,091,372	$10,281,018	$8,186,195	50.00%	$24,558,584
3.24	. . . . Year 24	$9,279,388	$16,476,481	$12,877,935	50.00%	$38,633,804
3.24.1	. . . . . Facility Maintenance	$3,188,016	$5,660,641	$4,424,329	50.00%	$13,272,986
3.24.2	. . . . . Facility Operations	$6,091,372	$10,815,840	$8,453,606	50.00%	$25,360,818
3.25	. . . . Year 25	$9,279,388	$17,318,122	$13,298,755	50.00%	$39,896,265
3.25.1	. . . . . Facility Maintenance	$3,188,016	$5,949,794	$4,568,905	50.00%	$13,706,715
3.25.2	. . . . . Facility Operations	$6,091,372	$11,368,328	$8,729,850	50.00%	$26,189,549
3.26	. . . . Year 26	$9,279,388	$18,186,673	$13,733,030	50.00%	$41,199,091
3.26.1	. . . . . Facility Maintenance	$3,188,016	$6,248,193	$4,718,104	50.00%	$14,154,313
3.26.2	. . . . . Facility Operations	$6,091,372	$11,938,480	$9,014,926	50.00%	$27,044,778
3.27	. . . . Year 27	$9,279,388	$19,083,989	$14,181,689	50.00%	$42,545,066
3.27.1	. . . . . Facility Maintenance	$3,188,016	$6,556,474	$4,872,245	50.00%	$14,616,735
3.27.2	. . . . . Facility Operations	$6,091,372	$12,527,516	$9,309,444	50.00%	$27,928,331
3.28	. . . . Year 28	$9,279,388	$20,010,072	$14,644,730	50.00%	$43,934,190
3.28.1	. . . . . Facility Maintenance	$3,188,016	$6,874,638	$5,031,327	50.00%	$15,093,981
3.28.2	. . . . . Facility Operations	$6,091,372	$13,135,435	$9,613,403	50.00%	$28,840,210
3.29	. . . . Year 29	$9,279,388	$20,966,777	$15,123,083	50.00%	$45,369,248
3.29.1	. . . . . Facility Maintenance	$3,188,016	$7,203,322	$5,195,669	50.00%	$15,587,007
3.29.2	. . . . . Facility Operations	$6,091,372	$13,763,455	$9,927,414	50.00%	$29,782,241
3.30	. . . . Year 30	$27,018,484	$63,925,733	$45,472,109	50.00%	$136,416,326
3.30.1	. . . . . Facility Maintenance	$3,188,016	$7,542,846	$5,365,431	50.00%	$16,096,293
3.30.2	. . . . . Facility Operations	$6,091,372	$14,412,186	$10,251,779	50.00%	$30,755,337
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.31	. . . . Year 31	$9,279,388	$22,975,765	$16,127,576	50.00%	$48,382,729

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.31.1	. . . . . Facility Maintenance	$3,188,016	$7,893,528	$5,540,772	50.00%	$16,622,315
3.31.2	. . . . . Facility Operations	$6,091,372	$15,082,237	$10,586,805	50.00%	$31,760,414
3.32	. . . . Year 32	$9,279,388	$24,028,975	$16,654,182	50.00%	$49,962,545
3.32.1	. . . . . Facility Maintenance	$3,188,016	$8,255,367	$5,721,692	50.00%	$17,165,075
3.32.2	. . . . . Facility Operations	$6,091,372	$15,773,608	$10,932,490	50.00%	$32,797,470
3.33	. . . . Year 33	$9,279,388	$25,117,447	$17,198,418	50.00%	$51,595,253
3.33.1	. . . . . Facility Maintenance	$3,188,016	$8,629,322	$5,908,669	50.00%	$17,726,007
3.33.2	. . . . . Facility Operations	$6,091,372	$16,488,126	$11,289,749	50.00%	$33,869,247
3.34	. . . . Year 34	$9,279,388	$26,241,181	$17,760,285	50.00%	$53,280,854
3.34.1	. . . . . Facility Maintenance	$3,188,016	$9,015,390	$6,101,703	50.00%	$18,305,110
3.34.2	. . . . . Facility Operations	$6,091,372	$17,225,791	$11,658,581	50.00%	$34,975,744
3.35	. . . . Year 35	$9,279,388	$27,401,105	$18,340,246	50.00%	$55,020,739
3.35.1	. . . . . Facility Maintenance	$3,188,016	$9,413,892	$6,300,954	50.00%	$18,902,863
3.35.2	. . . . . Facility Operations	$6,091,372	$17,987,212	$12,039,292	50.00%	$36,117,877
3.36	. . . . Year 36	$9,279,388	$28,599,074	$18,939,231	50.00%	$56,817,693
3.36.1	. . . . . Facility Maintenance	$3,188,016	$9,825,465	$6,506,741	50.00%	$19,520,222
3.36.2	. . . . . Facility Operations	$6,091,372	$18,773,609	$12,432,490	50.00%	$37,297,471
3.37	. . . . Year 37	$9,279,388	$29,836,944	$19,558,166	50.00%	$58,674,498
3.37.1	. . . . . Facility Maintenance	$3,188,016	$10,250,747	$6,719,381	50.00%	$20,158,144
3.37.2	. . . . . Facility Operations	$6,091,372	$19,586,198	$12,838,785	50.00%	$38,516,354
3.38	. . . . Year 38	$9,279,388	$31,114,716	$20,197,052	50.00%	$60,591,156
3.38.1	. . . . . Facility Maintenance	$3,188,016	$10,689,736	$6,938,876	50.00%	$20,816,629
3.38.2	. . . . . Facility Operations	$6,091,372	$20,424,979	$13,258,176	50.00%	$39,774,527
3.39	. . . . Year 39	$9,279,388	$32,434,245	$20,856,816	50.00%	$62,570,449
3.39.1	. . . . . Facility Maintenance	$3,188,016	$11,143,072	$7,165,544	50.00%	$21,496,632
3.39.2	. . . . . Facility Operations	$6,091,372	$21,291,173	$13,691,272	50.00%	$41,073,817

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.40	. . . . Year 40	$9,279,388	$33,796,459	$21,537,924	50.00%	$64,613,771
3.40.1	. . . . . Facility Maintenance	$3,188,016	$11,611,073	$7,399,545	50.00%	$22,198,634
3.40.2	. . . . . Facility Operations	$6,091,372	$22,185,386	$14,138,379	50.00%	$42,415,137
4	Post Irradiation Examination	$178,178,400	$295,107,975	$236,643,188	50.00%	$709,929,563
4.1	. . . . Year 1	$4,454,460	$1,448,590	$2,951,525	50.00%	$8,854,576
4.2	. . . . Year 2	$4,454,460	$1,641,469	$3,047,964	50.00%	$9,143,893
4.3	. . . . Year 3	$4,454,460	$1,840,583	$3,147,521	50.00%	$9,442,564
4.4	. . . . Year 4	$4,454,460	$2,045,933	$3,250,197	50.00%	$9,750,590
4.5	. . . . Year 5	$4,454,460	$2,258,411	$3,356,436	50.00%	$10,069,307
4.6	. . . . Year 6	$4,454,460	$2,477,571	$3,466,015	50.00%	$10,398,046
4.7	. . . . Year 7	$4,454,460	$2,704,303	$3,579,381	50.00%	$10,738,144
4.8	. . . . Year 8	$4,454,460	$2,938,162	$3,696,311	50.00%	$11,088,933
4.9	. . . . Year 9	$4,454,460	$3,179,594	$3,817,027	50.00%	$11,451,080
4.10	. . . . Year 10	$4,454,460	$3,429,043	$3,941,752	50.00%	$11,825,255
4.11	. . . . Year 11	$4,454,460	$3,686,511	$4,070,486	50.00%	$12,211,457
4.12	. . . . Year 12	$4,454,460	$3,952,442	$4,203,451	50.00%	$12,610,354
4.13	. . . . Year 13	$4,454,460	$4,226,837	$4,340,649	50.00%	$13,021,946
4.14	. . . . Year 14	$4,454,460	$4,510,586	$4,482,523	50.00%	$13,447,569
1.15	. . . . Year 15	$4,454,460	$5,105,702	$4,780,081	50.00%	$14,340,243
4.16	. . . . Year 16	$4,454,460	$5,105,702	$4,780,081	50.00%	$14,340,243
4.17	. . . . Year 17	$4,454,460	$5,417,960	$4,936,210	50.00%	$14,808,630
4.18	. . . . Year 18	$4,454,460	$5,740,463	$5,097,461	50.00%	$15,292,384
4.19	. . . . Year 19	$4,454,460	$6,073,656	$5,264,058	50.00%	$15,792,174
4.20	. . . . Year 20	$4,454,460	$6,417,541	$5,436,000	50.00%	$16,308,001

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.21	. . . . Year 21	$4,454,460	$6,772,561	$5,613,510	50.00%	$16,840,531
4.22	. . . . Year 22	$4,454,460	$7,139,608	$5,797,034	50.00%	$17,391,103
4.23	. . . . Year 23	$4,454,460	$7,518,238	$5,986,349	50.00%	$17,959,046
4.24	. . . . Year 24	$4,454,460	$7,909,339	$6,181,900	50.00%	$18,545,699
4.25	. . . . Year 25	$4,454,460	$8,313,359	$6,383,909	50.00%	$19,151,728
4.26	. . . . Year 26	$4,454,460	$8,730,296	$6,592,378	50.00%	$19,777,134
4.27	. . . . Year 27	$4,454,460	$9,161,042	$6,807,751	50.00%	$20,423,254
4.28	. . . . Year 28	$4,454,460	$9,605,598	$7,030,029	50.00%	$21,090,086
4.29	. . . . Year 29	$4,454,460	$10,064,852	$7,259,656	50.00%	$21,778,969
4.30	. . . . Year 30	$4,454,460	$10,539,252	$7,496,856	50.00%	$22,490,569
4.31	. . . . Year 31	$4,454,460	$11,029,243	$7,741,851	50.00%	$23,225,554
4.32	. . . . Year 32	$4,454,460	$11,534,824	$7,994,642	50.00%	$23,983,926
4.33	. . . . Year 33	$4,454,460	$12,057,332	$8,255,896	50.00%	$24,767,688
4.34	. . . . Year 34	$4,454,460	$12,596,767	$8,525,614	50.00%	$25,576,841
4.35	. . . . Year 35	$4,454,460	$13,153,575	$8,804,017	50.00%	$26,412,052
4.36	. . . . Year 36	$4,454,460	$13,728,646	$9,091,553	50.00%	$27,274,659
4.37	. . . . Year 37	$4,454,460	$14,322,871	$9,388,665	50.00%	$28,165,996
4.38	. . . . Year 38	$4,454,460	$14,936,250	$9,695,355	50.00%	$29,086,065
4.39	. . . . Year 39	$4,454,460	$15,569,674	$10,012,067	50.00%	$30,036,201
4.40	. . . . Year 40	$4,454,460	$16,223,589	$10,339,024	50.00%	$31,017,073
5	Transportation	$212,314,000	$351,645,063	$281,979,531	50.00%	$845,938,594
5.1	. . . . Year 1	$5,307,850	$1,726,113	$3,516,981	50.00%	$10,550,944
5.2	. . . . Year 2	$5,307,850	$1,955,943	$3,631,896	50.00%	$10,895,689
5.3	. . . . Year 3	$5,307,850	$2,193,204	$3,750,527	50.00%	$11,251,580

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.4	. . . . Year 4	$5,307,850	$2,437,896	$3,872,873	50.00%	$11,618,618
5.5	. . . . Year 5	$5,307,850	$2,691,080	$3,999,465	50.00%	$11,998,395
5.6	. . . . Year 6	$5,307,850	$2,952,226	$4,130,038	50.00%	$12,390,114
5.7	. . . . Year 7	$5,307,850	$3,222,396	$4,265,123	50.00%	$12,795,369
5.8	. . . . Year 8	$5,307,850	$3,501,058	$4,404,454	50.00%	$13,213,362
5.9	. . . . Year 9	$5,307,850	$3,788,743	$4,548,297	50.00%	$13,644,890
5.10	. . . . Year 10	$5,307,850	$4,085,983	$4,696,916	50.00%	$14,090,749
5.11	. . . . Year 11	$5,307,850	$4,392,777	$4,850,313	50.00%	$14,550,940
5.12	. . . . Year 12	$5,307,850	$4,709,655	$5,008,753	50.00%	$15,026,258
5.13	. . . . Year 13	$5,307,850	$5,036,619	$5,172,234	50.00%	$15,516,703
5.14	. . . . Year 14	$5,307,850	$5,374,729	$5,341,289	50.00%	$16,023,868
5.15	. . . . Year 15	$5,307,850	$6,083,858	$5,695,854	50.00%	$17,087,562
5.16	. . . . Year 16	$5,307,850	$6,083,858	$5,695,854	50.00%	$17,087,562
5.17	. . . . Year 17	$5,307,850	$6,455,938	$5,881,894	50.00%	$17,645,682
5.18	. . . . Year 18	$5,307,850	$6,840,226	$6,074,038	50.00%	$18,222,114
5.19	. . . . Year 19	$5,307,850	$7,237,253	$6,272,552	50.00%	$18,817,655
5.20	. . . . Year 20	$5,307,850	$7,647,019	$6,477,435	50.00%	$19,432,304
5.21	. . . . Year 21	$5,307,850	$8,070,055	$6,688,953	50.00%	$20,066,858
5.22	. . . . Year 22	$5,307,850	$8,507,422	$6,907,636	50.00%	$20,722,908
5.23	. . . . Year 23	$5,307,850	$8,958,589	$7,133,220	50.00%	$21,399,659
5.24	. . . . Year 24	$5,307,850	$9,424,618	$7,366,234	50.00%	$22,098,703
5.25	. . . . Year 25	$5,307,850	$9,906,040	$7,606,945	50.00%	$22,820,836
5.25	. . . . Year 26	$5,307,850	$10,402,855	$7,855,353	50.00%	$23,566,058
5.27	. . . . Year 27	$5,307,850	$10,916,124	$8,111,987	50.00%	$24,335,961

Project Summary Report

Project Name: ***Lifecycle INL Estimate for Advanced PIE Alternate 4A***
Project Location: ***MFC***
Estimate Number: ***8B26-D***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.28	. . . . Year 28	$5,307,850	$11,445,848	$8,376,849	50.00%	$25,130,547
5.29	. . . . Year 29	$5,307,850	$11,993,087	$8,650,469	50.00%	$25,951,406
5.30	. . . . Year 30	$5,307,850	$12,558,373	$8,933,112	50.00%	$26,799,335
5.31	. . . . Year 31	$5,307,850	$13,142,237	$9,225,043	50.00%	$27,675,130
5.32	. . . . Year 32	$5,307,850	$13,744,678	$9,526,264	50.00%	$28,578,791
5.33	. . . . Year 33	$5,307,850	$14,367,288	$9,837,569	50.00%	$29,512,708
5.34	. . . . Year 34	$5,307,850	$15,010,069	$10,158,960	50.00%	$30,476,879
5.35	. . . . Year 35	$5,307,850	$15,673,550	$10,490,700	50.00%	$31,472,100
5.36	. . . . Year 36	$5,307,850	$16,358,794	$10,833,322	50.00%	$32,499,966
5.37	. . . . Year 37	$5,307,850	$17,066,861	$11,187,355	50.00%	$33,562,066
5.38	. . . . Year 38	$5,307,850	$17,797,752	$11,552,801	50.00%	$34,658,403
5.39	. . . . Year 39	$5,307,850	$18,552,528	$11,930,189	50.00%	$35,790,567
5.40	. . . . Year 40	$5,307,850	$19,331,720	$12,319,785	50.00%	$36,959,356
6	Deactivation, Decommissioning, and Demolition	$23,113,116	$87,686,539	$55,399,828	50.00%	$166,199,483
Total	Lifecycle INL Estimate for Advanced PIE	$974,117,525	$1,458,756,520	$1,182,292,502	48.60%	$3,615,166,547

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman

From: D. J. Radford / R. D. Allen, Cost Estimators

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #4B Oak Ridge National Laboratory

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $4,800,000,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, markup, and labor sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate

and/or schedule and should be reviewed by me. If you have any questions or comments, do not hesitate to contact me at 419-4165 or e-mail dradford@portageinc.com or Ross Allen at 526-0769 or e-mail ross.allen@inl.gov.

Attachments

cc: Estimate File 8B26-E

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Summary Report

Project Name: *Lifecycle ORNL Estimate for Advanced PIE Alternate 4B*
Project Location: *ORNL*
Project Number: *8B26-E*

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		153.61%	*48.95%*	
Total Estimated Cost (TEC)	$1,278,957,623	$1,964,550,359	$1,587,845,312	$4,831,353,293
		153.61%	*48.95%*	
Total Cost	$1,278,957,623	$1,964,550,359	$1,587,845,312	$4,831,353,293
Rounded Total Cost (Rounded to the nearest $ 100000000)				$4,800,000,000

		Remarks
Type of Estimate:	Class 5	
Estimator:	D. Radford	
Checked By:		
Approved By:		

Battelle Energy Alliance, LLC

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #4B
Estimator:	D. J. Radford / R. D. Allen
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26-E
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**

The objective of this work is to provide a life-cycle cost (LCC) for a scaled down version of the Post Irradiation Examination (PIE) Facility proposed to be located at Idaho National Laboratory (INL) to support advanced PIE activities for highly-irradiated nuclear fuels and materials. The scaled down version removes the space that was allocated for future expansion, and assumes that construction will be performed at Oak Ridge National Laboratory (ORNL).

B. **Included:**

This cost estimate includes LCC as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs, including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration. Includes DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Construction of a new facility at ORNL.
6. Construction subcontract management costs.
7. Operational readiness costs, including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR.
8. Facility operations costs for 40 years. See estimate back-up for more details.
9. Facility maintenance costs for 40 years, including annual facility maintenance costs, and equipment replacement costs.
10. Post irradiation examination for 40 years.

11. Transportation costs for 100 experiments per year.
12. Deactivation, decommissioning, and demolition (DD&D) of facility. Includes costs to DD&D the facility space to be used by the APIEC project. See estimate back-up for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Physical security personnel costs.
3. Additional utility upgrades outside of the facility

III. **ESTIMATE METHODOLOGY:** *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of them are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled Low Level Waste project. Engineering and design development costs are based on the DOE Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range.

Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

A "forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. **BASIS OF THE ESTIMATE:** *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association of the advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012, developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th, 9th, and 29th 2012. On August 17, 2012 B. Landman provided information regarding the scaling of the original PIE estimate (1D03-A).

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. The DOE operating contractor will provide resources for all project management and construction management resources.

2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by the DOE operating contractor.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Sales tax for materials in construction items is included as part of the contractor mark-ups.
4. Sales tax for equipment replacement has been included in the equipment purchase cost.
5. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.
6. Contractor markup rates are based information developed by BEA estimating. The application of markups varies based on cost basis and estimate methodology used.
7. Construction costs have been adjusted using the relative location factors published by RS Means between the INL and ORNL.
8. The Post Irradiation Examination Facility; estimate File #1D03-A was used as a cost basis.
9. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.

V. **ESTIMATE QUALITY ASSURANCE:** *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. **ASSUMPTIONS:** *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Mock-up space will be available at an ORNL facility and will not require space rental charges to the project.
B. Project Management and Project Integration are each 6% of all direct facility construction costs.
C. Procurement is included in the 6% project management adder.
D. Construction Management is 4% of all direct facility construction costs not including process equipment, or characterization equipment.
E. The effort to mock-up / install the three pieces that do not require being remote (TEM,APM, and SIMS) are equivalent to a low complexity piece of process equipment.
F. The testing verification effort is 20% of the remotize /mock-up/ install effort.

VII. **MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:**

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

Due to the preliminary nature of the design a detailed risk assessment has not been performed. With the exception of conceptual design a management reserve of 30% applied to the work through the completion of facility construction was included in the original estimate. As agreed to by the project team this has not been changed. Management reserve for conceptual design was included at the rates identified in the source estimate (1B33-A) by S. Wasley.

A blanket MR rate of 50% was applied to this cost estimate for all out year lifecycle costs. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.
2. Facility maintenance, refurbishment, and DD&D costs are based on anticipated facility area. If the facility area usage is determined to be greater than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is great than assumed, project costs may be impacted.
4. Based on the assumed life of the building no major refurbishments are anticipated. If major refurbishments are required due to environmental or other unforeseen impacts, project lifecycle costs will be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased production, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are based on anticipated facility area. If the facility area usage is determined to be less than anticipated project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. **OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:**

The construction portion of this estimate has been derived from an estimate developed by an outside source. While the estimate does include mark-ups they are incorporated in a manner incompatible with the standard BEA contractor mark-up report. As a result this report is not included in the estimate package.

Standard AACEI guidance for a Class 5 estimate indicates that the expected estimate at completion accuracy range of the estimate is -50% to +100% of the estimated costs including MR.

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation (Spent Cost)	$1,510,356	$0	$0	0.00%	$1,510,356
2	Advanced Post Irradiation (APEX) (PIE) Capabilities (TPC)	$133,640,074	$28,166,469	$47,749,771	29.51%	$209,556,314
2.1	. . . . Project Management	$5,674,426	$995,830	$1,879,721	28.18%	$8,549,977
2.1.1	. . . . . PM Definition Phase	$517,743	$9,889	$36,934	7.00%	$564,566
2.1.1.1	. . . . . Project Management	$517,743	$9,889	$36,934	7.00%	$564,566
2.1.1.1.1	*. . . . . CD -1 PM Oversight - Level of Effort (LOE)*	*$517,743*	*$9,889*	*$36,934*	*7.00%*	*$564,566*
2.1.2	. . . . . PM Execution Phase	$4,898,849	$916,761	$1,744,683	30.00%	$7,560,293
2.1.2.1	. . . . . PM Execution Phase	$4,898,849	$916,761	$1,744,683	30.00%	$7,560,293
2.1.2.1.1	*. . . . . Project Management CD2 through CD4*	*$4,898,849*	*$916,761*	*$1,744,683*	*30.00%*	*$7,560,293*
2.1.3	. . . . . PM Closeout Phase	$257,834	$69,180	$98,104	30.00%	$425,118
2.1.3.1	. . . . . PM Closeout Phase	$257,834	$69,180	$98,104	30.00%	$425,118
2.2	. . . . Conceptual Design of APEX Capability Studies	$2,483,822	$54,773	$380,789	15.00%	$2,919,384
2.2.1	. . . . . Alternatives Analysis	$443,458	$1,901	$66,804	15.00%	$512,162
2.2.1.1	. . . . . Alternative Definition and Selection	$288,554	$1,265	$43,473	15.00%	$333,291
2.2.1.1.1	*. . . . . Project Engineering - Alternatives Definition*	*$288,554*	*$1,265*	*$43,473*	*15.00%*	*$333,291*
2.2.1.1.1.1	*. . . . . General Studies*	*$147,090*	*$954*	*$22,206*	*15.00%*	*$170,250*
2.2.1.1.1.1.1	*. . . . . Existing U. S. Capabilities*	*$42,088*	*$848*	*$6,440*	*15.00%*	*$49,376*
2.2.1.1.1.1.2	*. . . . . Shipping Costs*	*$18,728*	*$35*	*$2,814*	*15.00%*	*$21,578*
2.2.1.1.1.1.3	*. . . . . Comparison Basis*	*$16,873*	*$18*	*$2,534*	*15.00%*	*$19,424*
2.2.1.1.1.1.4	*. . . . . Path Forward*	*$18,760*	*$35*	*$2,819*	*15.00%*	*$21,615*
2.2.1.1.1.1.5	*. . . . . Review Alternative Analysis*	*$40,876*	*$0*	*$6,131*	*15.00%*	*$47,008*
2.2.1.1.1.1.6	*. . . . . Incorporate Comments*	*$9,764*	*$18*	*$1,467*	*15.00%*	*$11,249*
2.2.1.1.1.2	*. . . . . No Action Alternative - Write Report*	*$14,054*	*$35*	*$2,113*	*15.00%*	*$16,203*
2.2.1.1.1.3	*. . . . . Complex Wide Distributed Capability - Identify, Estimate, Write Report*	*$62,411*	*$133*	*$9,382*	*15.00%*	*$71,926*

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.1.1.4	*. . . . . MFC Wide Distributed Capacity - Identify, Estimate, Write Report*	*$39,129*	*$108*	*$5,886*	*15.00%*	*$45,122*
2.2.1.1.5	*. . . . . PIE LIB - Write Report*	*$25,870*	*$35*	*$3,886*	*15.00%*	*$29,791*
2.2.1.2	. . . . . Tradeoff Studies	$154,904	$636	$23,331	15.00%	$178,871
2.2.1.2.1	*. . . . . Trade-off Studies*	*$154,904*	*$636*	*$23,331*	*15.00%*	*$178,871*
2.2.1.2.1.1	*. . . . . Site Location Trade-Off - Footprint Determination and Utilities*	*$111,004*	*$636*	*$16,746*	*15.00%*	*$128,386*
2.2.1.2.1.2	*. . . . . Electrical Capacity Study*	*$28,690*	*$0*	*$4,303*	*15.00%*	*$32,993*
2.2.1.2.1.3	*. . . . . Fire Water Availability Study*	*$6,821*	*$0*	*$1,023*	*15.00%*	*$7,844*
2.2.1.2.1.4	*. . . . . Sewer Water Availability Study*	*$8,389*	*$0*	*$1,258*	*15.00%*	*$9,648*
2.2.2	**. . . . . Conceptual Design of Preferred Alternative**	**$2,040,364**	**$52,872**	**$313,985**	**15.00%**	**$2,407,222**
2.2.2.1	. . . . . Engineering Supervision	$246,633	$4,711	$37,701	15.00%	$289,045
2.2.2.1.1	*. . . . . Engineering Supervision and Support*	*$246,633*	*$4,711*	*$37,701*	*15.00%*	*$289,045*
2.2.2.2	. . . . . Site D&D and Development	$191,432	$7,700	$29,870	15.00%	$229,002
2.2.2.2.1	*. . . . . Civil*	*$191,432*	*$7,700*	*$29,870*	*15.00%*	*$229,002*
2.2.2.3	. . . . . Facilities and Ancillary Support Systems	$861,053	$26,304	$133,103	15.00%	$1,020,460
2.2.2.3.1	*. . . . . Architectural*	*$83,543*	*$5,135*	*$13,302*	*15.00%*	*$101,979*
2.2.2.3.3	*. . . . . Electrical*	*$164,235*	*$5,664*	*$25,485*	*15.00%*	*$195,384*
2.2.2.3.4	*. . . . . Fire Protection*	*$25,237*	*$482*	*$3,858*	*15.00%*	*$29,577*
2.2.2.3.5.5	*. . . . . H&V*	*$100,370*	*$1,917*	*$15,343*	*15.00%*	*$117,630*
2.2.2.3.6	*. . . . . I&C*	*$76,005*	*$1,452*	*$11,618*	*15.00%*	*$89,075*
2.2.2.3.7	*. . . . . Mechanical*	*$184,316*	*$7,311*	*$28,744*	*15.00%*	*$220,371*
2.2.2.3.8	*. . . . . Structural*	*$227,348*	*$4,342*	*$34,754*	*15.00%*	*$266,444*
2.2.2.4	. . . . . Process Cell Equipment Design	$453,226	$8,657	$69,282	15.00%	$531,165
2.2.2.4.1	*. . . . . Sample Process Cell Equipment Design*	*$453,226*	*$8,657*	*$69,282*	*15.00%*	*$531,165*
2.2.2.5	. . . . . Exam Equipment and Modular Cells	$288,020	$5,501	$44,028	15.00%	$337,550
2.2.2.5.1	*. . . . . Examination Equipment Design*	*$288,020*	*$5,501*	*$44,028*	*15.00%*	*$337,550*

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3	**. . . . Project Integration and DOE 413 Deliverables Integration**	**$11,060,974**	**$1,943,654**	**$3,611,341**	**27.77%**	**$16,615,968**
2.3.1	**. . . . . Critical Decision 1 Evaluations**	**$790,402**	**$16,686**	**$111,651**	**13.83%**	**$918,739**
2.3.1.1	. . . . . Nuclear Safety	$346,286	$6,614	$52,935	15.00%	$405,836
2.3.1.1.1	*. . . . . Nuclear Safety Work Package*	*$346,286*	*$6,614*	*$52,935*	*15.00%*	*$405,836*
2.3.1.1.1.1	*. . . . . Safety Design Strategy*	*$95,228*	*$1,819*	*$14,557*	*15.00%*	*$111,604*
2.3.1.1.1.2	*. . . . . Preliminary Hazard Analysis Report*	*$43,817*	*$837*	*$6,698*	*15.00%*	*$51,352*
2.3.1.1.1.3	*. . . . . Conceptual Safety Design Report*	*$78,489*	*$1,499*	*$11,998*	*15.00%*	*$91,987*
2.3.1.1.1.4	*. . . . . Nuclear Safety Support*	*$128,752*	*$2,459*	*$19,682*	*15.00%*	*$150,893*
2.3.1.2	. . . . . Risk Management	$102,074	$1,950	$15,603	15.00%	$119,627
2.3.1.2.1	*. . . . . Risk Management Plan*	*$33,810*	*$646*	*$5,168*	*15.00%*	*$39,624*
2.3.1.2.2	*. . . . . Initial Risk Assessment Report*	*$47,261*	*$903*	*$7,225*	*15.00%*	*$55,388*
2.3.1.2.3	*. . . . . Support Risk Assessment*	*$21,003*	*$401*	*$3,211*	*15.00%*	*$24,614*
2.3.1.3	. . . . . DOE 413.3B Documents	$193,237	$5,280	$21,054	10.61%	$219,571
2.3.1.3.1	*. . . . . Project Management*	*$45,436*	*$868*	*$6,946*	*15.00%*	*$53,249*
2.3.1.3.1.1	*. . . . . Acquisition Strategy*	*$18,174*	*$347*	*$2,778*	*15.00%*	*$21,300*
2.3.1.3.1.2	*. . . . . Develop Project Execution Plan*	*$27,262*	*$521*	*$4,167*	*15.00%*	*$31,950*
2.3.1.3.2	*. . . . . Systems Engineering Work Package*	*$42,103*	*$1,060*	*$6,475*	*15.00%*	*$49,638*
2.3.1.3.2.1	*. . . . . Compile CD-1 Work Package*	*$42,103*	*$1,060*	*$6,475*	*15.00%*	*$49,638*
2.3.1.3.3	*. . . . . Cost Estimating and Scheduling CD1*	*$105,698*	*$3,352*	*$7,634*	*7.00%*	*$116,684*
2.3.1.3.3.1	*. . . . . Develop Project Cost Estimate (Baseline)*	*$48,699*	*$1,674*	*$3,526*	*7.00%*	*$53,899*
2.3.1.3.3.2	*. . . . . Develop Prelim Design Cost Estimate*	*$21,226*	*$637*	*$1,530*	*7.00%*	*$23,394*
2.3.1.3.3.3	*. . . . . Develop Project Schedule*	*$22,223*	*$581*	*$1,596*	*7.00%*	*$24,400*
2.3.1.3.3.4	*. . . . . Develop Prelim Design Schedule*	*$13,550*	*$460*	*$981*	*7.00%*	*$14,991*
2.3.1.4	. . . . . ESHQ&SS	$49,782	$951	$6,922	13.64%	$57,655
2.3.1.4.1	*. . . . . ES&H Plan*	*$23,606*	*$451*	*$3,608*	*15.00%*	*$27,665*
2.3.1.4.1.1	*. . . . . Prepare Preliminary ES&H Plan*	*$23,606*	*$451*	*$3,608*	*15.00%*	*$27,665*
2.3.1.4.2	*. . . . . Environmental Compliance*	*$17,739*	*$339*	*$2,712*	*15.00%*	*$20,789*

Portage

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.1.4.2.1	*. . . . . NEPA Documents*	*$17,739*	*$339*	*$2,712*	*15.00%*	*$20,789*
2.3.1.4.3	*. . . . . Quality Assurance*	*$8,437*	*$161*	*$602*	*7.00%*	*$9,200*
2.3.1.4.3.1	*. . . . . Quality Assurance Program Plan*	*$8,437*	*$161*	*$602*	*7.00%*	*$9,200*
2.3.1.5	. . . . . CD-1 Reviews	$99,023	$1,891	$15,137	15.00%	$116,051
2.3.1.5.1	*. . . . . Reviewers (Internal)*	*$43,384*	*$829*	*$6,632*	*15.00%*	*$50,844*
2.3.1.5.1.1	*. . . . . Conduct Conceptual Design Review*	*$43,384*	*$829*	*$6,632*	*15.00%*	*$50,844*
2.3.1.5.2	*. . . . . Reviewers (Independent/External)*	*$19,158*	*$366*	*$2,929*	*15.00%*	*$22,452*
2.3.1.5.2.1	*. . . . . Support DOE Technical Independent Project Review*	*$19,158*	*$366*	*$2,929*	*15.00%*	*$22,452*
2.3.1.5.3	*. . . . . Safeguards and Security*	*$36,482*	*$697*	*$5,577*	*15.00%*	*$42,755*
2.3.1.5.3.1	*. . . . . Preliminary Security Vulnerability Assessment Report*	*$36,482*	*$697*	*$5,577*	*15.00%*	*$42,755*
2.3.2	**. . . . . Critical Decision 2 Evaluations**	**$967,043**	**$142,585**	**$332,888**	**30.00%**	**$1,442,516**
2.3.2.1	. . . . . Critical Decision 2	$967,043	$142,585	$332,888	30.00%	$1,442,516
2.3.2.1.1	*. . . . . Nuclear Safety*	*$719,543*	*$106,092*	*$247,691*	*30.00%*	*$1,073,326*
2.3.2.1.2	*. . . . . Nuclear Safety Support*	*$247,500*	*$36,492*	*$85,198*	*30.00%*	*$369,190*
2.3.3	**. . . . . Critical Decision 3 Evaluations**	**$960,422**	**$179,731**	**$342,046**	**30.00%**	**$1,482,199**
2.3.3.1	. . . . . Critical Decision 3	$960,422	$179,731	$342,046	30.00%	$1,482,199
2.3.3.1.1	*. . . . . Nuclear Safety*	*$960,422*	*$179,731*	*$342,046*	*30.00%*	*$1,482,199*
2.3.4	**. . . . . Critical Decision 4 Evaluations**	**$206,267**	**$72,997**	**$83,779**	**30.00%**	**$363,043**
2.3.5	**. . . . . Post Critical Decision 4**	**$51,567**	**$18,249**	**$20,945**	**30.00%**	**$90,761**
2.3.6	**. . . . . Project Integration (Definition Phase)**	**$773,398**	**$14,948**	**$76,931**	**9.76%**	**$865,278**
2.3.6.1	. . . . . System Engineering Evaluations	$773,398	$14,948	$76,931	9.76%	$865,278
2.3.6.1.1	*. . . . . Project Integration CD1*	*$773,398*	*$14,948*	*$76,931*	*9.76%*	*$865,278*
2.3.6.1.1.1	*. . . . . Project Engineering and Support*	*$506,655*	*$9,853*	*$36,156*	*7.00%*	*$552,664*
2.3.6.1.1.2	*. . . . . DR - Systems Engineering*	*$266,744*	*$5,095*	*$40,776*	*15.00%*	*$312,614*
2.3.6.1.1.2.1	*. . . . . Systems Engineering Managment Plan (SEMP)*	*$42,455*	*$811*	*$6,490*	*15.00%*	*$49,755*

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.6.1.1.2.2	*. . . . . Systems Engineering -T&FRs*	*$106,137*	*$2,027*	*$16,225*	*15.00%*	*$124,389*
2.3.6.1.1.2.3	*. . . . . Systems Engineering -Action Tracking*	*$39,384*	*$752*	*$6,020*	*15.00%*	*$46,157*
2.3.6.1.1.2.4	*. . . . . Systems Engineering -Trade Study Support*	*$78,768*	*$1,504*	*$12,041*	*15.00%*	*$92,313*
2.3.7	**. . . . . Project Integration-Execution Phase**	**$4,898,849**	**$916,761**	**$1,744,683**	**30.00%**	**$7,560,293**
2.3.7.1	. . . . . Project Integration	$4,898,849	$916,761	$1,744,683	30.00%	$7,560,293
2.3.8	**. . . . . Project Integration-Closeout Phase**	**$257,834**	**$91,246**	**$104,724**	**30.00%**	**$453,804**
2.3.8.1	. . . . . Project Integration	$257,834	$91,246	$104,724	30.00%	$453,804
2.3.9	**. . . . . PM-Construction Management**	**$2,155,192**	**$490,450**	**$793,693**	**30.00%**	**$3,439,335**
2.3.9.1	. . . . . Construction Management	$2,155,192	$490,450	$793,693	30.00%	$3,439,335
2.4	**. . . . Preliminary Design**	**$10,281,266**	**$1,115,369**	**$3,418,990**	**30.00%**	**$14,815,625**
2.4.1	**. . . . . Preliminary Design**	**$10,281,266**	**$1,115,369**	**$3,418,990**	**30.00%**	**$14,815,625**
2.4.1.1	. . . . . Preliminary Design	$10,281,266	$1,115,369	$3,418,990	30.00%	$14,815,625
2.4.1.1.1	*. . . . . Site Development Preliminary Design (Title I)*	*$854,921*	*$92,747*	*$284,300*	*30.00%*	*$1,231,968*
2.4.1.1.2	*. . . . . Facility Structure & Ancillary Supt. Sys. Preliminary Design (Title I)*	*$4,480,959*	*$486,119*	*$1,490,123*	*30.00%*	*$6,457,201*
2.4.1.1.3	*. . . . . Modular Hot Cells Preliminary Design (Title I)*	*$4,945,386*	*$536,503*	*$1,644,567*	*30.00%*	*$7,126,455*
2.5	**. . . . Final Design**	**$150,066**	**$28,083**	**$53,445**	**30.00%**	**$231,593**
2.5.1	**. . . . . Final Design**	**$150,066**	**$28,083**	**$53,445**	**30.00%**	**$231,593**
2.5.1.1	. . . . . Final Design	$150,066	$28,083	$53,445	30.00%	$231,593
2.5.1.1.1	*. . . . . Site D&D Preliminary & Final Design (Title I)*	*$150,066*	*$28,083*	*$53,445*	*30.00%*	*$231,593*
2.6	**. . . . Procurement**	**$39,861,893**	**$9,071,248**	**$14,679,942**	**30.00%**	**$63,613,083**
2.6.1	**. . . . . Procurement**	**$39,861,893**	**$9,071,248**	**$14,679,942**	**30.00%**	**$63,613,083**
2.6.1.1	. . . . . Procurement	$39,861,893	$9,071,248	$14,679,942	30.00%	$63,613,083
2.6.1.1.1	*. . . . . Facility Structure & Ancillary Supt. Sys. Procurement/Fabrication*	*$3,208,395*	*$730,125*	*$1,181,556*	*30.00%*	*$5,120,076*
2.6.1.1.1.1	*. . . . . Miscellaneous Equipment*	*$772,186*	*$175,724*	*$284,373*	*30.00%*	*$1,232,283*
2.6.1.1.1.2	*. . . . . Mechanical Equipment*	*$2,436,209*	*$554,401*	*$897,183*	*30.00%*	*$3,887,793*

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.6.1.1.2.1	*. . . . . Exhaust Stack*	*$108,899*	*$24,782*	*$40,104*	*30.00%*	*$173,785*
2.6.1.1.2.2	*. . . . . Building HVAC Equipment*	*$208,565*	*$47,462*	*$76,808*	*30.00%*	*$332,835*
80.15.50.10.10.4.2.3	*. . . . . Exhaust System Equipment*	*$2,118,746*	*$482,156*	*$780,271*	*30.00%*	*$3,381,172*
2.6.1.1.2	*. . . . . Facility Process Equipment Procurement/Fabrication*	*$1,233,983*	*$280,814*	*$454,439*	*30.00%*	*$1,969,236*
2.6.1.1.3	*. . . . . Modular Hot Cells Procurement/Fabrication*	*$24,393,031*	*$5,551,046*	*$8,983,223*	*30.00%*	*$38,927,301*
2.6.1.1.4	*. . . . . Characterization Specialty Equipment Procurement/Fabrication*	*$11,026,484*	*$2,509,263*	*$4,060,724*	*30.00%*	*$17,596,471*
2.6.1.1.4.1	*. . . . . Thermal Examination*	*$860,000*	*$195,708*	*$316,712*	*30.00%*	*$1,372,420*
2.6.1.1.4.2	*. . . . . Microstructure Examination*	*$10,166,484*	*$2,313,555*	*$3,744,012*	*30.00%*	*$16,224,051*
2.7	**. . . . Construction**	**$59,171,296**	**$13,538,357**	**$21,812,896**	**30.00%**	**$94,522,550**
2.7.1	**. . . . . Construction**	**$59,171,296**	**$13,538,357**	**$21,812,896**	**30.00%**	**$94,522,550**
2.7.1.1	. . . . . Construction	$59,171,296	$13,538,357	$21,812,896	30.00%	$94,522,550
2.7.1.1.1	*. . . . . Title 3 Design*	*$926,733*	*$248,652*	*$352,615*	*30.00%*	*$1,528,000*
2.7.1.1.2	*. . . . . Site D&D Construction/Installation*	*$770,633*	*$206,769*	*$293,221*	*30.00%*	*$1,270,623*
2.7.1.1.2.1	*. . . . . Building Deactivation & Demolition*	*$770,633*	*$206,769*	*$293,221*	*30.00%*	*$1,270,623*
2.7.1.1.3	*. . . . . Site Development Construction/Installation*	*$5,064,129*	*$1,316,729*	*$1,914,257*	*30.00%*	*$8,295,115*
2.7.1.1.3.1	*. . . . . Civil*	*$3,627,521*	*$967,983*	*$1,378,651*	*30.00%*	*$5,974,155*
2.7.1.1.3.1.1	*. . . . . Site Preparation*	*$2,554,200*	*$685,319*	*$971,856*	*30.00%*	*$4,211,375*
2.7.1.1.3.1.2	*. . . . . Landscaping*	*$851,400*	*$228,440*	*$323,952*	*30.00%*	*$1,403,792*
2.7.1.1.3.1.3	*. . . . . Asphalt Paving*	*$113,478*	*$29,040*	*$42,755*	*30.00%*	*$185,274*
2.7.1.1.3.1.4	*. . . . . Concrete Paving*	*$108,442*	*$25,184*	*$40,088*	*30.00%*	*$173,714*
2.7.1.1.3.2	*. . . . . Electrical*	*$1,246,215*	*$309,182*	*$466,619*	*30.00%*	*$2,022,015*
2.7.1.1.3.2.1	*. . . . . Equipment*	*$714,784*	*$188,464*	*$270,974*	*30.00%*	*$1,174,222*
2.7.1.1.3.2.2	*. . . . . Raceway*	*$315,321*	*$69,955*	*$115,583*	*30.00%*	*$500,859*
2.7.1.1.3.2.3	*. . . . . Cable*	*$167,367*	*$39,780*	*$62,144*	*30.00%*	*$269,290*
2.7.1.1.3.2.4	*. . . . . Demo*	*$48,743*	*$10,983*	*$17,918*	*30.00%*	*$77,643*
2.7.1.1.3.3	*. . . . . Overtime (Distributed)*	*$190,394*	*$39,564*	*$68,987*	*30.00%*	*$298,945*

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4	. . . . . Facility Structure & Ancillary Supt. Sys. Construction/Installation	$24,231,385	$5,666,842	$8,969,468	30.00%	$38,867,695
2.7.1.1.4.1	. . . . . Main Facility	$16,293,061	$3,843,948	$6,041,103	30.00%	$26,178,112
2.7.1.1.4.1.1	 Civil	$8,140,246	$1,881,250	$3,006,449	30.00%	$13,027,945
2.7.1.1.4.1.1.1	. . . . . Concrete	$3,726,448	$829,453	$1,366,770	30.00%	$5,922,671
2.7.1.1.4.1.1.2	. . . . . Masonry	$513,202	$110,991	$187,258	30.00%	$811,451
2.7.1.1.4.1.1.3	. . . . . Metals	$1,591,350	$380,532	$591,565	30.00%	$2,563,447
2.7.1.1.4.1.1.4	. . . . . Openings	$199,204	$48,647	$74,355	30.00%	$322,207
2.7.1.1.4.1.1.5	. . . . . Thermal & Moisture Protection	$489,276	$113,334	$180,783	30.00%	$783,393
2.7.1.1.4.1.1.6	. . . . . Finishes	$1,513,891	$375,347	$566,771	30.00%	$2,456,010
2.7.1.1.4.1.1.7	. . . . . Miscellaneous Equipment	$106,874	$22,946	$38,946	30.00%	$168,767
2.7.1.1.4.1.2	. . . . . Mechanical	$7,406,297	$1,788,915	$2,758,563	30.00%	$11,953,775
2.7.1.1.4.1.2.1	. . . . . HVAC, Entire Bldg.	$4,870,848	$1,180,146	$1,815,298	30.00%	$7,866,292
2.7.1.1.4.1.2.1.1	. . . . . Heating, AC & Air Supply	$967,944	$237,757	$361,710	30.00%	$1,567,412
2.7.1.1.4.1.2.1.2	. . . . . Primary Exhaust System & Stack	$2,706,954	$658,237	$1,009,557	30.00%	$4,374,748
2.7.1.1.4.1.2.1.3	. . . . . Suspect Exhaust System	$1,195,949	$284,153	$444,030	30.00%	$1,924,132
2.7.1.1.4.1.2.2	. . . . . Piping, Entire Bldg.	$2,275,070	$544,549	$845,886	30.00%	$3,665,506
2.7.1.1.4.1.2.2.01	. . . . . Sanitary Waste System	$122,378	$26,999	$44,813	30.00%	$194,190
2.7.1.1.4.1.2.2.01.1	 Civil	$9,305	$2,177	$3,445	30.00%	$14,926
2.7.1.1.4.1.2.2.01.2	. . . . . Mechanical	$113,073	$24,822	$41,369	30.00%	$179,264
2.7.1.1.4.1.2.2.01.1	. . . . . Equipment	$12,737	$3,115	$4,756	30.00%	$20,607
2.7.1.1.4.1.2.2.01.2	. . . . . Piping	$100,336	$21,707	$36,613	30.00%	$158,656
2.7.1.1.4.1.2.2.02	. . . . . Safety Shower System	$34,805	$7,984	$12,837	30.00%	$55,626
2.7.1.1.4.1.2.2.02.1	. . . . . Equipment	$6,870	$1,700	$2,571	30.00%	$11,140
2.7.1.1.4.1.2.2.02.2	. . . . . Piping	$25,221	$5,681	$9,271	30.00%	$40,173
2.7.1.1.4.1.2.2.02.3	. . . . . Insulation	$2,714	$603	$995	30.00%	$4,312

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.1.2.2.03	Clear Water Drain System	$50,811	$11,581	$18,718	30.00%	$81,110
2.7.1.1.4.1.2.2.03.1	Equipment	$19,095	$4,735	$7,149	30.00%	$30,978
2.7.1.1.4.1.2.2.03.2	Piping & Valves	$31,716	$6,846	$11,569	30.00%	$50,132
2.7.1.1.4.1.2.2.04	Cooling Water System	$357,725	$80,746	$131,541	30.00%	$570,013
2.7.1.1.4.1.2.2.04.1	Equipment	$83,656	$21,056	$31,414	30.00%	$136,126
2.7.1.1.4.1.2.2.04.2	Piping	$242,144	$52,734	$88,463	30.00%	$383,342
2.7.1.1.4.1.2.2.04.3	Fiberglass Insul,ASJ/SSL,1"	$19,634	$4,293	$7,178	30.00%	$31,105
2.7.1.1.4.1.2.2.04.4	1" Fiberglass w/0.016" Alum. Jacket, 2" dia.	$10,088	$2,181	$3,681	30.00%	$15,951
2.7.1.1.4.1.2.2.04.5	1" Fiberglass w/0.016" Alum. Jacket, 5" dia.	$2,203	$482	$805	30.00%	$3,490
2.7.1.1.4.1.2.2.05	Facility DP Monitoring System	$91,281	$21,818	$33,930	30.00%	$147,029
2.7.1.1.4.1.2.2.05.1	Equipment	$70,292	$17,219	$26,253	30.00%	$113,764
2.7.1.1.4.1.2.2.05.2	Piping	$20,989	$4,600	$7,677	30.00%	$33,265
2.7.1.1.4.1.2.2.06	Nitrogen Liquid & Gas System	$178,075	$43,833	$66,572	30.00%	$288,481
2.7.1.1.4.1.2.2.06.1	Civil	$5,585	$1,246	$2,049	30.00%	$8,880
2.7.1.1.4.1.2.2.06.2	Instrumentation & Controls	$11,157	$2,696	$4,156	30.00%	$18,010
2.7.1.1.4.1.2.2.06.3	Equipment	$67,680	$17,505	$25,555	30.00%	$110,740
2.7.1.1.4.1.2.2.06.4	Piping/Valves	$80,641	$19,541	$30,055	30.00%	$130,237
2.7.1.1.4.1.2.2.06.5	1.5" Cal-Sil. w/0.016" Alum. Jacket, 1" dia. & dn.	$6,070	$1,326	$2,219	30.00%	$9,615
2.7.1.1.4.1.2.2.06.6	1.5" Cal-Sil. w/0.016" Alum. Jacket, 1.25" & 1.5" dia.	$6,941	$1,520	$2,538	30.00%	$10,999
2.7.1.1.4.1.2.2.07	Leak Monitoring System	$123,431	$30,210	$46,093	30.00%	$199,734
2.7.1.1.4.1.2.2.07.1	Equipment	$29,393	$7,682	$11,123	30.00%	$48,198

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.1.2.2.07.2	Piping	$94,038	$22,528	$34,970	30.00%	$151,536
2.7.1.1.4.1.2.2.08	Pneumatic Transfer System	$386,146	$95,409	$144,466	30.00%	$626,021
2.7.1.1.4.1.2.2.08.1	Civil/Structural	$47,737	$10,999	$17,621	30.00%	$76,356
2.7.1.1.4.1.2.2.08.2	Equipment	$116,660	$29,452	$43,834	30.00%	$189,945
2.7.1.1.4.1.2.2.08.3	Piping/Valves	$221,749	$54,959	$83,012	30.00%	$359,719
2.7.1.1.4.1.2.2.09	Fixed Air Sampling System	$123,819	$26,734	$45,166	30.00%	$195,720
2.7.1.1.4.1.2.2.10	Plant Air System	$247,372	$64,577	$93,585	30.00%	$405,533
2.7.1.1.4.1.2.2.11	Breathing Air System	$272,768	$65,261	$101,409	30.00%	$439,437
2.7.1.1.4.1.2.2.12	Nitrogen Gas System	$29,615	$6,715	$10,899	30.00%	$47,230
2.7.1.1.4.1.2.2.13	P-10 Gas System	$29,615	$6,715	$10,899	30.00%	$47,230
2.7.1.1.4.1.2.2.14	Specialty No. 1 Gas System	$29,615	$6,715	$10,899	30.00%	$47,230
2.7.1.1.4.1.2.2.15	Specialty No. 2 Gas System	$29,615	$6,715	$10,899	30.00%	$47,230
2.7.1.1.4.1.2.2.16	Deionized Water	$167,997	$42,536	$63,160	30.00%	$273,692
2.7.1.1.4.1.2.3	Fire Protection, Entire Bldg.	$260,379	$64,219	$97,379	30.00%	$421,977
2.7.1.1.4.1.3	Electrical	$746,518	$173,783	$276,091	30.00%	$1,196,392
2.7.1.1.4.1.3.1	Gallery	$501,051	$116,266	$185,195	30.00%	$802,512
2.7.1.1.4.1.3.2	Office	$215,033	$50,425	$79,637	30.00%	$345,095
2.7.1.1.4.1.3.3	Grounding and Lightning Protection	$30,434	$7,092	$11,258	30.00%	$48,785
2.7.1.1.4.2	Storage Annex	$3,409,064	$780,571	$1,256,890	30.00%	$5,446,524
2.7.1.1.4.2.1	Civil	$3,051,288	$697,613	$1,124,670	30.00%	$4,873,570
2.7.1.1.4.2.1.1	Concrete	$1,607,661	$356,175	$589,151	30.00%	$2,552,988
2.7.1.1.4.2.1.2	Masonry	$116,497	$25,195	$42,508	30.00%	$184,200
2.7.1.1.4.2.1.3	Metals	$723,623	$174,806	$269,529	30.00%	$1,167,958
2.7.1.1.4.2.1.4	Openings	$98,217	$24,613	$36,849	30.00%	$159,679

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.2.1.5	Thermal & Moisture Protection	$246,299	$57,188	$91,046	30.00%	$394,533
2.7.1.1.4.2.1.6	Finishes	$258,990	$59,635	$95,588	30.00%	$414,213
2.7.1.1.4.2.2	Electrical	$357,776	$82,958	$132,220	30.00%	$572,954
2.7.1.1.4.3	HVAC & Mechanical Room	$3,364,535	$787,500	$1,245,610	30.00%	$5,397,645
2.7.1.1.4.3.1	Civil	$2,790,936	$649,030	$1,031,990	30.00%	$4,471,955
2.7.1.1.4.3.1.1	Concrete	$409,836	$87,968	$149,341	30.00%	$647,146
2.7.1.1.4.3.1.2	Masonry	$245,258	$53,042	$89,490	30.00%	$387,790
2.7.1.1.4.3.1.3	Metals	$1,141,808	$277,509	$425,795	30.00%	$1,845,111
2.7.1.1.4.3.1.4	Openings	$78,531	$20,068	$29,580	30.00%	$128,179
2.7.1.1.4.3.1.5	Thermal & Moisture Protection	$586,257	$135,900	$216,647	30.00%	$938,804
2.7.1.1.4.3.1.6	Finishes	$329,245	$74,543	$121,136	30.00%	$524,924
2.7.1.1.4.3.2	Mechanical	$292,600	$72,324	$109,477	30.00%	$474,401
2.7.1.1.4.3.2.1	HVAC	$158,247	$38,870	$59,135	30.00%	$256,253
2.7.1.1.4.3.2.2	Piping	$92,180	$22,138	$34,296	30.00%	$148,614
2.7.1.1.4.3.2.2.1	Cooling Water System	$54,496	$12,301	$20,039	30.00%	$86,836
2.7.1.1.4.3.2.2.1.1	Equipment	$12,744	$3,208	$4,786	30.00%	$20,737
2.7.1.1.4.3.2.2.1.2	Piping	$36,888	$8,034	$13,476	30.00%	$58,398
2.7.1.1.4.3.2.2.1.3	Insulation	$4,864	$1,060	$1,777	30.00%	$7,700
2.7.1.1.4.3.2.2.1.31	Fiberglass Insul,ASJ/SSL,1", 2006	$2,991	$654	$1,094	30.00%	$4,739
2.7.1.1.4.3.2.2.1.32	1" Fiberglass w/0.016" Alum. Jacket, 2" dia.	$1,537	$332	$561	30.00%	$2,430
2.7.1.1.4.3.2.2.1.33	1" Fiberglass w/0.016" Alum. Jacket, 5" dia.	$336	$73	$123	30.00%	$532
2.7.1.1.4.3.2.2.2	Plant Air System	$37,685	$9,838	$14,257	30.00%	$61,779
2.7.1.1.4.3.2.3	Fire Protection	$42,172	$11,315	$16,046	30.00%	$69,534
2.7.1.1.4.3.3	Electrical	$280,999	$66,146	$104,144	30.00%	$451,289
2.7.1.1.4.4	Earthwork	$277,095	$70,373	$104,240	30.00%	$451,709

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.4.1	*. . . . . Building Excavation*	*$277,095*	*$70,373*	*$104,240*	*30.00%*	*$451,709*
2.7.1.1.4.5	*. . . . . Overtime (Distributed)*	*$887,631*	*$184,450*	*$321,624*	*30.00%*	*$1,393,704*
2.7.1.1.5	*. . . . . Facility Process Equipment Construction/Installation*	*$8,933,172*	*$1,984,802*	*$3,275,392*	*30.00%*	*$14,193,365*
2.7.1.1.5.1	*. . . . . Remotize/ Mockup/ Install Process Equipment*	*$6,933,172*	*$1,448,180*	*$2,514,406*	*30.00%*	*$10,895,757*
2.7.1.1.5.2	*. . . . . Waste Packaging Cell*	*$1,000,000*	*$268,311*	*$380,493*	*30.00%*	*$1,648,804*
2.7.1.1.5.3	*. . . . . Sample Storage Cell*	*$1,000,000*	*$268,311*	*$380,493*	*30.00%*	*$1,648,804*
2.7.1.1.6	*. . . . . Modular Hot Cells Construction/Installation*	*$10,148,746*	*$2,181,685*	*$3,699,129*	*30.00%*	*$16,029,560*
2.7.1.1.6.1	*. . . . . Civil*	*$9,070,842*	*$1,942,735*	*$3,304,073*	*30.00%*	*$14,317,650*
2.7.1.1.6.1.1	*. . . . . Concrete*	*$1,723,694*	*$376,266*	*$629,988*	*30.00%*	*$2,729,947*
2.7.1.1.6.1.2	*. . . . . Metals*	*$6,649,391*	*$1,417,940*	*$2,420,199*	*30.00%*	*$10,487,530*
2.7.1.1.6.1.3	*. . . . . Openings*	*$649,330*	*$138,466*	*$236,339*	*30.00%*	*$1,024,134*
2.7.1.1.6.1.4	*. . . . . Penetrations*	*$48,428*	*$10,063*	*$17,547*	*30.00%*	*$76,038*
2.7.1.1.6.2	*. . . . . Mechanical*	*$286,231*	*$62,140*	*$104,511*	*30.00%*	*$452,883*
2.7.1.1.6.3	*. . . . . Electrical*	*$213,008*	*$56,564*	*$80,872*	*30.00%*	*$350,443*
2.7.1.1.6.4	*. . . . . Overtime (Distributed)*	*$578,664*	*$120,246*	*$209,673*	*30.00%*	*$908,583*
2.7.1.1.7	*. . . . . Characterization Specialty Equipment Construction/Installation*	*$9,096,499*	*$1,932,879*	*$3,308,813*	*30.00%*	*$14,338,192*
2.7.1.1.7.1	*. . . . . Remotize/ Mockup/ Instal Thermal Examination*	*$4,207,408*	*$879,503*	*$1,526,074*	*30.00%*	*$6,612,985*
2.7.1.1.7.2	*. . . . . Remotize/ Mockup/ Instal Microstructure Examination*	*$4,889,091*	*$1,053,376*	*$1,782,740*	*30.00%*	*$7,725,206*
2.8	**. . . . Startup**	**$3,167,693**	**$786,169**	**$1,186,159**	**30.00%**	**$5,140,020**
2.8.1	**. . . . . Startup**	**$3,167,693**	**$786,169**	**$1,186,159**	**30.00%**	**$5,140,020**
2.8.1.1	. . . . . Startup	$3,167,693	$786,169	$1,186,159	30.00%	$5,140,020
2.8.1.1.1	*. . . . . Facility Process Equipment Testing & Verification*	*$1,464,491*	*$363,047*	*$548,261*	*30.00%*	*$2,375,799*
2.8.1.1.2	*. . . . . Characterization Specialty Equipment Testing & Verification*	*$1,703,203*	*$423,121*	*$637,897*	*30.00%*	*$2,764,221*
2.8.1.1.2.1	*. . . . . Testing & Verification Thermal Examination*	*$824,282*	*$204,339*	*$308,586*	*30.00%*	*$1,337,207*

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.8.1.1.2.2	*. . . . . Testing & Verification Microstructure Examination*	*$878,921*	*$218,782*	*$329,311*	*30.00%*	*$1,427,014*
2.9	**. . . . Closeout**	**$1,788,638**	**$632,988**	**$726,488**	**30.00%**	**$3,148,113**
2.9.1	**. . . . . Closeout**	**$1,788,638**	**$632,988**	**$726,488**	**30.00%**	**$3,148,113**
2.9.1.2	. . . . . Closeout	$1,788,638	$632,988	$726,488	30.00%	$3,148,113
2.9.1.2.1	*. . . . . Site D&D Operations Readiness & Turnover*	*$25,732*	*$9,106*	*$10,451*	*30.00%*	*$45,289*
2.9.1.2.2	*. . . . . Site Development Operations Readiness & Turnover*	*$146,592*	*$51,878*	*$59,541*	*30.00%*	*$258,010*
2.9.1.2.3	*. . . . . Facility Structure & Ancillary Supt. Sys.Operations Readiness & Turnover*	*$768,340*	*$271,911*	*$312,075*	*30.00%*	*$1,352,326*
2.9.1.2.4	*. . . . . Modular Hot Cells Operations Readiness & Turnover*	*$847,975*	*$300,093*	*$344,420*	*30.00%*	*$1,492,488*
3	**Facility Operations and Maintenance**	**$424,392,808**	**$695,942,428**	**$560,167,618**	**50.00%**	**$1,680,502,854**
3.1	**. . . . Year 1**	**$9,279,388**	**$3,017,657**	**$6,148,522**	**50.00%**	**$18,445,567**
3.1.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,036,743**	**$2,112,379**	**50.00%**	**$6,337,138**
3.1.2	**. . . . . Facility Operations**	**$6,091,372**	**$1,980,914**	**$4,036,143**	**50.00%**	**$12,108,429**
3.2	**. . . . Year 2**	**$9,279,388**	**$3,419,454**	**$6,349,421**	**50.00%**	**$19,048,264**
3.2.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,174,784**	**$2,181,400**	**50.00%**	**$6,544,200**
3.2.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,244,671**	**$4,168,021**	**50.00%**	**$12,504,064**
3.3	**. . . . Year 3**	**$9,279,388**	**$3,834,243**	**$6,556,816**	**50.00%**	**$19,670,447**
3.3.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,317,288**	**$2,252,652**	**50.00%**	**$6,757,956**
3.3.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,516,955**	**$4,304,163**	**50.00%**	**$12,912,490**
3.4	**. . . . Year 4**	**$9,279,388**	**$4,262,023**	**$6,770,705**	**50.00%**	**$20,312,116**
3.4.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,464,256**	**$2,326,136**	**50.00%**	**$6,978,408**
3.4.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,797,767**	**$4,444,570**	**50.00%**	**$13,333,709**
3.5	**. . . . Year 5**	**$9,279,388**	**$4,704,650**	**$6,992,019**	**50.00%**	**$20,976,057**
3.5.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,616,324**	**$2,402,170**	**50.00%**	**$7,206,510**
3.5.2	**. . . . . Facility Operations**	**$6,091,372**	**$3,088,326**	**$4,589,849**	**50.00%**	**$13,769,546**
3.6	**. . . . Year 6**	**$9,279,388**	**$5,161,196**	**$7,220,292**	**50.00%**	**$21,660,875**

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.6.1	. . . . . Facility Maintenance	$3,188,016	$1,773,174	$2,480,595	50.00%	$7,441,786
3.6.2	. . . . . Facility Operations	$6,091,372	$3,388,021	$4,739,697	50.00%	$14,219,090
3.7	. . . . Year 7	$9,279,388	$5,633,516	$7,456,452	50.00%	$22,369,357
3.7.1	. . . . . Facility Maintenance	$3,188,016	$1,935,445	$2,561,730	50.00%	$7,685,191
3.7.2	. . . . . Facility Operations	$6,091,372	$3,698,072	$4,894,722	50.00%	$14,684,166
3.8	. . . . Year 8	$9,279,388	$6,120,684	$7,700,036	50.00%	$23,100,108
3.8.1	. . . . . Facility Maintenance	$3,188,016	$2,102,815	$2,645,416	50.00%	$7,936,247
3.8.2	. . . . . Facility Operations	$6,091,372	$4,017,869	$5,054,620	50.00%	$15,163,861
3.9	. . . . Year 9	$9,279,388	$6,623,627	$7,951,508	50.00%	$23,854,523
3.9.1	. . . . . Facility Maintenance	$3,188,016	$2,275,606	$2,731,811	50.00%	$8,195,433
3.9.2	. . . . . Facility Operations	$6,091,372	$4,348,021	$5,219,697	50.00%	$15,659,090
3.10	. . . . Year 10	$27,018,484	$20,798,829	$23,908,656	50.00%	$71,725,969
3.10.1	. . . . . Facility Maintenance	$3,188,016	$2,454,135	$2,821,075	50.00%	$8,463,226
3.10.2	. . . . . Facility Operations	$6,091,372	$4,689,138	$5,390,255	50.00%	$16,170,765
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.11	. . . . Year 11	$9,279,388	$7,679,622	$8,479,505	50.00%	$25,438,514
3.11.1	. . . . . Facility Maintenance	$3,188,016	$2,638,402	$2,913,209	50.00%	$8,739,627
3.11.2	. . . . . Facility Operations	$6,091,372	$5,041,219	$5,566,296	50.00%	$16,698,887
3.12	. . . . Year 12	$9,279,388	$8,233,601	$8,756,494	50.00%	$26,269,483
3.12.1	. . . . . Facility Maintenance	$3,188,016	$2,828,727	$3,008,371	50.00%	$9,025,114
3.12.2	. . . . . Facility Operations	$6,091,372	$5,404,874	$5,748,123	50.00%	$17,244,370
3.13	. . . . Year 13	$9,279,388	$8,805,211	$9,042,300	50.00%	$27,126,899
3.13.1	. . . . . Facility Maintenance	$3,188,016	$3,025,108	$3,106,562	50.00%	$9,319,687
3.13.2	. . . . . Facility Operations	$6,091,372	$5,780,103	$5,935,737	50.00%	$17,807,212
3.14	. . . . Year 14	$9,279,388	$9,396,308	$9,337,848	50.00%	$28,013,544
3.14.1	. . . . . Facility Maintenance	$3,188,016	$3,228,185	$3,208,101	50.00%	$9,624,302

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.14.2	. . . . . Facility Operations	$6,091,372	$6,168,123	$6,129,748	50.00%	$18,389,243
3.15	. . . . Year 15	$9,279,388	$10,636,035	$9,957,711	50.00%	$29,873,134
3.15.1	. . . . . Facility Maintenance	$3,188,016	$3,654,104	$3,421,060	50.00%	$10,263,180
3.15.2	. . . . . Facility Operations	$6,091,372	$6,981,931	$6,536,651	50.00%	$19,609,954
3.16	. . . . Year 16	$9,279,388	$10,636,035	$9,957,711	50.00%	$29,873,134
3.16.1	. . . . . Facility Maintenance	$3,188,016	$3,654,104	$3,421,060	50.00%	$10,263,180
3.16.2	. . . . . Facility Operations	$6,091,372	$6,981,931	$6,536,651	50.00%	$19,609,954
3.17	. . . . Year 17	$9,279,388	$11,286,520	$10,282,954	50.00%	$30,848,861
3.17.1	. . . . . Facility Maintenance	$3,188,016	$3,877,584	$3,532,800	50.00%	$10,598,400
3.17.2	. . . . . Facility Operations	$6,091,372	$7,408,936	$6,750,154	50.00%	$20,250,462
3.18	. . . . Year 18	$9,279,388	$11,958,347	$10,618,868	50.00%	$31,856,603
3.18.1	. . . . . Facility Maintenance	$3,188,016	$4,108,396	$3,648,206	50.00%	$10,944,618
3.18.2	. . . . . Facility Operations	$6,091,372	$7,849,951	$6,970,662	50.00%	$20,911,985
3.19	. . . . Year 19	$9,279,388	$12,652,446	$10,965,917	50.00%	$32,897,750
3.19.1	. . . . . Facility Maintenance	$3,188,016	$4,346,860	$3,767,438	50.00%	$11,302,314
3.19.2	. . . . . Facility Operations	$6,091,372	$8,305,586	$7,198,479	50.00%	$21,595,437
3.20	. . . . Year 20	$27,018,484	$38,925,530	$32,972,007	50.00%	$98,916,021
3.20.1	. . . . . Facility Maintenance	$3,188,016	$4,592,975	$3,890,495	50.00%	$11,671,486
3.20.2	. . . . . Facility Operations	$6,091,372	$8,775,840	$7,433,606	50.00%	$22,300,817
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.21	. . . . Year 21	$9,279,388	$14,108,382	$11,693,885	50.00%	$35,081,654
3.21.1	. . . . . Facility Maintenance	$3,188,016	$4,847,060	$4,017,538	50.00%	$12,052,613
3.21.2	. . . . . Facility Operations	$6,091,372	$9,261,322	$7,676,347	50.00%	$23,029,041
3.22	. . . . Year 22	$9,279,388	$14,873,003	$12,076,196	50.00%	$36,228,587
3.22.1	. . . . . Facility Maintenance	$3,188,016	$5,109,752	$4,148,884	50.00%	$12,446,652
3.22.2	. . . . . Facility Operations	$6,091,372	$9,763,251	$7,927,312	50.00%	$23,781,935

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.23	. . . . Year 23	$9,279,388	$15,661,751	$12,470,570	50.00%	$37,411,709
3.23.1	. . . . . Facility Maintenance	$3,188,016	$5,380,733	$4,284,375	50.00%	$12,853,124
3.23.2	. . . . . Facility Operations	$6,091,372	$10,281,018	$8,186,195	50.00%	$24,558,584
3.24	. . . . Year 24	$9,279,388	$16,476,481	$12,877,935	50.00%	$38,633,804
3.24.1	. . . . . Facility Maintenance	$3,188,016	$5,660,641	$4,424,329	50.00%	$13,272,986
3.24.2	. . . . . Facility Operations	$6,091,372	$10,815,840	$8,453,606	50.00%	$25,360,818
3.25	. . . . Year 25	$9,279,388	$17,318,122	$13,298,755	50.00%	$39,896,265
3.25.1	. . . . . Facility Maintenance	$3,188,016	$5,949,794	$4,568,905	50.00%	$13,706,715
3.25.2	. . . . . Facility Operations	$6,091,372	$11,368,328	$8,729,850	50.00%	$26,189,549
3.26	. . . . Year 26	$9,279,388	$18,186,673	$13,733,030	50.00%	$41,199,091
3.26.1	. . . . . Facility Maintenance	$3,188,016	$6,248,193	$4,718,104	50.00%	$14,154,313
3.26.2	. . . . . Facility Operations	$6,091,372	$11,938,480	$9,014,926	50.00%	$27,044,778
3.27	. . . . Year 27	$9,279,388	$19,083,989	$14,181,689	50.00%	$42,545,066
3.27.1	. . . . . Facility Maintenance	$3,188,016	$6,556,474	$4,872,245	50.00%	$14,616,735
3.27.2	. . . . . Facility Operations	$6,091,372	$12,527,516	$9,309,444	50.00%	$27,928,331
3.28	. . . . Year 28	$9,279,388	$20,010,072	$14,644,730	50.00%	$43,934,190
3.28.1	. . . . . Facility Maintenance	$3,188,016	$6,874,638	$5,031,327	50.00%	$15,093,981
3.28.2	. . . . . Facility Operations	$6,091,372	$13,135,435	$9,613,403	50.00%	$28,840,210
3.29	. . . . Year 29	$9,279,388	$20,966,777	$15,123,083	50.00%	$45,369,248
3.29.1	. . . . . Facility Maintenance	$3,188,016	$7,203,322	$5,195,669	50.00%	$15,587,007
3.29.2	. . . . . Facility Operations	$6,091,372	$13,763,455	$9,927,414	50.00%	$29,782,241
3.30	. . . . Year 30	$27,018,484	$63,925,733	$45,472,109	50.00%	$136,416,326
3.30.1	. . . . . Facility Maintenance	$3,188,016	$7,542,846	$5,365,431	50.00%	$16,096,293
3.30.2	. . . . . Facility Operations	$6,091,372	$14,412,186	$10,251,779	50.00%	$30,755,337
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.31	. . . . Year 31	$9,279,388	$22,975,765	$16,127,576	50.00%	$48,382,729

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.31.1	. . . . . Facility Maintenance	$3,188,016	$7,893,528	$5,540,772	50.00%	$16,622,315
3.31.2	. . . . . Facility Operations	$6,091,372	$15,082,237	$10,586,805	50.00%	$31,760,414
3.32	. . . . Year 32	$9,279,388	$24,028,975	$16,654,182	50.00%	$49,962,545
3.32.1	. . . . . Facility Maintenance	$3,188,016	$8,255,367	$5,721,692	50.00%	$17,165,075
3.32.2	. . . . . Facility Operations	$6,091,372	$15,773,608	$10,932,490	50.00%	$32,797,470
3.33	. . . . Year 33	$9,279,388	$25,117,447	$17,198,418	50.00%	$51,595,253
3.33.1	. . . . . Facility Maintenance	$3,188,016	$8,629,322	$5,908,669	50.00%	$17,726,007
3.33.2	. . . . . Facility Operations	$6,091,372	$16,488,126	$11,289,749	50.00%	$33,869,247
3.34	. . . . Year 34	$9,279,388	$26,241,181	$17,760,285	50.00%	$53,280,854
3.34.1	. . . . . Facility Maintenance	$3,188,016	$9,015,390	$6,101,703	50.00%	$18,305,110
3.34.2	. . . . . Facility Operations	$6,091,372	$17,225,791	$11,658,581	50.00%	$34,975,744
3.35	. . . . Year 35	$9,279,388	$27,401,105	$18,340,246	50.00%	$55,020,739
3.35.1	. . . . . Facility Maintenance	$3,188,016	$9,413,892	$6,300,954	50.00%	$18,902,863
3.35.2	. . . . . Facility Operations	$6,091,372	$17,987,212	$12,039,292	50.00%	$36,117,877
3.36	. . . . Year 36	$9,279,388	$28,599,074	$18,939,231	50.00%	$56,817,693
3.36.1	. . . . . Facility Maintenance	$3,188,016	$9,825,465	$6,506,741	50.00%	$19,520,222
3.36.2	. . . . . Facility Operations	$6,091,372	$18,773,609	$12,432,490	50.00%	$37,297,471
3.37	. . . . Year 37	$9,279,388	$29,836,944	$19,558,166	50.00%	$58,674,498
3.37.1	. . . . . Facility Maintenance	$3,188,016	$10,250,747	$6,719,381	50.00%	$20,158,144
3.37.2	. . . . . Facility Operations	$6,091,372	$19,586,198	$12,838,785	50.00%	$38,516,354
3.38	. . . . Year 38	$9,279,388	$31,114,716	$20,197,052	50.00%	$60,591,156
3.38.1	. . . . . Facility Maintenance	$3,188,016	$10,689,736	$6,938,876	50.00%	$20,816,629
3.38.2	. . . . . Facility Operations	$6,091,372	$20,424,979	$13,258,176	50.00%	$39,774,527
3.39	. . . . Year 39	$9,279,388	$32,434,245	$20,856,816	50.00%	$62,570,449
3.39.1	. . . . . Facility Maintenance	$3,188,016	$11,143,072	$7,165,544	50.00%	$21,496,632
3.39.2	. . . . . Facility Operations	$6,091,372	$21,291,173	$13,691,272	50.00%	$41,073,817

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.40	. . . . Year 40	$9,279,388	$33,796,459	$21,537,924	50.00%	$64,613,771
3.40.1	. . . . . Facility Maintenance	$3,188,016	$11,611,073	$7,399,545	50.00%	$22,198,634
3.40.2	. . . . . Facility Operations	$6,091,372	$22,185,386	$14,138,379	50.00%	$42,415,137
4	Post Irradiation Examination	$178,178,400	$295,107,975	$236,643,188	50.00%	$709,929,563
4.1	. . . . Year 1	$4,454,460	$1,448,590	$2,951,525	50.00%	$8,854,576
4.2	. . . . Year 2	$4,454,460	$1,641,469	$3,047,964	50.00%	$9,143,893
4.3	. . . . Year 3	$4,454,460	$1,840,583	$3,147,521	50.00%	$9,442,564
4.4	. . . . Year 4	$4,454,460	$2,045,933	$3,250,197	50.00%	$9,750,590
4.5	. . . . Year 5	$4,454,460	$2,258,411	$3,356,436	50.00%	$10,069,307
4.6	. . . . Year 6	$4,454,460	$2,477,571	$3,466,015	50.00%	$10,398,046
4.7	. . . . Year 7	$4,454,460	$2,704,303	$3,579,381	50.00%	$10,738,144
4.8	. . . . Year 8	$4,454,460	$2,938,162	$3,696,311	50.00%	$11,088,933
4.9	. . . . Year 9	$4,454,460	$3,179,594	$3,817,027	50.00%	$11,451,080
4.10	. . . . Year 10	$4,454,460	$3,429,043	$3,941,752	50.00%	$11,825,255
4.11	. . . . Year 11	$4,454,460	$3,686,511	$4,070,486	50.00%	$12,211,457
4.12	. . . . Year 12	$4,454,460	$3,952,442	$4,203,451	50.00%	$12,610,354
4.13	. . . . Year 13	$4,454,460	$4,226,837	$4,340,649	50.00%	$13,021,946
4.14	. . . . Year 14	$4,454,460	$4,510,586	$4,482,523	50.00%	$13,447,569
1.15	. . . . Year 15	$4,454,460	$5,105,702	$4,780,081	50.00%	$14,340,243
4.16	. . . . Year 16	$4,454,460	$5,105,702	$4,780,081	50.00%	$14,340,243
4.17	. . . . Year 17	$4,454,460	$5,417,960	$4,936,210	50.00%	$14,808,630
4.18	. . . . Year 18	$4,454,460	$5,740,463	$5,097,461	50.00%	$15,292,384
4.19	. . . . Year 19	$4,454,460	$6,073,656	$5,264,058	50.00%	$15,792,174
4.20	. . . . Year 20	$4,454,460	$6,417,541	$5,436,000	50.00%	$16,308,001

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.21	. . . . Year 21	$4,454,460	$6,772,561	$5,613,510	50.00%	$16,840,531
4.22	. . . . Year 22	$4,454,460	$7,139,608	$5,797,034	50.00%	$17,391,103
4.23	. . . . Year 23	$4,454,460	$7,518,238	$5,986,349	50.00%	$17,959,046
4.24	. . . . Year 24	$4,454,460	$7,909,339	$6,181,900	50.00%	$18,545,699
4.25	. . . . Year 25	$4,454,460	$8,313,359	$6,383,909	50.00%	$19,151,728
4.26	. . . . Year 26	$4,454,460	$8,730,296	$6,592,378	50.00%	$19,777,134
4.27	. . . . Year 27	$4,454,460	$9,161,042	$6,807,751	50.00%	$20,423,254
4.28	. . . . Year 28	$4,454,460	$9,605,598	$7,030,029	50.00%	$21,090,086
4.29	. . . . Year 29	$4,454,460	$10,064,852	$7,259,656	50.00%	$21,778,969
4.30	. . . . Year 30	$4,454,460	$10,539,252	$7,496,856	50.00%	$22,490,569
4.31	. . . . Year 31	$4,454,460	$11,029,243	$7,741,851	50.00%	$23,225,554
4.32	. . . . Year 32	$4,454,460	$11,534,824	$7,994,642	50.00%	$23,983,926
4.33	. . . . Year 33	$4,454,460	$12,057,332	$8,255,896	50.00%	$24,767,688
4.34	. . . . Year 34	$4,454,460	$12,596,767	$8,525,614	50.00%	$25,576,841
4.35	. . . . Year 35	$4,454,460	$13,153,575	$8,804,017	50.00%	$26,412,052
4.36	. . . . Year 36	$4,454,460	$13,728,646	$9,091,553	50.00%	$27,274,659
4.37	. . . . Year 37	$4,454,460	$14,322,871	$9,388,665	50.00%	$28,165,996
4.38	. . . . Year 38	$4,454,460	$14,936,250	$9,695,355	50.00%	$29,086,065
4.39	. . . . Year 39	$4,454,460	$15,569,674	$10,012,067	50.00%	$30,036,201
4.40	. . . . Year 40	$4,454,460	$16,223,589	$10,339,024	50.00%	$31,017,073
5	Transportation	$518,354,000	$858,523,813	$688,438,906	50.00%	$2,065,316,719
5.1	. . . . Year 1	$12,958,850	$4,214,218	$8,586,534	50.00%	$25,759,602
5.2	. . . . Year 2	$12,958,850	$4,775,336	$8,867,093	50.00%	$26,601,279
5.3	. . . . Year 3	$12,958,850	$5,354,597	$9,156,723	50.00%	$27,470,170

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.4	. . . . Year 4	$12,958,850	$5,952,000	$9,455,425	50.00%	$28,366,275
5.5	. . . . Year 5	$12,958,850	$6,570,137	$9,764,493	50.00%	$29,293,480
5.6	. . . . Year 6	$12,958,850	$7,207,712	$10,083,281	50.00%	$30,249,844
5.7	. . . . Year 7	$12,958,850	$7,867,318	$10,413,084	50.00%	$31,239,252
5.8	. . . . Year 8	$12,958,850	$8,547,657	$10,753,254	50.00%	$32,259,761
5.9	. . . . Year 9	$12,958,850	$9,250,027	$11,104,439	50.00%	$33,313,316
5.10	. . . . Year 10	$12,958,850	$9,975,723	$11,467,286	50.00%	$34,401,859
5.11	. . . . Year 11	$12,958,850	$10,724,744	$11,841,797	50.00%	$35,525,391
5.12	. . . . Year 12	$12,958,850	$11,498,388	$12,228,619	50.00%	$36,685,856
5.13	. . . . Year 13	$12,958,850	$12,296,653	$12,627,751	50.00%	$37,883,254
5.14	. . . . Year 14	$12,958,850	$13,122,132	$13,040,491	50.00%	$39,121,472
5.15	. . . . Year 15	$12,958,850	$14,853,434	$13,906,142	50.00%	$41,718,426
5.16	. . . . Year 16	$12,958,850	$14,853,434	$13,906,142	50.00%	$41,718,426
5.17	. . . . Year 17	$12,958,850	$15,761,849	$14,360,350	50.00%	$43,081,049
5.18	. . . . Year 18	$12,958,850	$16,700,070	$14,829,460	50.00%	$44,488,380
5.19	. . . . Year 19	$12,958,850	$17,669,392	$15,314,121	50.00%	$45,942,363
5.20	. . . . Year 20	$12,958,850	$18,669,815	$15,814,333	50.00%	$47,442,998
5.21	. . . . Year 21	$12,958,850	$19,702,636	$16,330,743	50.00%	$48,992,228
5.22	. . . . Year 22	$12,958,850	$20,770,445	$16,864,647	50.00%	$50,593,942
5.23	. . . . Year 23	$12,958,850	$21,871,947	$17,415,399	50.00%	$52,246,196
5.24	. . . . Year 24	$12,958,850	$23,009,734	$17,984,292	50.00%	$53,952,876
5.25	. . . . Year 25	$12,958,850	$24,185,102	$18,571,976	50.00%	$55,715,928
5.25	. . . . Year 26	$12,958,850	$25,398,050	$19,178,450	50.00%	$57,535,350
5.27	. . . . Year 27	$12,958,850	$26,651,171	$19,805,010	50.00%	$59,415,031

Project Summary Report

Project Name: ***Lifecycle ORNL Estimate for Advanced PIE Alternate 4B***
Project Location: ***ORNL***
Estimate Number: ***8B26-E***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.28	. . . . Year 28	$12,958,850	$27,944,464	$20,451,657	50.00%	$61,354,971
5.29	. . . . Year 29	$12,958,850	$29,280,522	$21,119,686	50.00%	$63,359,057
5.30	. . . . Year 30	$12,958,850	$30,660,639	$21,809,745	50.00%	$65,429,234
5.31	. . . . Year 31	$12,958,850	$32,086,113	$22,522,481	50.00%	$67,567,444
5.32	. . . . Year 32	$12,958,850	$33,556,942	$23,257,896	50.00%	$69,773,688
5.33	. . . . Year 33	$12,958,850	$35,077,015	$24,017,933	50.00%	$72,053,798
5.34	. . . . Year 34	$12,958,850	$36,646,332	$24,802,591	50.00%	$74,407,773
5.35	. . . . Year 35	$12,958,850	$38,266,188	$25,612,519	50.00%	$76,837,557
5.36	. . . . Year 36	$12,958,850	$39,939,176	$26,449,013	50.00%	$79,347,039
5.37	. . . . Year 37	$12,958,850	$41,667,886	$27,313,368	50.00%	$81,940,104
5.38	. . . . Year 38	$12,958,850	$43,452,320	$28,205,585	50.00%	$84,616,755
5.39	. . . . Year 39	$12,958,850	$45,295,068	$29,126,959	50.00%	$87,380,878
5.40	. . . . Year 40	$12,958,850	$47,197,428	$30,078,139	50.00%	$90,234,416
6	Deactivation, Decommissioning, and Demolition	$22,881,985	$86,809,674	$54,845,829	50.00%	$164,537,488
Total	Lifecycle ORNL Estimate for Advanced PIE	$1,278,957,622	$1,964,550,359	$1,587,845,312	48.95%	$4,831,353,293

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date: August 30, 2012

To: B. Landman

From: D. J. Radford / R. D. Allen, Cost Estimators

Subject: Advanced Post Irradiation Examination Capabilities (APIEC) – Alternative #4C Los Alamos National Laboratory

Per your request, Cost Estimating prepared a cost estimate (Class 5) for the above-mentioned subject. The estimated cost, including escalation and management reserve, is $4,900,000,000.

A. Per the requester, this work will be direct funded. General and Administrative (G&A) costs are included in this estimate. G&A has been added to the construction and procurement costs only. G&A is already included in all other costs.
B. This estimate includes life cycle-costs (LCC). Note that the attached summary report indicating total estimated costs (TEC) is not a correct description.
C. Due to the high-level planning nature of this cost estimate, operating, capital, and other project costs have not been identified.
D. Through an estimate classification evaluation using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet and the Association for the Advancement of Cost Engineering (AACE) International estimate classification criteria, it has been determined by the cost estimator that this is a Class 5 estimate. The intent of this classification is to assist in the interpretation of the quality and value of the information available to prepare this cost estimate and the expected accuracy levels that can be produced. Per AACE, a Class 5 indicates the lowest amount of project information quality and value with a graded approach to a Class 1, which indicates the highest amount of project information quality and value.
E. A review of this cost estimate was held on August 29, 2012, with B. Landman, J.D. Bryan, D. Radford, and this cost estimator. This review allowed the estimator to discuss, in detail, the perceived scope, basis of estimates, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
F. Due to the high-level planning nature of this cost estimate an Idaho National Laboratory (INL) Construction Commercial Practices Evaluation has not been completed.

Refer to the cost estimating summary, detail, markup, and labor sheets with the cost breakdowns. Also included for your use are the cost estimate recapitulation sheets describing the basis and assumptions used in development of this estimate.

This estimate, the work, and the work breakdown structure are based on the information perceived by this estimator as to the scope of work to be completed. Any changes to the methodology used to prepare this estimate could have a significant effect on the cost estimate

and/or schedule and should be reviewed by me. If you have any questions or comments, do not hesitate to contact me at 419-4165 or e-mail dradford@portageinc.com or Ross Allen at 526-0769 or e-mail ross.allen@inl.gov.

Attachments

cc: Estimate File 8B26-K

Uniform File Code: 8309
Disposition Authority: A16-1.5-b
Retention Schedule: Cut off at the end of each fiscal year. Destroy 10 years after cutoff.

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Project Name: *Lifecycle LANL Estimate for Advanced PIE Alternate 4C*
Project Location: *LANL*
Project Number: *8B26 -F*

Summary Report

ESTIMATE ELEMENT	Estimate Subtotal	Escalation & Inflation	Management Reserve	TOTAL
		153.22%	*48.91%*	
Total Estimated Cost (TEC)	$1,304,974,264	$1,999,518,579	$1,616,215,164	$4,920,708,007
		153.22%	*48.91%*	
Total Cost	$1,304,974,264	$1,999,518,579	$1,616,215,164	$4,920,708,007
Rounded Total Cost (Rounded to the nearest $ 100000000)				$4,900,000,000

		Remarks
Type of Estimate:	Class 5	
Estimator:	D. Radford	
Checked By:		
Approved By:		

Battelle Energy Alliance, LLC

FORMAL COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title:	Advanced Post Irradiation Examination Capabilities - Alternative #4C
Estimator:	D. J. Radford / R. D. Allen
Date:	August 30, 2012
Estimate Type:	Class 5
File:	8B26-F
Approved By:	

I. **PURPOSE:** *Brief description from the requester of the intent of how the estimate is to be used, i.e., for engineering study, comparative analysis, request for funding, proposal, etc.*

The purpose of this estimate is to provide costs for the Advanced Post Irradiation Examination Capabilities (APIEC) alternatives analysis to assist the APIEC project team and the Department of Energy (DOE) in evaluating project alternatives.

II. **SCOPE OF WORK:** *Brief statement of the project's objective. Thorough overview and description of the proposed project. Identify work to be accomplished, as well as any specific work to be excluded.*

A. **Objective:**
The objective of this work is provide a life-cycle cost (LCC) for a scaled down version of the Post Irradiation Examination (PIE) Facility proposed to be located at Idaho National Laboratory (INL) to support advanced PIE activities for highly-irradiated nuclear fuels and materials. The scaled down version removes the space that was allocated for future expansion, and assumes that construction will be performed at Los Alamos National Laboratory (LANL).

B. **Included:**
This cost estimate includes LCC as required by DOE Cost Estimating Guide 413.3-21 for alternatives analysis. The scope of work includes the following:

1. Project initiation / mission need costs.
2. Project management oversight.
3. Engineering and design development costs, including alternatives analysis, conceptual design, preliminary design, final design, and construction support.
4. Project integration and DOE Order 413.3B deliverables integration. Includes DOE Order 413.3B critical decision (CD) support, reviews, and documents.
5. Construction of a new facility at LANL.
6. Construction subcontract management costs.
7. Operational readiness costs, including updating the documented safety analysis (DSA), performing a management self assessment (MSA) and contractor operation readiness review (ORR), and DOE ORR.
8. Facility operations costs for 40 years. See estimate back-up for more details.
9. Facility maintenance costs for 40 years. Including annual facility maintenance costs, and equipment replacement costs.
10. Post irradiation examination for 40 years.

11. Transportation costs for 100 experiments per year.
12. Deactivation, decommissioning, and demolition (DD&D) of facility. Includes costs to DD&D the facility space to be used by the APIEC project. See estimate back-up for additional information.

C. **Excluded:**

This scope of work specifically excludes the following:

1. Additional facility upgrades not specifically included above.
2. Physical security personnel costs.
3. Additional utility upgrades outside of the facility.

III. **ESTIMATE METHODOLOGY:** *Overall methodology and rationale of how the estimate was developed, i.e., parametric, forced detail, bottom up, etc. Total dollars/hours and rough order of magnitude (ROM) allocations of the methodologies used to develop the cost estimate.*

Multiple estimating methods were used in the development of this estimate. Due to the lack of maturity of the design a majority of them are parametric in nature as indicated below. A description of the methods used below is available in the DOE Cost Estimating Guide 413.3-21.

A "percentage method," calculated as a percentage of the total direct costs, was used to calculate project management, engineering and design development costs, project integration, and construction management costs. Project management, project integration, and construction management costs are based on percentages from the Remote Handled Low Level Waste project. Engineering and design development costs are based on the DOE Cost Estimating Guide which indicates that total project design costs range in the 15-25 percent range.

Operational readiness, equipment procurement, and a majority of the construction costs were developed using a "specific analogy method." This method uses known costs of a similar item from another estimate in a new estimate. A list of estimates used in this method is included in the cost basis below.

A "forced detail" and "expert opinion" methods were used to develop the facility operations, post irradiation, transportation, and remaining construction costs.

Facility maintenance and deactivation, decommissioning and demolition were developed using a "physical dimension method."

Estimate Methodology	ROM Percentage (%)
Project Team	10
Recorded Actuals	5
Parametric	80
Vendor Quotes	0
Other (e.g., RS Means)	5
TOTAL	100

IV. **BASIS OF THE ESTIMATE:** *Overall explanation of sources for resource quantities, pricing, and schedules.*

A. **Classification Basis:** *The source for the determination of the classification of the estimate or sections of the estimate when a rolling wave planning process is utilized. Source documents include Association of the Advancement of Cost Engineering (AACE) Recommended Practices (RP) and are driven by the Primary and Secondary Characteristics available at the time the estimate is completed.*

The estimate classification has been evaluated using Battelle Energy Alliance, LLC (BEA) Cost Estimate Classification Worksheet to determine the primary characteristic and criteria established by the *Association of the advancement of Cost Engineering (AACE) Recommended Practices (RP)* to determine the secondary characteristic.

An evaluation of the estimate classification determined the primary and secondary characteristics will support a Class 5 estimate.

B. **Quantification Basis:** *The source for the measureable quantities in the estimate that can be used in support of earned value management. Source documents may include drawings, design reports, engineers' notes, and other documentation upon which the estimate is originated.*

The requester provided a draft APIEC alternatives analysis report, dated June 2012, developed by BEA. Activities and quantities were developed through project team meetings held on July 17th and 25th and August 8th, 9th, and 29th 2012. On August 17, 2012 B. Landman provided information regarding the scaling of the original PIE estimate (1D03-A).

C. **Planning Basis:** *The source for the execution and strategies of the work that can be used to support the project execution plan, identification of long-lead items, acquisition strategy, schedules, market conditions, and other documentation upon which the estimate is originated.*

1. The DOE operating contractor will provide resources for all project management and construction management resources.

2. Subcontractors will perform the engineering and design development.
3. Subcontractors will perform the facility modifications.
4. Examination equipment, sample preparation, rough sizing, and waste processing equipment will be procured by the DOE operating contractor.
5. Work will be able to progress consecutively and will not require delays between work segments.
6. The cost estimate does not consider or address funding or labor resource restrictions. Sufficient funding and labor resources will be available in a manner allowing optimum usage of that funding and resources as estimated.
7. It is anticipated construction and operational readiness will be completed by fiscal year (FY) 2020, PIE activities will be from FY 2021 through FY 2060, facilities will undergo DD&D in FY 2061.

D. **Cost Basis:** *The source for the costing on the estimate that can be used in support of earned value management, funding profiles, and schedule of values. Sources may include published costing references, judgment, actual costs, preliminary quotes and/or other documentation upon which the estimate is originated.*

1. INL labor rates, fees, and burdens are based on the current published rates as provided by BEA Planning and Financial Controls.
2. Craft labor rates are based on information provided by the "*INL Site Stabilization Agreement."* Adders (such as FICA, SUTA, and federal insurances) are based on an interpretation by Cost Estimating.
3. Sales tax for materials in construction items is included as part of the contractor mark-ups.
4. Sales tax for equipment replacement has been included in the equipment purchase cost.
5. Estimated escalation rates are based on historical indexes from 1962 to today, as published by RS Means. Five-year, ten-year, and lifecycle trends were developed to estimate the most likely rates that have been used in this estimate. Inflationary and deflationary impacts will be addressed in management reserve.
6. Contractor markup rates are based information developed by BEA estimating. The application of markups varies based on cost basis and estimate methodology used.
7. Construction costs have been adjusted using the relative location factors published by RS Means between the INL and LANL.
8. The Post Irradiation Examination Facility; estimate File #1D03-A was used as a cost basis.
9. Standard published industry references were used to help develop some of the estimated resources and their productivities and some material costs.

V. **ESTIMATE QUALITY ASSURANCE:** *A listing of all estimate reviews that have taken place and the actions taken from those reviews*.

A. A review of the cost estimate was held on August 29, 2012, with the requester and this cost estimator. This review allowed for the requester to review and comment, in detail, on the perceived scope, basis of estimate, assumptions, project risks, and the resources that make up this cost estimate. Comments from this review have been incorporated into this estimate to reflect a project team consensus of this document.
B. An internal organizational check has been performed on this estimate with the purpose of checking the methodology approach used, discussing the document with the estimator, and ensuring the document has been reviewed and discussed with the requester, reflects a team consensus, has adequately documented the basis, assumptions, and risks to the project, and has mitigated those risks.

VI. **ASSUMPTIONS:** *Condition statements accepted or supposed true without proof of demonstration; statements adding clarification to scope. An assumption has a direct impact on total estimated cost.*

A. Mock-up space will be available at an ORNL facility and will not require space rental charges to the project.
B. Project Management and Project Integration are each 6% of all direct facility construction costs.
C. Procurement is included in the 6% project management adder.
D. Construction Management is 4% of all direct facility construction costs not including process equipment, or characterization equipment.
E. The effort to mock-up / install the three pieces that do not require being remote (TEM, APM, and SIMS) are equivalent to a low complexity piece of process equipment.
F. The testing verification effort is 20% of the remotize /mock-up /install effort.

VII. **MANAGEMENT RESERVE (MR) GUIDELINE IMPLEMENTATION:**

MR Methodologies: *Explanation of methodology used in determining overall MR. Identify any specific drivers or items of concern and any inherent risks typical with this type of environment. Inflationary and deflationary impacts are addressed in this section.*

Due to the preliminary nature of the design a detailed risk assessment has not been performed. With the exception of conceptual design a management reserve of 30% applied to the work through the completion of facility construction was included in the original estimate. As agreed to by the project team this has not been changed. Management reserve for conceptual design was included at the rates identified in the source estimate (1B33-A) by S. Wasley.

A blanket MR rate of 50% was applied to this cost estimate for all out year lifecycle costs. This rate was developed by the project team through evaluations of the associated project risks. It was determined to be generally reflective of the project risks and appropriate for the purpose of this cost estimate.

A. **Threats:** *Uncertain events that are potentially negative or reduce the probability that the desired outcome will happen.*

1. No detailed design exists for this project. The estimated costs were based on the project team's perceived idea as to the design requirements and project scope that will be required. Completion of the design may increase the costs due to requirements or needs not identified in the scope of this estimate.
2. Facility maintenance, refurbishment, and DD&D costs are based on anticipated facility area. If the facility area usage is determined to be greater than anticipated, project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is great than assumed, project costs may be impacted.
4. Based on the assumed life of the building no major refurbishments are anticipated. If major refurbishments are required due to environmental or other unforeseen impacts, project lifecycle costs will be impacted.

B. **Opportunities:** *Uncertain events that could improve the results or improve the probability that the desired outcome will happen.*

1. Well-planned-out work activities and scheduling by the subcontractors could result in increased production, thus producing lower bids and operating contractor oversight costs than what have been estimated.
2. Facility maintenance, refurbishment, and DD&D costs are based on anticipated facility area. If the facility area usage is determined to be less than anticipated project costs may be impacted.
3. Transportation costs are based on processing 100 experiments per year. If the number of experiments processed is less than assumed project costs may be impacted.

C. **Accepted Risks:** *Activities with a greater than 50% and less than 100% probability of occurrence have been accepted as part of this scope of work.*

None.

D. **Excluded Risks:** *Risks that have been identified and have a probability of occurrence but are specifically excluded from this estimate.*

None.

Note: Management reserve does not increase the overall accuracy of the estimate; it does, however, reduce the level of risk associated with the estimate. Management reserve is intended to cover the inadequacies in the complete project scope definition, estimating methods, and estimating data. Management reserve specifically excludes changes in project scope, unexpected work stoppages, (e.g., strikes, disasters, and earthquakes) and excessive and/or unexpected inflation or currency fluctuations. This estimate does not contain any contingencies and has not been evaluated to include any contingencies and has not been evaluated to include any of the risks that pertain to Department of Energy.

VIII. OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:

The construction portion of this estimate has been derived from an estimate developed by an outside source. While the estimate does include mark-ups they are incorporated in a manner incompatible with the standard BEA contractor mark-up report. As a result this report is not included in the estimate package.

Standard AACEI guidance for a Class 5 estimate indicates that the expected estimate at completion accuracy range of the estimate is -50% to +100% of the estimated costs including MR.

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
1	Project Initiation (Spent Cost)	$1,510,356	$0	$0	0.00%	$1,510,356
2	Advanced Post Irradiation (APEX) (PIE) Capabilities (TPC)	$142,359,015	$30,038,883	$50,922,870	29.54%	$223,320,768
2.1	. . . . Project Management	$6,143,215	$1,085,461	$2,047,247	28.32%	$9,275,923
2.1.1	. . . . . PM Definition Phase	$517,743	$9,889	$36,934	7.00%	$564,566
2.1.1.1	. . . . . Project Management	$517,743	$9,889	$36,934	7.00%	$564,566
2.1.1.1.1	*. . . . . CD -1 PM Oversight - Level of Effort (LOE)*	*$517,743*	*$9,889*	*$36,934*	*7.00%*	*$564,566*
2.1.2	. . . . . PM Execution Phase	$5,344,199	$1,000,103	$1,903,290	30.00%	$8,247,592
2.1.2.1	. . . . . PM Execution Phase	$5,344,199	$1,000,103	$1,903,290	30.00%	$8,247,592
2.1.2.1.1	*. . . . . Project Management CD2 through CD4*	*$5,344,199*	*$1,000,103*	*$1,903,290*	*30.00%*	*$8,247,592*
2.1.3	. . . . . PM Closeout Phase	$281,274	$75,469	$107,023	30.00%	$463,765
2.1.3.1	. . . . . PM Closeout Phase	$281,274	$75,469	$107,023	30.00%	$463,765
2.2	. . . . Conceptual Design of APEX Capability Studies	$2,509,222	$56,542	$384,865	15.00%	$2,950,628
2.2.1	. . . . . Alternatives Analysis	$444,106	$1,933	$66,906	15.00%	$512,945
2.2.1.1	. . . . . Alternative Definition and Selection	$288,554	$1,265	$43,473	15.00%	$333,291
2.2.1.1.1	*. . . . . Project Engineering - Alternatives Definition*	*$288,554*	*$1,265*	*$43,473*	*15.00%*	*$333,291*
2.2.1.1.1.1	*. . . . . General Studies*	*$147,090*	*$954*	*$22,206*	*15.00%*	*$170,250*
2.2.1.1.1.1.1	*. . . . . Existing U. S. Capabilities*	*$42,088*	*$848*	*$6,440*	*15.00%*	*$49,376*
2.2.1.1.1.1.2	*. . . . . Shipping Costs*	*$18,728*	*$35*	*$2,814*	*15.00%*	*$21,578*
2.2.1.1.1.1.3	*. . . . . Comparison Basis*	*$16,873*	*$18*	*$2,534*	*15.00%*	*$19,424*
2.2.1.1.1.1.4	*. . . . . Path Forward*	*$18,760*	*$35*	*$2,819*	*15.00%*	*$21,615*
2.2.1.1.1.1.5	*. . . . . Review Alternative Analysis*	*$40,876*	*$0*	*$6,131*	*15.00%*	*$47,008*
2.2.1.1.1.1.6	*. . . . . Incorporate Comments*	*$9,764*	*$18*	*$1,467*	*15.00%*	*$11,249*
2.2.1.1.1.2	*. . . . . No Action Alternative - Write Report*	*$14,054*	*$35*	*$2,113*	*15.00%*	*$16,203*
2.2.1.1.1.3	*. . . . . Complex Wide Distributed Capability - Identify, Estimate, Write Report*	*$62,411*	*$133*	*$9,382*	*15.00%*	*$71,926*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.2.1.1.4	*. . . . . MFC Wide Distributed Capacity - Identify, Estimate, Write Report*	*$39,129*	*$108*	*$5,886*	*15.00%*	*$45,122*
2.2.1.1.5	*. . . . . PIE LIB - Write Report*	*$25,870*	*$35*	*$3,886*	*15.00%*	*$29,791*
2.2.1.2	. . . . . Tradeoff Studies	$155,552	$668	$23,433	15.00%	$179,653
2.2.1.2.1	*. . . . . Trade-off Studies*	*$155,552*	*$668*	*$23,433*	*15.00%*	*$179,653*
2.2.1.2.1.1	*. . . . . Site Location Trade-Off - Footprint Determination and Utilities*	*$111,652*	*$668*	*$16,848*	*15.00%*	*$129,169*
2.2.1.2.1.2	*. . . . . Electrical Capacity Study*	*$28,690*	*$0*	*$4,303*	*15.00%*	*$32,993*
2.2.1.2.1.3	*. . . . . Fire Water Availability Study*	*$6,821*	*$0*	*$1,023*	*15.00%*	*$7,844*
2.2.1.2.1.4	*. . . . . Sewer Water Availability Study*	*$8,389*	*$0*	*$1,258*	*15.00%*	*$9,648*
2.2.2	**. . . . . Conceptual Design of Preferred Alternative**	**$2,065,116**	**$54,609**	**$317,959**	**15.00%**	**$2,437,683**
2.2.2.1	. . . . . Engineering Supervision	$246,633	$4,711	$37,701	15.00%	$289,045
2.2.2.1.1	*. . . . . Engineering Supervision and Support*	*$246,633*	*$4,711*	*$37,701*	*15.00%*	*$289,045*
2.2.2.2	. . . . . Site D&D and Development	$198,632	$8,205	$31,026	15.00%	$237,863
2.2.2.2.1	*. . . . . Civil*	*$198,632*	*$8,205*	*$31,026*	*15.00%*	*$237,863*
2.2.2.3	. . . . . Facilities and Ancillary Support Systems	$878,605	$27,535	$135,921	15.00%	$1,042,061
2.2.2.3.1	*. . . . . Architectural*	*$89,844*	*$5,577*	*$14,313*	*15.00%*	*$109,735*
2.2.2.3.3	*. . . . . Electrical*	*$168,735*	*$5,980*	*$26,207*	*15.00%*	*$200,922*
2.2.2.3.4	*. . . . . Fire Protection*	*$25,237*	*$482*	*$3,858*	*15.00%*	*$29,577*
2.2.2.3.5.5	*. . . . . H&V*	*$100,370*	*$1,917*	*$15,343*	*15.00%*	*$117,630*
2.2.2.3.6	*. . . . . I&C*	*$76,005*	*$1,452*	*$11,618*	*15.00%*	*$89,075*
2.2.2.3.7	*. . . . . Mechanical*	*$191,066*	*$7,785*	*$29,828*	*15.00%*	*$228,678*
2.2.2.3.8	*. . . . . Structural*	*$227,348*	*$4,342*	*$34,754*	*15.00%*	*$266,444*
2.2.2.4	. . . . . Process Cell Equipment Design	$453,226	$8,657	$69,282	15.00%	$531,165
2.2.2.4.1	*. . . . . Sample Process Cell Equipment Design*	*$453,226*	*$8,657*	*$69,282*	*15.00%*	*$531,165*
2.2.2.5	. . . . . Exam Equipment and Modular Cells	$288,020	$5,501	$44,028	15.00%	$337,550
2.2.2.5.1	*. . . . . Examination Equipment Design*	*$288,020*	*$5,501*	*$44,028*	*15.00%*	*$337,550*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3	**. . . . Project Integration and DOE 413 Deliverables Integration**	**$11,925,451**	**$2,117,551**	**$3,922,621**	**27.93%**	**$17,965,623**
2.3.1	**. . . . . Critical Decision 1 Evaluations**	**$791,500**	**$16,763**	**$111,772**	**13.83%**	**$920,035**
2.3.1.1	. . . . . Nuclear Safety	$346,286	$6,614	$52,935	15.00%	$405,836
2.3.1.1.1	*. . . . . Nuclear Safety Work Package*	*$346,286*	*$6,614*	*$52,935*	*15.00%*	*$405,836*
2.3.1.1.1.1	*. . . . . Safety Design Strategy*	*$95,228*	*$1,819*	*$14,557*	*15.00%*	*$111,604*
2.3.1.1.1.2	*. . . . . Preliminary Hazard Analysis Report*	*$43,817*	*$837*	*$6,698*	*15.00%*	*$51,352*
2.3.1.1.1.3	*. . . . . Conceptual Safety Design Report*	*$78,489*	*$1,499*	*$11,998*	*15.00%*	*$91,987*
2.3.1.1.1.4	*. . . . . Nuclear Safety Support*	*$128,752*	*$2,459*	*$19,682*	*15.00%*	*$150,893*
2.3.1.2	. . . . . Risk Management	$102,074	$1,950	$15,603	15.00%	$119,627
2.3.1.2.1	*. . . . . Risk Management Plan*	*$33,810*	*$646*	*$5,168*	*15.00%*	*$39,624*
2.3.1.2.2	*. . . . . Initial Risk Assessment Report*	*$47,261*	*$903*	*$7,225*	*15.00%*	*$55,388*
2.3.1.2.3	*. . . . . Support Risk Assessment*	*$21,003*	*$401*	*$3,211*	*15.00%*	*$24,614*
2.3.1.3	. . . . . DOE 413.3B Documents	$194,335	$5,357	$21,174	10.60%	$220,867
2.3.1.3.1	*. . . . . Project Management*	*$45,436*	*$868*	*$6,946*	*15.00%*	*$53,249*
2.3.1.3.1.1	*. . . . . Acquisition Strategy*	*$18,174*	*$347*	*$2,778*	*15.00%*	*$21,300*
2.3.1.3.1.2	*. . . . . Develop Project Execution Plan*	*$27,262*	*$521*	*$4,167*	*15.00%*	*$31,950*
2.3.1.3.2	*. . . . . Systems Engineering Work Package*	*$42,553*	*$1,092*	*$6,547*	*15.00%*	*$50,192*
2.3.1.3.2.1	*. . . . . Compile CD-1 Work Package*	*$42,553*	*$1,092*	*$6,547*	*15.00%*	*$50,192*
2.3.1.3.3	*. . . . . Cost Estimating and Scheduling CD1*	*$106,346*	*$3,398*	*$7,682*	*7.00%*	*$117,426*
2.3.1.3.3.1	*. . . . . Develop Project Cost Estimate (Baseline)*	*$48,699*	*$1,674*	*$3,526*	*7.00%*	*$53,899*
2.3.1.3.3.2	*. . . . . Develop Prelim Design Cost Estimate*	*$21,550*	*$660*	*$1,555*	*7.00%*	*$23,765*
2.3.1.3.3.3	*. . . . . Develop Project Schedule*	*$22,223*	*$581*	*$1,596*	*7.00%*	*$24,400*
2.3.1.3.3.4	*. . . . . Develop Prelim Design Schedule*	*$13,874*	*$483*	*$1,005*	*7.00%*	*$15,362*
2.3.1.4	. . . . . ESHQ&SS	$49,782	$951	$6,922	13.64%	$57,655
2.3.1.4.1	*. . . . . ES&H Plan*	*$23,606*	*$451*	*$3,608*	*15.00%*	*$27,665*
2.3.1.4.1.1	*. . . . . Prepare Preliminary ES&H Plan*	*$23,606*	*$451*	*$3,608*	*15.00%*	*$27,665*
2.3.1.4.2	*. . . . . Environmental Compliance*	*$17,739*	*$339*	*$2,712*	*15.00%*	*$20,789*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.1.4.2.1	*. . . . . NEPA Documents*	*$17,739*	*$339*	*$2,712*	*15.00%*	*$20,789*
2.3.1.4.3	*. . . . . Quality Assurance*	*$8,437*	*$161*	*$602*	*7.00%*	*$9,200*
2.3.1.4.3.1	*. . . . . Quality Assurance Program Plan*	*$8,437*	*$161*	*$602*	*7.00%*	*$9,200*
2.3.1.5	. . . . . CD-1 Reviews	$99,023	$1,891	$15,137	15.00%	$116,051
2.3.1.5.1	*. . . . . Reviewers (Internal)*	*$43,384*	*$829*	*$6,632*	*15.00%*	*$50,844*
2.3.1.5.1.1	*. . . . . Conduct Conceptual Design Review*	*$43,384*	*$829*	*$6,632*	*15.00%*	*$50,844*
2.3.1.5.2	*. . . . . Reviewers (Independent/External)*	*$19,158*	*$366*	*$2,929*	*15.00%*	*$22,452*
2.3.1.5.2.1	*. . . . . Support DOE Technical Independent Project Review*	*$19,158*	*$366*	*$2,929*	*15.00%*	*$22,452*
2.3.1.5.3	*. . . . . Safeguards and Security*	*$36,482*	*$697*	*$5,577*	*15.00%*	*$42,755*
2.3.1.5.3.1	*. . . . . Preliminary Security Vulnerability Assessment Report*	*$36,482*	*$697*	*$5,577*	*15.00%*	*$42,755*
2.3.2	**. . . . . Critical Decision 2 Evaluations**	**$1,054,956**	**$155,547**	**$363,151**	**30.00%**	**$1,573,654**
2.3.2.1	. . . . . Critical Decision 2	$1,054,956	$155,547	$363,151	30.00%	$1,573,654
2.3.2.1.1	*. . . . . Nuclear Safety*	*$784,956*	*$115,737*	*$270,208*	*30.00%*	*$1,170,901*
2.3.2.1.2	*. . . . . Nuclear Safety Support*	*$270,000*	*$39,810*	*$92,943*	*30.00%*	*$402,753*
2.3.3	**. . . . . Critical Decision 3 Evaluations**	**$1,047,733**	**$196,071**	**$373,141**	**30.00%**	**$1,616,945**
2.3.3.1	. . . . . Critical Decision 3	$1,047,733	$196,071	$373,141	30.00%	$1,616,945
2.3.3.1.1	*. . . . . Nuclear Safety*	*$1,047,733*	*$196,071*	*$373,141*	*30.00%*	*$1,616,945*
2.3.4	**. . . . . Critical Decision 4 Evaluations**	**$225,019**	**$79,633**	**$91,396**	**30.00%**	**$396,047**
2.3.5	**. . . . . Post Critical Decision 4**	**$56,255**	**$19,908**	**$22,849**	**30.00%**	**$99,012**
2.3.6	**. . . . . Project Integration (Definition Phase)**	**$773,398**	**$14,948**	**$76,931**	**9.76%**	**$865,278**
2.3.6.1	. . . . . System Engineering Evaluations	$773,398	$14,948	$76,931	9.76%	$865,278
2.3.6.1.1	*. . . . . Project Integration CD1*	*$773,398*	*$14,948*	*$76,931*	*9.76%*	*$865,278*
2.3.6.1.1.1	*. . . . . Project Engineering and Support*	*$506,655*	*$9,853*	*$36,156*	*7.00%*	*$552,664*
2.3.6.1.1.2	*. . . . . DR - Systems Engineering*	*$266,744*	*$5,095*	*$40,776*	*15.00%*	*$312,614*
2.3.6.1.1.2.1	*. . . . . Systems Engineering Managment Plan (SEMP)*	*$42,455*	*$811*	*$6,490*	*15.00%*	*$49,755*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.3.6.1.1.2.2	*. . . . . Systems Engineering -T&FRs*	*$106,137*	*$2,027*	*$16,225*	*15.00%*	*$124,389*
2.3.6.1.1.2.3	*. . . . . Systems Engineering -Action Tracking*	*$39,384*	*$752*	*$6,020*	*15.00%*	*$46,157*
2.3.6.1.1.2.4	*. . . . . Systems Engineering -Trade Study Support*	*$78,768*	*$1,504*	*$12,041*	*15.00%*	*$92,313*
2.3.7	**. . . . . Project Integration-Execution Phase**	**$5,344,199**	**$1,000,103**	**$1,903,290**	**30.00%**	**$8,247,592**
2.3.7.1	. . . . . Project Integration	$5,344,199	$1,000,103	$1,903,290	30.00%	$8,247,592
2.3.8	**. . . . . Project Integration-Closeout Phase**	**$281,274**	**$99,541**	**$114,244**	**30.00%**	**$495,059**
2.3.8.1	. . . . . Project Integration	$281,274	$99,541	$114,244	30.00%	$495,059
2.3.9	**. . . . . PM-Construction Management**	**$2,351,119**	**$535,037**	**$865,847**	**30.00%**	**$3,752,002**
2.3.9.1	. . . . . Construction Management	$2,351,119	$535,037	$865,847	30.00%	$3,752,002
2.4	**. . . . Preliminary Design**	**$11,215,926**	**$1,216,766**	**$3,729,808**	**30.00%**	**$16,162,500**
2.4.1	**. . . . . Preliminary Design**	**$11,215,926**	**$1,216,766**	**$3,729,808**	**30.00%**	**$16,162,500**
2.4.1.1	. . . . . Preliminary Design	$11,215,926	$1,216,766	$3,729,808	30.00%	$16,162,500
2.4.1.1.1	*. . . . . Site Development Preliminary Design (Title I)*	*$932,641*	*$101,178*	*$310,146*	*30.00%*	*$1,343,965*
2.4.1.1.2	*. . . . . Facility Structure & Ancillary Supt. Sys. Preliminary Design (Title I)*	*$4,888,318*	*$530,312*	*$1,625,589*	*30.00%*	*$7,044,220*
2.4.1.1.3	*. . . . . Modular Hot Cells Preliminary Design (Title I)*	*$5,394,966*	*$585,276*	*$1,794,073*	*30.00%*	*$7,774,315*
2.5	**. . . . Final Design**	**$163,708**	**$30,636**	**$58,303**	**30.00%**	**$252,647**
2.5.1	**. . . . . Final Design**	**$163,708**	**$30,636**	**$58,303**	**30.00%**	**$252,647**
2.5.1.1	. . . . . Final Design	$163,708	$30,636	$58,303	30.00%	$252,647
2.5.1.1.1	*. . . . . Site D&D Preliminary & Final Design (Title I)*	*$163,708*	*$30,636*	*$58,303*	*30.00%*	*$252,647*
2.6	**. . . . Procurement**	**$42,371,114**	**$9,642,263**	**$15,604,013**	**30.00%**	**$67,617,390**
2.6.1	**. . . . . Procurement**	**$42,371,114**	**$9,642,263**	**$15,604,013**	**30.00%**	**$67,617,390**
2.6.1.1	. . . . . Procurement	$42,371,114	$9,642,263	$15,604,013	30.00%	$67,617,390
2.6.1.1.1	*. . . . . Facility Structure & Ancillary Supt. Sys. Procurement/Fabrication*	*$3,500,068*	*$796,500*	*$1,288,970*	*30.00%*	*$5,585,537*
2.6.1.1.1.1	*. . . . . Miscellaneous Equipment*	*$842,385*	*$191,699*	*$310,225*	*30.00%*	*$1,344,309*
2.6.1.1.1.2	*. . . . . Mechanical Equipment*	*$2,657,683*	*$604,801*	*$978,745*	*30.00%*	*$4,241,228*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.6.1.1.2.1	*. . . . . Exhaust Stack*	*$118,799*	*$27,035*	*$43,750*	*30.00%*	*$189,584*
2.6.1.1.2.2	*. . . . . Building HVAC Equipment*	*$227,525*	*$51,777*	*$83,791*	*30.00%*	*$363,093*
80.15.50.10.10.4.2.3	*. . . . . Exhaust System Equipment*	*$2,311,359*	*$525,989*	*$851,204*	*30.00%*	*$3,688,552*
2.6.1.1.2	*. . . . . Facility Process Equipment Procurement/Fabrication*	*$1,233,983*	*$280,814*	*$454,439*	*30.00%*	*$1,969,236*
2.6.1.1.3	*. . . . . Modular Hot Cells Procurement/Fabrication*	*$26,610,579*	*$6,055,687*	*$9,799,880*	*30.00%*	*$42,466,146*
2.6.1.1.4	*. . . . . Characterization Specialty Equipment Procurement/Fabrication*	*$11,026,484*	*$2,509,263*	*$4,060,724*	*30.00%*	*$17,596,471*
2.6.1.1.4.1	*. . . . . Thermal Examination*	*$860,000*	*$195,708*	*$316,712*	*30.00%*	*$1,372,420*
2.6.1.1.4.2	*. . . . . Microstructure Examination*	*$10,166,484*	*$2,313,555*	*$3,744,012*	*30.00%*	*$16,224,051*
2.7	**. . . . Construction**	**$62,911,444**	**$14,412,964**	**$23,197,323**	**30.00%**	**$100,521,731**
2.7.1	**. . . . . Construction**	**$62,911,444**	**$14,412,964**	**$23,197,323**	**30.00%**	**$100,521,731**
2.7.1.1	. . . . . Construction	$62,911,444	$14,412,964	$23,197,323	30.00%	$100,521,731
2.7.1.1.1	*. . . . . Title 3 Design*	*$1,010,981*	*$271,257*	*$384,671*	*30.00%*	*$1,666,910*
2.7.1.1.2	*. . . . . Site D&D Construction/Installation*	*$840,690*	*$225,566*	*$319,877*	*30.00%*	*$1,386,134*
2.7.1.1.2.1	*. . . . . Building Deactivation & Demolition*	*$840,690*	*$225,566*	*$319,877*	*30.00%*	*$1,386,134*
2.7.1.1.3	*. . . . . Site Development Construction/Installation*	*$5,524,505*	*$1,436,431*	*$2,088,281*	*30.00%*	*$9,049,217*
2.7.1.1.3.1	*. . . . . Civil*	*$3,957,295*	*$1,055,982*	*$1,503,983*	*30.00%*	*$6,517,260*
2.7.1.1.3.1.1	*. . . . . Site Preparation*	*$2,786,400*	*$747,621*	*$1,060,206*	*30.00%*	*$4,594,228*
2.7.1.1.3.1.2	*. . . . . Landscaping*	*$928,800*	*$249,207*	*$353,402*	*30.00%*	*$1,531,409*
2.7.1.1.3.1.3	*. . . . . Asphalt Paving*	*$123,794*	*$31,680*	*$46,642*	*30.00%*	*$202,117*
2.7.1.1.3.1.4	*. . . . . Concrete Paving*	*$118,301*	*$27,473*	*$43,732*	*30.00%*	*$189,506*
2.7.1.1.3.2	*. . . . . Electrical*	*$1,359,507*	*$337,289*	*$509,039*	*30.00%*	*$2,205,835*
2.7.1.1.3.2.1	*. . . . . Equipment*	*$779,764*	*$205,597*	*$295,608*	*30.00%*	*$1,280,970*
2.7.1.1.3.2.2	*. . . . . Raceway*	*$343,987*	*$76,315*	*$126,090*	*30.00%*	*$546,392*
2.7.1.1.3.2.3	*. . . . . Cable*	*$182,582*	*$43,396*	*$67,793*	*30.00%*	*$293,771*
2.7.1.1.3.2.4	*. . . . . Demo*	*$53,174*	*$11,981*	*$19,547*	*30.00%*	*$84,702*
2.7.1.1.3.3	*. . . . . Overtime (Distributed)*	*$207,703*	*$43,161*	*$75,259*	*30.00%*	*$326,122*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4	. . . . . Facility Structure & Ancillary Supt. Sys. Construction/Installation	$26,434,238	$6,182,009	$9,784,874	30.00%	$42,401,121
2.7.1.1.4.1	. . . . . Main Facility	$17,774,248	$4,193,398	$6,590,294	30.00%	$28,557,941
2.7.1.1.4.1.1	 Civil	$8,880,268	$2,052,273	$3,279,762	30.00%	$14,212,304
2.7.1.1.4.1.1.1	. . . . . Concrete	$4,065,216	$904,857	$1,491,022	30.00%	$6,461,096
2.7.1.1.4.1.1.2	. . . . . Masonry	$559,857	$121,081	$204,281	30.00%	$885,219
2.7.1.1.4.1.1.3	. . . . . Metals	$1,736,018	$415,126	$645,343	30.00%	$2,796,488
2.7.1.1.4.1.1.4	. . . . . Openings	$217,313	$53,070	$81,115	30.00%	$351,498
2.7.1.1.4.1.1.5	. . . . . Thermal & Moisture Protection	$533,756	$123,637	$197,218	30.00%	$854,610
2.7.1.1.4.1.1.6	. . . . . Finishes	$1,651,518	$409,469	$618,296	30.00%	$2,679,283
2.7.1.1.4.1.1.7	. . . . . Miscellaneous Equipment	$116,590	$25,033	$42,487	30.00%	$184,110
2.7.1.1.4.1.2	. . . . . Mechanical	$8,079,596	$1,951,543	$3,009,342	30.00%	$13,040,482
2.7.1.1.4.1.2.1	. . . . . HVAC, Entire Bldg.	$5,313,652	$1,287,433	$1,980,325	30.00%	$8,581,410
2.7.1.1.4.1.2.1.1	. . . . . Heating, AC & Air Supply	$1,055,939	$259,371	$394,593	30.00%	$1,709,904
2.7.1.1.4.1.2.1.2	. . . . . Primary Exhaust System & Stack	$2,953,041	$718,076	$1,101,335	30.00%	$4,772,453
2.7.1.1.4.1.2.1.3	. . . . . Suspect Exhaust System	$1,304,671	$309,985	$484,397	30.00%	$2,099,053
2.7.1.1.4.1.2.2	. . . . . Piping, Entire Bldg.	$2,481,895	$594,054	$922,785	30.00%	$3,998,734
2.7.1.1.4.1.2.2.01	. . . . . Sanitary Waste System	$133,504	$29,453	$48,887	30.00%	$211,844
2.7.1.1.4.1.2.2.01.1	 Civil	$10,151	$2,375	$3,758	30.00%	$16,283
2.7.1.1.4.1.2.2.01.2	. . . . . Mechanical	$123,352	$27,079	$45,129	30.00%	$195,560
2.7.1.1.4.1.2.2.01.1	. . . . . Equipment	$13,894	$3,398	$5,188	30.00%	$22,481
2.7.1.1.4.1.2.2.01.2	. . . . . Piping	$109,458	$23,680	$39,941	30.00%	$173,080
2.7.1.1.4.1.2.2.02	. . . . . Safety Shower System	$37,969	$8,710	$14,004	30.00%	$60,682
2.7.1.1.4.1.2.2.02.1	. . . . . Equipment	$7,494	$1,854	$2,805	30.00%	$12,153
2.7.1.1.4.1.2.2.02.2	. . . . . Piping	$27,514	$6,198	$10,114	30.00%	$43,825
2.7.1.1.4.1.2.2.02.3	. . . . . Insulation	$2,961	$658	$1,086	30.00%	$4,704

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.1.2.2.03	Clear Water Drain System	$55,430	$12,634	$20,419	30.00%	$88,483
2.7.1.1.4.1.2.2.03.1	Equipment	$20,830	$5,165	$7,799	30.00%	$33,794
2.7.1.1.4.1.2.2.03.2	Piping & Valves	$34,600	$7,469	$12,621	30.00%	$54,689
2.7.1.1.4.1.2.2.04	Cooling Water System	$390,246	$88,087	$143,500	30.00%	$621,832
2.7.1.1.4.1.2.2.04.1	Equipment	$91,261	$22,971	$34,269	30.00%	$148,501
2.7.1.1.4.1.2.2.04.2	Piping	$264,157	$57,528	$96,506	30.00%	$418,191
2.7.1.1.4.1.2.2.04.3	Fiberglass Insul,ASJ/SSL,1"	$21,419	$4,683	$7,831	30.00%	$33,933
2.7.1.1.4.1.2.2.04.4	1" Fiberglass w/0.016" Alum. Jacket, 2" dia.	$11,006	$2,380	$4,016	30.00%	$17,401
2.7.1.1.4.1.2.2.04.5	1" Fiberglass w/0.016" Alum. Jacket, 5" dia.	$2,403	$525	$879	30.00%	$3,807
2.7.1.1.4.1.2.2.05	Facility DP Monitoring System	$99,579	$23,802	$37,014	30.00%	$160,395
2.7.1.1.4.1.2.2.05.1	Equipment	$76,682	$18,784	$28,640	30.00%	$124,106
2.7.1.1.4.1.2.2.05.2	Piping	$22,897	$5,018	$8,374	30.00%	$36,289
2.7.1.1.4.1.2.2.06	Nitrogen Liquid & Gas System	$194,263	$47,818	$72,625	30.00%	$314,706
2.7.1.1.4.1.2.2.06.1	Civil	$6,092	$1,359	$2,235	30.00%	$9,687
2.7.1.1.4.1.2.2.06.2	Instrumentation & Controls	$12,172	$2,941	$4,534	30.00%	$19,647
2.7.1.1.4.1.2.2.06.3	Equipment	$73,833	$19,096	$27,879	30.00%	$120,808
2.7.1.1.4.1.2.2.06.4	Piping/Valves	$87,972	$21,317	$32,787	30.00%	$142,076
2.7.1.1.4.1.2.2.06.5	1.5" Cal-Sil. w/0.016" Alum. Jacket, 1" dia. & dn.	$6,622	$1,447	$2,421	30.00%	$10,489
2.7.1.1.4.1.2.2.06.6	1.5" Cal-Sil. w/0.016" Alum. Jacket, 1.25" & 1.5" dia.	$7,572	$1,658	$2,769	30.00%	$11,999
2.7.1.1.4.1.2.2.07	Leak Monitoring System	$134,652	$32,957	$50,283	30.00%	$217,892
2.7.1.1.4.1.2.2.07.1	Equipment	$32,065	$8,381	$12,134	30.00%	$52,580

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.1.2.2.07.2	Piping	$102,587	$24,576	$38,149	30.00%	$165,312
2.7.1.1.4.1.2.2.08	Pneumatic Transfer System	$421,250	$104,082	$157,600	30.00%	$682,932
2.7.1.1.4.1.2.2.08.1	Civil/Structural	$52,077	$11,999	$19,223	30.00%	$83,298
2.7.1.1.4.1.2.2.08.2	Equipment	$127,266	$32,129	$47,818	30.00%	$207,213
2.7.1.1.4.1.2.2.08.3	Piping/Valves	$241,908	$59,955	$90,559	30.00%	$392,421
2.7.1.1.4.1.2.2.09	Fixed Air Sampling System	$135,076	$29,165	$49,272	30.00%	$213,513
2.7.1.1.4.1.2.2.10	Plant Air System	$269,861	$70,447	$102,092	30.00%	$442,400
2.7.1.1.4.1.2.2.11	Breathing Air System	$297,565	$71,193	$110,628	30.00%	$479,386
2.7.1.1.4.1.2.2.12	Nitrogen Gas System	$32,308	$7,326	$11,890	30.00%	$51,524
2.7.1.1.4.1.2.2.13	P-10 Gas System	$32,308	$7,326	$11,890	30.00%	$51,524
2.7.1.1.4.1.2.2.14	Specialty No. 1 Gas System	$32,308	$7,326	$11,890	30.00%	$51,524
2.7.1.1.4.1.2.2.15	Specialty No. 2 Gas System	$32,308	$7,326	$11,890	30.00%	$51,524
2.7.1.1.4.1.2.2.16	Deionized Water	$183,269	$46,402	$68,901	30.00%	$298,573
2.7.1.1.4.1.2.3	Fire Protection, Entire Bldg.	$284,050	$70,057	$106,232	30.00%	$460,339
2.7.1.1.4.1.3	Electrical	$814,384	$189,582	$301,190	30.00%	$1,305,155
2.7.1.1.4.1.3.1	Gallery	$546,601	$126,835	$202,031	30.00%	$875,468
2.7.1.1.4.1.3.2	Office	$234,581	$55,009	$86,877	30.00%	$376,468
2.7.1.1.4.1.3.3	Grounding and Lightning Protection	$33,201	$7,737	$12,281	30.00%	$53,220
2.7.1.1.4.2	Storage Annex	$3,718,978	$851,532	$1,371,153	30.00%	$5,941,663
2.7.1.1.4.2.1	Civil	$3,328,677	$761,032	$1,226,913	30.00%	$5,316,622
2.7.1.1.4.2.1.1	Concrete	$1,753,813	$388,555	$642,710	30.00%	$2,785,078
2.7.1.1.4.2.1.2	Masonry	$127,088	$27,486	$46,372	30.00%	$200,946
2.7.1.1.4.2.1.3	Metals	$789,407	$190,698	$294,031	30.00%	$1,274,136
2.7.1.1.4.2.1.4	Openings	$107,145	$26,851	$40,199	30.00%	$174,195

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.2.1.5	Thermal & Moisture Protection	$268,689	$62,387	$99,323	30.00%	$430,399
2.7.1.1.4.2.1.6	Finishes	$282,535	$65,056	$104,277	30.00%	$451,868
2.7.1.1.4.2.2	Electrical	$390,301	$90,500	$144,240	30.00%	$625,041
2.7.1.1.4.3	HVAC & Mechanical Room	$3,670,402	$859,091	$1,358,848	30.00%	$5,888,340
2.7.1.1.4.3.1	Civil	$3,044,657	$708,032	$1,125,807	30.00%	$4,878,496
2.7.1.1.4.3.1.1	Concrete	$447,094	$95,965	$162,918	30.00%	$705,977
2.7.1.1.4.3.1.2	Masonry	$267,554	$57,864	$97,625	30.00%	$423,044
2.7.1.1.4.3.1.3	Metals	$1,245,609	$302,737	$464,504	30.00%	$2,012,849
2.7.1.1.4.3.1.4	Openings	$85,670	$21,893	$32,269	30.00%	$139,832
2.7.1.1.4.3.1.5	Thermal & Moisture Protection	$639,554	$148,254	$236,342	30.00%	$1,024,150
2.7.1.1.4.3.1.6	Finishes	$359,176	$81,320	$132,149	30.00%	$572,645
2.7.1.1.4.3.2	Mechanical	$319,200	$78,899	$119,430	30.00%	$517,528
2.7.1.1.4.3.2.1	HVAC	$172,633	$42,404	$64,511	30.00%	$279,548
2.7.1.1.4.3.2.2	Piping	$100,560	$24,151	$37,413	30.00%	$162,125
2.7.1.1.4.3.2.2.1	Cooling Water System	$59,450	$13,419	$21,861	30.00%	$94,730
2.7.1.1.4.3.2.2.1.1	Equipment	$13,903	$3,499	$5,221	30.00%	$22,623
2.7.1.1.4.3.2.2.1.2	Piping	$40,242	$8,764	$14,702	30.00%	$63,707
2.7.1.1.4.3.2.2.1.3	Insulation	$5,306	$1,156	$1,938	30.00%	$8,400
2.7.1.1.4.3.2.2.1.31	Fiberglass Insul,ASJ/SSL,1", 2006	$3,263	$713	$1,193	30.00%	$5,169
2.7.1.1.4.3.2.2.1.32	1" Fiberglass w/0.016" Alum. Jacket, 2" dia.	$1,677	$363	$612	30.00%	$2,651
2.7.1.1.4.3.2.2.1.33	1" Fiberglass w/0.016" Alum. Jacket, 5" dia.	$366	$80	$134	30.00%	$580
2.7.1.1.4.3.2.2.2	Plant Air System	$41,110	$10,732	$15,553	30.00%	$67,395
2.7.1.1.4.3.2.3	Fire Protection	$46,006	$12,344	$17,505	30.00%	$75,855
2.7.1.1.4.3.3	Electrical	$306,545	$72,159	$113,611	30.00%	$492,315
2.7.1.1.4.4	Earthwork	$302,285	$76,771	$113,717	30.00%	$492,773

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.7.1.1.4.4.1	*. . . . . Building Excavation*	*$302,285*	*$76,771*	*$113,717*	*30.00%*	*$492,773*
2.7.1.1.4.5	*. . . . . Overtime (Distributed)*	*$968,324*	*$201,218*	*$350,863*	*30.00%*	*$1,520,405*
2.7.1.1.5	*. . . . . Facility Process Equipment Construction/Installation*	*$8,933,172*	*$1,984,802*	*$3,275,392*	*30.00%*	*$14,193,365*
2.7.1.1.5.1	*. . . . . Remotize/ Mockup/ Install Process Equipment*	*$6,933,172*	*$1,448,180*	*$2,514,406*	*30.00%*	*$10,895,757*
2.7.1.1.5.2	*. . . . . Waste Packaging Cell*	*$1,000,000*	*$268,311*	*$380,493*	*30.00%*	*$1,648,804*
2.7.1.1.5.3	*. . . . . Sample Storage Cell*	*$1,000,000*	*$268,311*	*$380,493*	*30.00%*	*$1,648,804*
2.7.1.1.6	*. . . . . Modular Hot Cells Construction/Installation*	*$11,071,359*	*$2,380,020*	*$4,035,414*	*30.00%*	*$17,486,793*
2.7.1.1.6.1	*. . . . . Civil*	*$9,895,464*	*$2,119,347*	*$3,604,443*	*30.00%*	*$15,619,255*
2.7.1.1.6.1.1	*. . . . . Concrete*	*$1,880,393*	*$410,472*	*$687,259*	*30.00%*	*$2,978,124*
2.7.1.1.6.1.2	*. . . . . Metals*	*$7,253,881*	*$1,546,844*	*$2,640,217*	*30.00%*	*$11,440,942*
2.7.1.1.6.1.3	*. . . . . Openings*	*$708,360*	*$151,053*	*$257,824*	*30.00%*	*$1,117,238*
2.7.1.1.6.1.4	*. . . . . Penetrations*	*$52,830*	*$10,978*	*$19,143*	*30.00%*	*$82,951*
2.7.1.1.6.2	*. . . . . Mechanical*	*$312,252*	*$67,789*	*$114,013*	*30.00%*	*$494,054*
2.7.1.1.6.3	*. . . . . Electrical*	*$232,372*	*$61,706*	*$88,223*	*30.00%*	*$382,302*
2.7.1.1.6.4	*. . . . . Overtime (Distributed)*	*$631,270*	*$131,178*	*$228,734*	*30.00%*	*$991,182*
2.7.1.1.7	*. . . . . Characterization Specialty Equipment Construction/Installation*	*$9,096,499*	*$1,932,879*	*$3,308,813*	*30.00%*	*$14,338,192*
2.7.1.1.7.1	*. . . . . Remotize/ Mockup/ Instal Thermal Examination*	*$4,207,408*	*$879,503*	*$1,526,074*	*30.00%*	*$6,612,985*
2.7.1.1.7.2	*. . . . . Remotize/ Mockup/ Instal Microstructure Examination*	*$4,889,091*	*$1,053,376*	*$1,782,740*	*30.00%*	*$7,725,206*
2.8	**. . . . Startup**	**$3,167,693**	**$786,169**	**$1,186,159**	**30.00%**	**$5,140,020**
2.8.1	**. . . . . Startup**	**$3,167,693**	**$786,169**	**$1,186,159**	**30.00%**	**$5,140,020**
2.8.1.1	. . . . . Startup	$3,167,693	$786,169	$1,186,159	30.00%	$5,140,020
2.8.1.1.1	*. . . . . Facility Process Equipment Testing & Verification*	*$1,464,491*	*$363,047*	*$548,261*	*30.00%*	*$2,375,799*
2.8.1.1.2	*. . . . . Characterization Specialty Equipment Testing & Verification*	*$1,703,203*	*$423,121*	*$637,897*	*30.00%*	*$2,764,221*
2.8.1.1.2.1	*. . . . . Testing & Verification Thermal Examination*	*$824,282*	*$204,339*	*$308,586*	*30.00%*	*$1,337,207*

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
2.8.1.1.2.2	*. . . . . Testing & Verification Microstructure Examination*	*$878,921*	*$218,782*	*$329,311*	*30.00%*	*$1,427,014*
2.9	**. . . . Closeout**	**$1,951,241**	**$690,532**	**$792,532**	**30.00%**	**$3,434,305**
2.9.1	**. . . . . Closeout**	**$1,951,241**	**$690,532**	**$792,532**	**30.00%**	**$3,434,305**
2.9.1.2	. . . . . Closeout	$1,951,241	$690,532	$792,532	30.00%	$3,434,305
2.9.1.2.1	*. . . . . Site D&D Operations Readiness & Turnover*	*$28,071*	*$9,934*	*$11,401*	*30.00%*	*$49,406*
2.9.1.2.2	*. . . . . Site Development Operations Readiness & Turnover*	*$159,918*	*$56,594*	*$64,954*	*30.00%*	*$281,466*
2.9.1.2.3	*. . . . . Facility Structure & Ancillary Supt. Sys.Operations Readiness & Turnover*	*$838,189*	*$296,630*	*$340,446*	*30.00%*	*$1,475,264*
2.9.1.2.4	*. . . . . Modular Hot Cells Operations Readiness & Turnover*	*$925,063*	*$327,374*	*$375,731*	*30.00%*	*$1,628,169*
3	**Facility Operations and Maintenance**	**$424,392,808**	**$695,942,428**	**$560,167,618**	**50.00%**	**$1,680,502,854**
3.1	**. . . . Year 1**	**$9,279,388**	**$3,017,657**	**$6,148,522**	**50.00%**	**$18,445,567**
3.1.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,036,743**	**$2,112,379**	**50.00%**	**$6,337,138**
3.1.2	**. . . . . Facility Operations**	**$6,091,372**	**$1,980,914**	**$4,036,143**	**50.00%**	**$12,108,429**
3.2	**. . . . Year 2**	**$9,279,388**	**$3,419,454**	**$6,349,421**	**50.00%**	**$19,048,264**
3.2.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,174,784**	**$2,181,400**	**50.00%**	**$6,544,200**
3.2.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,244,671**	**$4,168,021**	**50.00%**	**$12,504,064**
3.3	**. . . . Year 3**	**$9,279,388**	**$3,834,243**	**$6,556,816**	**50.00%**	**$19,670,447**
3.3.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,317,288**	**$2,252,652**	**50.00%**	**$6,757,956**
3.3.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,516,955**	**$4,304,163**	**50.00%**	**$12,912,490**
3.4	**. . . . Year 4**	**$9,279,388**	**$4,262,023**	**$6,770,705**	**50.00%**	**$20,312,116**
3.4.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,464,256**	**$2,326,136**	**50.00%**	**$6,978,408**
3.4.2	**. . . . . Facility Operations**	**$6,091,372**	**$2,797,767**	**$4,444,570**	**50.00%**	**$13,333,709**
3.5	**. . . . Year 5**	**$9,279,388**	**$4,704,650**	**$6,992,019**	**50.00%**	**$20,976,057**
3.5.1	**. . . . . Facility Maintenance**	**$3,188,016**	**$1,616,324**	**$2,402,170**	**50.00%**	**$7,206,510**
3.5.2	**. . . . . Facility Operations**	**$6,091,372**	**$3,088,326**	**$4,589,849**	**50.00%**	**$13,769,546**
3.6	**. . . . Year 6**	**$9,279,388**	**$5,161,196**	**$7,220,292**	**50.00%**	**$21,660,875**

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.6.1	. . . . . Facility Maintenance	$3,188,016	$1,773,174	$2,480,595	50.00%	$7,441,786
3.6.2	. . . . . Facility Operations	$6,091,372	$3,388,021	$4,739,697	50.00%	$14,219,090
3.7	. . . . Year 7	$9,279,388	$5,633,516	$7,456,452	50.00%	$22,369,357
3.7.1	. . . . . Facility Maintenance	$3,188,016	$1,935,445	$2,561,730	50.00%	$7,685,191
3.7.2	. . . . . Facility Operations	$6,091,372	$3,698,072	$4,894,722	50.00%	$14,684,166
3.8	. . . . Year 8	$9,279,388	$6,120,684	$7,700,036	50.00%	$23,100,108
3.8.1	. . . . . Facility Maintenance	$3,188,016	$2,102,815	$2,645,416	50.00%	$7,936,247
3.8.2	. . . . . Facility Operations	$6,091,372	$4,017,869	$5,054,620	50.00%	$15,163,861
3.9	. . . . Year 9	$9,279,388	$6,623,627	$7,951,508	50.00%	$23,854,523
3.9.1	. . . . . Facility Maintenance	$3,188,016	$2,275,606	$2,731,811	50.00%	$8,195,433
3.9.2	. . . . . Facility Operations	$6,091,372	$4,348,021	$5,219,697	50.00%	$15,659,090
3.10	. . . . Year 10	$27,018,484	$20,798,829	$23,908,656	50.00%	$71,725,969
3.10.1	. . . . . Facility Maintenance	$3,188,016	$2,454,135	$2,821,075	50.00%	$8,463,226
3.10.2	. . . . . Facility Operations	$6,091,372	$4,689,138	$5,390,255	50.00%	$16,170,765
3.10.3	. . . . . Equipment Replacement	$17,739,096	$13,655,556	$15,697,326	50.00%	$47,091,978
3.11	. . . . Year 11	$9,279,388	$7,679,622	$8,479,505	50.00%	$25,438,514
3.11.1	. . . . . Facility Maintenance	$3,188,016	$2,638,402	$2,913,209	50.00%	$8,739,627
3.11.2	. . . . . Facility Operations	$6,091,372	$5,041,219	$5,566,296	50.00%	$16,698,887
3.12	. . . . Year 12	$9,279,388	$8,233,601	$8,756,494	50.00%	$26,269,483
3.12.1	. . . . . Facility Maintenance	$3,188,016	$2,828,727	$3,008,371	50.00%	$9,025,114
3.12.2	. . . . . Facility Operations	$6,091,372	$5,404,874	$5,748,123	50.00%	$17,244,370
3.13	. . . . Year 13	$9,279,388	$8,805,211	$9,042,300	50.00%	$27,126,899
3.13.1	. . . . . Facility Maintenance	$3,188,016	$3,025,108	$3,106,562	50.00%	$9,319,687
3.13.2	. . . . . Facility Operations	$6,091,372	$5,780,103	$5,935,737	50.00%	$17,807,212
3.14	. . . . Year 14	$9,279,388	$9,396,308	$9,337,848	50.00%	$28,013,544
3.14.1	. . . . . Facility Maintenance	$3,188,016	$3,228,185	$3,208,101	50.00%	$9,624,302

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.14.2	. . . . . Facility Operations	$6,091,372	$6,168,123	$6,129,748	50.00%	$18,389,243
3.15	. . . . Year 15	$9,279,388	$10,636,035	$9,957,711	50.00%	$29,873,134
3.15.1	. . . . . Facility Maintenance	$3,188,016	$3,654,104	$3,421,060	50.00%	$10,263,180
3.15.2	. . . . . Facility Operations	$6,091,372	$6,981,931	$6,536,651	50.00%	$19,609,954
3.16	. . . . Year 16	$9,279,388	$10,636,035	$9,957,711	50.00%	$29,873,134
3.16.1	. . . . . Facility Maintenance	$3,188,016	$3,654,104	$3,421,060	50.00%	$10,263,180
3.16.2	. . . . . Facility Operations	$6,091,372	$6,981,931	$6,536,651	50.00%	$19,609,954
3.17	. . . . Year 17	$9,279,388	$11,286,520	$10,282,954	50.00%	$30,848,861
3.17.1	. . . . . Facility Maintenance	$3,188,016	$3,877,584	$3,532,800	50.00%	$10,598,400
3.17.2	. . . . . Facility Operations	$6,091,372	$7,408,936	$6,750,154	50.00%	$20,250,462
3.18	. . . . Year 18	$9,279,388	$11,958,347	$10,618,868	50.00%	$31,856,603
3.18.1	. . . . . Facility Maintenance	$3,188,016	$4,108,396	$3,648,206	50.00%	$10,944,618
3.18.2	. . . . . Facility Operations	$6,091,372	$7,849,951	$6,970,662	50.00%	$20,911,985
3.19	. . . . Year 19	$9,279,388	$12,652,446	$10,965,917	50.00%	$32,897,750
3.19.1	. . . . . Facility Maintenance	$3,188,016	$4,346,860	$3,767,438	50.00%	$11,302,314
3.19.2	. . . . . Facility Operations	$6,091,372	$8,305,586	$7,198,479	50.00%	$21,595,437
3.20	. . . . Year 20	$27,018,484	$38,925,530	$32,972,007	50.00%	$98,916,021
3.20.1	. . . . . Facility Maintenance	$3,188,016	$4,592,975	$3,890,495	50.00%	$11,671,486
3.20.2	. . . . . Facility Operations	$6,091,372	$8,775,840	$7,433,606	50.00%	$22,300,817
3.20.3	. . . . . Equipment Replacement	$17,739,096	$25,556,716	$21,647,906	50.00%	$64,943,717
3.21	. . . . Year 21	$9,279,388	$14,108,382	$11,693,885	50.00%	$35,081,654
3.21.1	. . . . . Facility Maintenance	$3,188,016	$4,847,060	$4,017,538	50.00%	$12,052,613
3.21.2	. . . . . Facility Operations	$6,091,372	$9,261,322	$7,676,347	50.00%	$23,029,041
3.22	. . . . Year 22	$9,279,388	$14,873,003	$12,076,196	50.00%	$36,228,587
3.22.1	. . . . . Facility Maintenance	$3,188,016	$5,109,752	$4,148,884	50.00%	$12,446,652
3.22.2	. . . . . Facility Operations	$6,091,372	$9,763,251	$7,927,312	50.00%	$23,781,935

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.23	. . . . Year 23	$9,279,388	$15,661,751	$12,470,570	50.00%	$37,411,709
3.23.1	. . . . . Facility Maintenance	$3,188,016	$5,380,733	$4,284,375	50.00%	$12,853,124
3.23.2	. . . . . Facility Operations	$6,091,372	$10,281,018	$8,186,195	50.00%	$24,558,584
3.24	. . . . Year 24	$9,279,388	$16,476,481	$12,877,935	50.00%	$38,633,804
3.24.1	. . . . . Facility Maintenance	$3,188,016	$5,660,641	$4,424,329	50.00%	$13,272,986
3.24.2	. . . . . Facility Operations	$6,091,372	$10,815,840	$8,453,606	50.00%	$25,360,818
3.25	. . . . Year 25	$9,279,388	$17,318,122	$13,298,755	50.00%	$39,896,265
3.25.1	. . . . . Facility Maintenance	$3,188,016	$5,949,794	$4,568,905	50.00%	$13,706,715
3.25.2	. . . . . Facility Operations	$6,091,372	$11,368,328	$8,729,850	50.00%	$26,189,549
3.26	. . . . Year 26	$9,279,388	$18,186,673	$13,733,030	50.00%	$41,199,091
3.26.1	. . . . . Facility Maintenance	$3,188,016	$6,248,193	$4,718,104	50.00%	$14,154,313
3.26.2	. . . . . Facility Operations	$6,091,372	$11,938,480	$9,014,926	50.00%	$27,044,778
3.27	. . . . Year 27	$9,279,388	$19,083,989	$14,181,689	50.00%	$42,545,066
3.27.1	. . . . . Facility Maintenance	$3,188,016	$6,556,474	$4,872,245	50.00%	$14,616,735
3.27.2	. . . . . Facility Operations	$6,091,372	$12,527,516	$9,309,444	50.00%	$27,928,331
3.28	. . . . Year 28	$9,279,388	$20,010,072	$14,644,730	50.00%	$43,934,190
3.28.1	. . . . . Facility Maintenance	$3,188,016	$6,874,638	$5,031,327	50.00%	$15,093,981
3.28.2	. . . . . Facility Operations	$6,091,372	$13,135,435	$9,613,403	50.00%	$28,840,210
3.29	. . . . Year 29	$9,279,388	$20,966,777	$15,123,083	50.00%	$45,369,248
3.29.1	. . . . . Facility Maintenance	$3,188,016	$7,203,322	$5,195,669	50.00%	$15,587,007
3.29.2	. . . . . Facility Operations	$6,091,372	$13,763,455	$9,927,414	50.00%	$29,782,241
3.30	. . . . Year 30	$27,018,484	$63,925,733	$45,472,109	50.00%	$136,416,326
3.30.1	. . . . . Facility Maintenance	$3,188,016	$7,542,846	$5,365,431	50.00%	$16,096,293
3.30.2	. . . . . Facility Operations	$6,091,372	$14,412,186	$10,251,779	50.00%	$30,755,337
3.30.3	. . . . . Equipment Replacement	$17,739,096	$41,970,701	$29,854,899	50.00%	$89,564,696
3.31	. . . . Year 31	$9,279,388	$22,975,765	$16,127,576	50.00%	$48,382,729

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.31.1	. . . . . Facility Maintenance	$3,188,016	$7,893,528	$5,540,772	50.00%	$16,622,315
3.31.2	. . . . . Facility Operations	$6,091,372	$15,082,237	$10,586,805	50.00%	$31,760,414
3.32	. . . . Year 32	$9,279,388	$24,028,975	$16,654,182	50.00%	$49,962,545
3.32.1	. . . . . Facility Maintenance	$3,188,016	$8,255,367	$5,721,692	50.00%	$17,165,075
3.32.2	. . . . . Facility Operations	$6,091,372	$15,773,608	$10,932,490	50.00%	$32,797,470
3.33	. . . . Year 33	$9,279,388	$25,117,447	$17,198,418	50.00%	$51,595,253
3.33.1	. . . . . Facility Maintenance	$3,188,016	$8,629,322	$5,908,669	50.00%	$17,726,007
3.33.2	. . . . . Facility Operations	$6,091,372	$16,488,126	$11,289,749	50.00%	$33,869,247
3.34	. . . . Year 34	$9,279,388	$26,241,181	$17,760,285	50.00%	$53,280,854
3.34.1	. . . . . Facility Maintenance	$3,188,016	$9,015,390	$6,101,703	50.00%	$18,305,110
3.34.2	. . . . . Facility Operations	$6,091,372	$17,225,791	$11,658,581	50.00%	$34,975,744
3.35	. . . . Year 35	$9,279,388	$27,401,105	$18,340,246	50.00%	$55,020,739
3.35.1	. . . . . Facility Maintenance	$3,188,016	$9,413,892	$6,300,954	50.00%	$18,902,863
3.35.2	. . . . . Facility Operations	$6,091,372	$17,987,212	$12,039,292	50.00%	$36,117,877
3.36	. . . . Year 36	$9,279,388	$28,599,074	$18,939,231	50.00%	$56,817,693
3.36.1	. . . . . Facility Maintenance	$3,188,016	$9,825,465	$6,506,741	50.00%	$19,520,222
3.36.2	. . . . . Facility Operations	$6,091,372	$18,773,609	$12,432,490	50.00%	$37,297,471
3.37	. . . . Year 37	$9,279,388	$29,836,944	$19,558,166	50.00%	$58,674,498
3.37.1	. . . . . Facility Maintenance	$3,188,016	$10,250,747	$6,719,381	50.00%	$20,158,144
3.37.2	. . . . . Facility Operations	$6,091,372	$19,586,198	$12,838,785	50.00%	$38,516,354
3.38	. . . . Year 38	$9,279,388	$31,114,716	$20,197,052	50.00%	$60,591,156
3.38.1	. . . . . Facility Maintenance	$3,188,016	$10,689,736	$6,938,876	50.00%	$20,816,629
3.38.2	. . . . . Facility Operations	$6,091,372	$20,424,979	$13,258,176	50.00%	$39,774,527
3.39	. . . . Year 39	$9,279,388	$32,434,245	$20,856,816	50.00%	$62,570,449
3.39.1	. . . . . Facility Maintenance	$3,188,016	$11,143,072	$7,165,544	50.00%	$21,496,632
3.39.2	. . . . . Facility Operations	$6,091,372	$21,291,173	$13,691,272	50.00%	$41,073,817

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
3.40	. . . . Year 40	$9,279,388	$33,796,459	$21,537,924	50.00%	$64,613,771
3.40.1	. . . . . Facility Maintenance	$3,188,016	$11,611,073	$7,399,545	50.00%	$22,198,634
3.40.2	. . . . . Facility Operations	$6,091,372	$22,185,386	$14,138,379	50.00%	$42,415,137
4	Post Irradiation Examination	$178,178,400	$295,107,975	$236,643,188	50.00%	$709,929,563
4.1	. . . . Year 1	$4,454,460	$1,448,590	$2,951,525	50.00%	$8,854,576
4.2	. . . . Year 2	$4,454,460	$1,641,469	$3,047,964	50.00%	$9,143,893
4.3	. . . . Year 3	$4,454,460	$1,840,583	$3,147,521	50.00%	$9,442,564
4.4	. . . . Year 4	$4,454,460	$2,045,933	$3,250,197	50.00%	$9,750,590
4.5	. . . . Year 5	$4,454,460	$2,258,411	$3,356,436	50.00%	$10,069,307
4.6	. . . . Year 6	$4,454,460	$2,477,571	$3,466,015	50.00%	$10,398,046
4.7	. . . . Year 7	$4,454,460	$2,704,303	$3,579,381	50.00%	$10,738,144
4.8	. . . . Year 8	$4,454,460	$2,938,162	$3,696,311	50.00%	$11,088,933
4.9	. . . . Year 9	$4,454,460	$3,179,594	$3,817,027	50.00%	$11,451,080
4.10	. . . . Year 10	$4,454,460	$3,429,043	$3,941,752	50.00%	$11,825,255
4.11	. . . . Year 11	$4,454,460	$3,686,511	$4,070,486	50.00%	$12,211,457
4.12	. . . . Year 12	$4,454,460	$3,952,442	$4,203,451	50.00%	$12,610,354
4.13	. . . . Year 13	$4,454,460	$4,226,837	$4,340,649	50.00%	$13,021,946
4.14	. . . . Year 14	$4,454,460	$4,510,586	$4,482,523	50.00%	$13,447,569
1.15	. . . . Year 15	$4,454,460	$5,105,702	$4,780,081	50.00%	$14,340,243
4.16	. . . . Year 16	$4,454,460	$5,105,702	$4,780,081	50.00%	$14,340,243
4.17	. . . . Year 17	$4,454,460	$5,417,960	$4,936,210	50.00%	$14,808,630
4.18	. . . . Year 18	$4,454,460	$5,740,463	$5,097,461	50.00%	$15,292,384
4.19	. . . . Year 19	$4,454,460	$6,073,656	$5,264,058	50.00%	$15,792,174
4.20	. . . . Year 20	$4,454,460	$6,417,541	$5,436,000	50.00%	$16,308,001

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
4.21	. . . . Year 21	$4,454,460	$6,772,561	$5,613,510	50.00%	$16,840,531
4.22	. . . . Year 22	$4,454,460	$7,139,608	$5,797,034	50.00%	$17,391,103
4.23	. . . . Year 23	$4,454,460	$7,518,238	$5,986,349	50.00%	$17,959,046
4.24	. . . . Year 24	$4,454,460	$7,909,339	$6,181,900	50.00%	$18,545,699
4.25	. . . . Year 25	$4,454,460	$8,313,359	$6,383,909	50.00%	$19,151,728
4.26	. . . . Year 26	$4,454,460	$8,730,296	$6,592,378	50.00%	$19,777,134
4.27	. . . . Year 27	$4,454,460	$9,161,042	$6,807,751	50.00%	$20,423,254
4.28	. . . . Year 28	$4,454,460	$9,605,598	$7,030,029	50.00%	$21,090,086
4.29	. . . . Year 29	$4,454,460	$10,064,852	$7,259,656	50.00%	$21,778,969
4.30	. . . . Year 30	$4,454,460	$10,539,252	$7,496,856	50.00%	$22,490,569
4.31	. . . . Year 31	$4,454,460	$11,029,243	$7,741,851	50.00%	$23,225,554
4.32	. . . . Year 32	$4,454,460	$11,534,824	$7,994,642	50.00%	$23,983,926
4.33	. . . . Year 33	$4,454,460	$12,057,332	$8,255,896	50.00%	$24,767,688
4.34	. . . . Year 34	$4,454,460	$12,596,767	$8,525,614	50.00%	$25,576,841
4.35	. . . . Year 35	$4,454,460	$13,153,575	$8,804,017	50.00%	$26,412,052
4.36	. . . . Year 36	$4,454,460	$13,728,646	$9,091,553	50.00%	$27,274,659
4.37	. . . . Year 37	$4,454,460	$14,322,871	$9,388,665	50.00%	$28,165,996
4.38	. . . . Year 38	$4,454,460	$14,936,250	$9,695,355	50.00%	$29,086,065
4.39	. . . . Year 39	$4,454,460	$15,569,674	$10,012,067	50.00%	$30,036,201
4.40	. . . . Year 40	$4,454,460	$16,223,589	$10,339,024	50.00%	$31,017,073
5	Transportation	$533,571,520	$883,727,830	$708,649,675	50.00%	$2,125,949,025
5.1	. . . . Year 1	$13,339,288	$4,337,936	$8,838,612	50.00%	$26,515,837
5.2	. . . . Year 2	$13,339,288	$4,915,528	$9,127,408	50.00%	$27,382,223
5.3	. . . . Year 3	$13,339,288	$5,511,794	$9,425,541	50.00%	$28,276,623

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.4	. . . . Year 4	$13,339,288	$6,126,735	$9,733,011	50.00%	$29,199,034
5.5	. . . . Year 5	$13,339,288	$6,763,019	$10,051,154	50.00%	$30,153,461
5.6	. . . . Year 6	$13,339,288	$7,419,312	$10,379,300	50.00%	$31,137,900
5.7	. . . . Year 7	$13,339,288	$8,098,282	$10,718,785	50.00%	$32,156,355
5.8	. . . . Year 8	$13,339,288	$8,798,594	$11,068,941	50.00%	$33,206,824
5.9	. . . . Year 9	$13,339,288	$9,521,584	$11,430,436	50.00%	$34,291,308
5.10	. . . . Year 10	$13,339,288	$10,268,584	$11,803,936	50.00%	$35,411,808
5.11	. . . . Year 11	$13,339,288	$11,039,595	$12,189,441	50.00%	$36,568,324
5.12	. . . . Year 12	$13,339,288	$11,835,950	$12,587,619	50.00%	$37,762,857
5.13	. . . . Year 13	$13,339,288	$12,657,650	$12,998,469	50.00%	$38,995,408
5.14	. . . . Year 14	$13,339,288	$13,507,363	$13,423,326	50.00%	$40,269,977
5.15	. . . . Year 15	$13,339,288	$15,289,492	$14,314,390	50.00%	$42,943,170
5.16	. . . . Year 16	$13,339,288	$15,289,492	$14,314,390	50.00%	$42,943,170
5.17	. . . . Year 17	$13,339,288	$16,224,576	$14,781,932	50.00%	$44,345,796
5.18	. . . . Year 18	$13,339,288	$17,190,340	$15,264,814	50.00%	$45,794,443
5.19	. . . . Year 19	$13,339,288	$18,188,119	$15,763,704	50.00%	$47,291,111
5.20	. . . . Year 20	$13,339,288	$19,217,912	$16,278,600	50.00%	$48,835,800
5.21	. . . . Year 21	$13,339,288	$20,281,053	$16,810,171	50.00%	$50,430,512
5.22	. . . . Year 22	$13,339,288	$21,380,211	$17,359,749	50.00%	$52,079,248
5.23	. . . . Year 23	$13,339,288	$22,514,050	$17,926,669	50.00%	$53,780,007
5.24	. . . . Year 24	$13,339,288	$23,685,240	$18,512,264	50.00%	$55,536,792
5.25	. . . . Year 25	$13,339,288	$24,895,113	$19,117,201	50.00%	$57,351,602
5.25	. . . . Year 26	$13,339,288	$26,143,671	$19,741,479	50.00%	$59,224,438
5.27	. . . . Year 27	$13,339,288	$27,433,580	$20,386,434	50.00%	$61,159,302

Project Summary Report

Project Name: ***Lifecycle LANL Estimate for Advanced PIE Alternate 4C***
Project Location: ***LANL***
Estimate Number: ***8B26 -F***

Client: ***BEA***
Prepared By: ***D. Radford***
Estimate Type: ***Class 5***

Level	Description	Estimate Subtotal	Escalation & Inflation	Management Reserve MR	MR %	TOTAL
5.28	. . . . Year 28	$13,339,288	$28,764,841	$21,052,064	50.00%	$63,156,193
5.29	. . . . Year 29	$13,339,288	$30,140,121	$21,739,705	50.00%	$65,219,114
5.30	. . . . Year 30	$13,339,288	$31,560,755	$22,450,022	50.00%	$67,350,065
5.31	. . . . Year 31	$13,339,288	$33,028,077	$23,183,683	50.00%	$69,551,048
5.32	. . . . Year 32	$13,339,288	$34,542,086	$23,940,687	50.00%	$71,822,061
5.33	. . . . Year 33	$13,339,288	$36,106,785	$24,723,036	50.00%	$74,169,109
5.34	. . . . Year 34	$13,339,288	$37,722,173	$25,530,730	50.00%	$76,592,191
5.35	. . . . Year 35	$13,339,288	$39,389,584	$26,364,436	50.00%	$79,093,307
5.36	. . . . Year 36	$13,339,288	$41,111,686	$27,225,487	50.00%	$81,676,460
5.37	. . . . Year 37	$13,339,288	$42,891,147	$28,115,217	50.00%	$84,345,652
5.38	. . . . Year 38	$13,339,288	$44,727,967	$29,033,627	50.00%	$87,100,882
5.39	. . . . Year 39	$13,339,288	$46,624,813	$29,982,051	50.00%	$89,946,152
5.40	. . . . Year 40	$13,339,288	$48,583,021	$30,961,154	50.00%	$92,883,463
6	Deactivation, Decommissioning, and Demolition	$24,962,165	$94,701,463	$59,831,814	50.00%	$179,495,442
Total	Lifecycle LANL Estimate for Advanced PIE	$1,304,974,264	$1,999,518,579	$1,616,215,164	48.91%	$4,920,708,007

This page intentionally left blank.

Appendix F

Logistical Analysis

Appendix F
Logistical Analysis

The Logistical Analysis develops the quantitative data that provide input to the utility curves for scoring the following criteria: Logistics, Intra-APIEC Transportation, Direct Experiment Cost, and Risk to Public and Environment. The analysis and assumptions for each of these criteria are presented in this appendix.

Logistics

The Logistics criterion addresses the type and complexity of the initial radioactive material transfers and is based on the numbers of on- and off-site transfers and destinations for analyzing irradiation experiments within each alternative.

The assumptions and overview of the basis are provided below.

Assumptions

1. The number of experiments irradiated per year is 100. This number is used as a basis for comparison of the alternatives. The actual number of experiments per year is not known at this stage of the project.
2. 80% of the experiments destined for advanced PIE are irradiated at ATR, 10% are irradiated at HFIR, and 10% are irradiated at other facilities (e.g., commercial nuclear power plants, MURR, MITR).
3. Experiment NDE, size reduction, and/or repackaging occurs at HFEF for experiments irradiated at ATR and at IFEL for experiments irradiated at HFIR. For experiments irradiated at all other facilities, the routing is assumed to be equally split between HFEF and IFEL.
4. Shipments between ATR and HFEF are batched (i.e., 20 experiments per shipment) based on observed shipping practices. All other shipments are assumed to be 1 per experiment.
5. Each shipment requires at least two cask handling "events" except for shipments from "other" irradiators which require only one handling event (i.e., when received). The loading of the experiment into a cask at any of the “other” irradiators is outside the system boundary for this analysis. A cask handling event is defined as a cask open, experiment package/unpackage, and cask close sequence.
6. In the distributed and consolidated alternatives, the sample is partitioned into an appropriate number of pieces (based on the number of facilities participating in the APIEC).
7. In the distributed and consolidated alternatives, all of the experiment pieces going off-site are placed in a single cask which then makes a circuit to all of the other facilities involved in that alternative via the shortest route.

Summary of Basis

The number of shipments per year for each of the alternatives is shown in Figure F-1. The yearly shipment totals shown in the right hand columns are the sum of the international, on-site, and off-site shipments. For example, in the case of Alternative 2, the number of shipments (i.e., 224) is calculated as follows:

- No international shipments are necessary
- On-site shipments include 4 from ATR to HFEF ((assuming 20 experiments in each shipment covering the 80 total experiments), 10 shipments from HFIR to IFEL (assuming 1 experiment

per shipments for 10 total experiments), and then 100 transfers which are broken down as follows:

  - One portion of each experiment which underwent NDE/sizing at HFEF (80 from ATR and 5 from "other" irradiators for a total of 85) transferring from HFEF to IMCL.
  - One portion of each experiment which underwent NDE/sizing at IFEL (10 from HFIR and 5 from "other" irradiators for a total of 15) transferring from IFEL to REDC 7930.

  Thus, the total on-site shipments is 4(ATR) + 10(HFIR) + 85(HFEF) + 15(IFEL) = 114.

- Off-site shipments include 110 transfers, which are broken down as follows:
  - A total of 10 off-site shipments being received at HFEF and IFEL (i.e., 5 at each facility)
  - Four portions of each experiment which underwent NDE/sizing at HFEF (85 total; see derivation above for on-site shipments) transferring off-site to participating APIEC locations including RPL (at PNNL), CMR Wing 9 (at LANL), HCF (at SRNL), and REDC 7930 (at ORNL).
  - Four portions of each experiment which underwent NDE/sizing at IFEL (15 total; see derivation above for on-site shipments) transferring off-site to participating APIEC locations including SCF (at SRNL), CMR Wing 9 (at LANL), IMCL (at INL), and RPL (at PNNL).

Thus, the total off-site shipments is 5(HFEF) + 5(IFEL) + 85(HFEF) + 15(IFEL) = 110. Then, using the total number of shipments, the logistics score is calculated as follows:

Logistics score = (number of yearly on-site shipments) +
4 × (number of yearly off-site shipments) +
16 × (number of yearly international shipments) +
(count of number of shipping legs per year).

The factor of 4 applied to the number of off-site shipments was selected to reflect the complexity of off-site shipments as compared to on-site shipments. The factor of 16 applied to the number of international shipments was selected to reflect the complexity of international shipments as compared to on-site shipments. The count of the number of off-site shipments represents, in effect, the number of handling events encountered during the path through the facilities that are involved in the alternative. For example, in Alternative 2 each experiment from ATR (of the 85 per year) would follow a route from HFEF to PNNL to LANL, etc. Similarly, each experiment from HFIR would follow a route from IFEL to SRNL to LANL, etc. Figures F-2 to F-11 show the basis for the off-site shipment leg count used in the logistics score calculation. These figures also contain information supporting score calculations for other criteria discussed in later sections of this appendix.

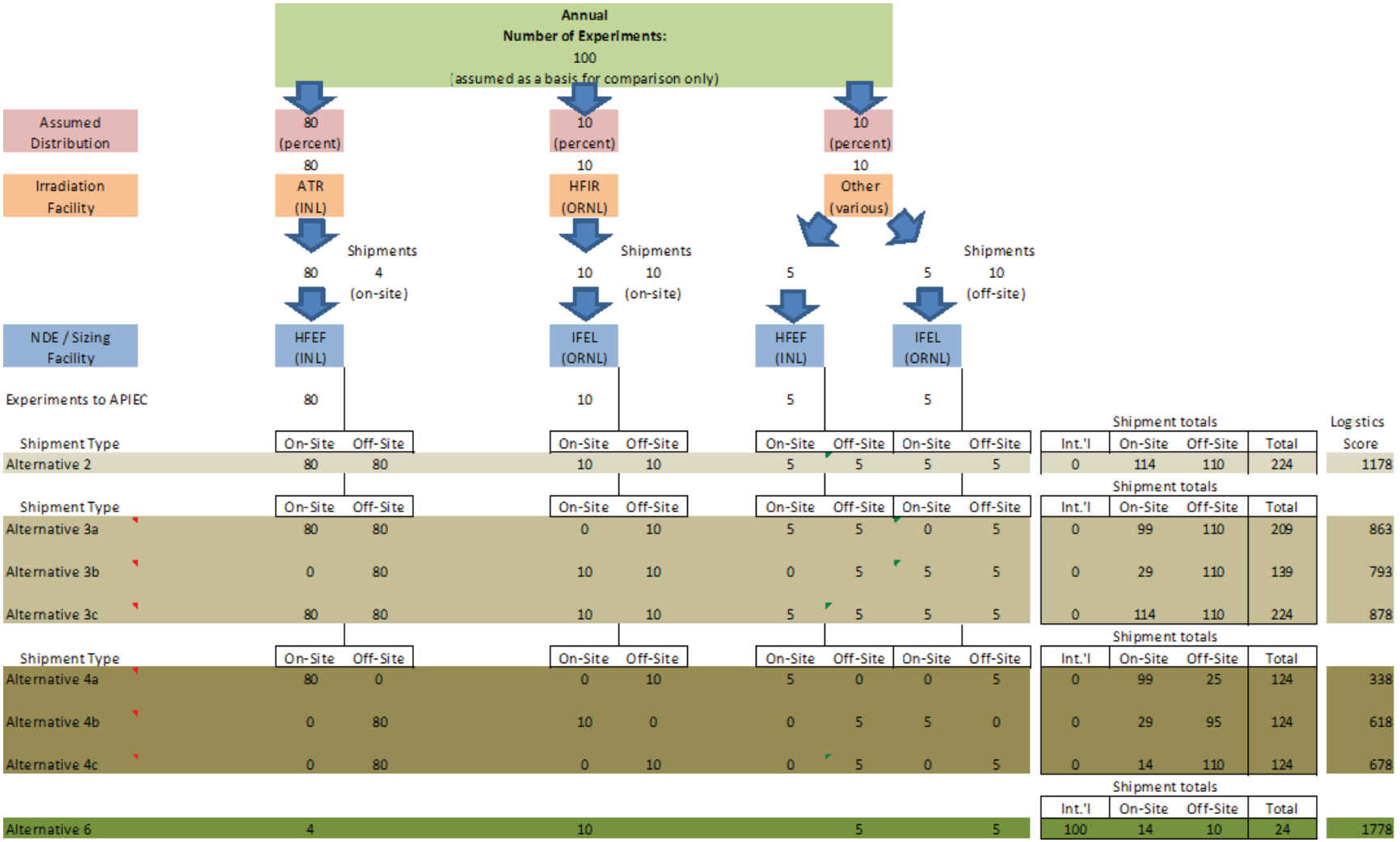


Figure F-1. Logistics (Type and Complexity)

Alternative #2					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	IMCL	85	On	1	85			0
HFEF	RPL	85	Off	580	49,300	85	49,300	49,300
RPL	CMR W9	85	Off	1240	105,400	85	105,400	105,400
CMR W9	REDC 7930	85	Off	1410	119,850	85	119,850	119,850
REDC 7930	SCF	85	Off	360	30,600	85	30,600	30,600
SCF	HFEF	85	RL	2160	183,600	85		183,600
IFEL	REDC 7930	15	On	2	30			0
IFEL	SCF	15	Off	360	5,400	15	5,400	5,400
SCF	CMR W9	15	Off	1590	23,850	15	23,850	23,850
CMR W9	IMCL	15	Off	810	12,150	15	12,150	12,150
IMCL	RPL	15	Off	580	8,700	15	8,700	8,700
RPL	IFEL	15	RL	2390	35,850	15		35,850
Totals		224			586,915	510	**367,250**	574,800

Figure F-2. Calculation of mileage, offsite legs, risk miles, and freight miles.

Alternative #3a (IMCL & CMR W9)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	IMCL	85	On	1	85			0
HFEF	CMR W9	85	Off	810	68,850	85	68,850	68,850
CMR W9	HFEF	85	RL	810	68,850	85		68,850
IFEL	IMCL	15	Off	1900	28,500	15	28,500	28,500
IMCL	CMR W9	15	Off	810	12,150	15	12,150	12,150
CMR W9	IFEL	15	RL	1410	21,150	15		21,150
Totals		209			211,685	225	**121,500**	199,600

Figure F-3. Alternative 3a Risk Miles

Alternative #3b (CMR W9 & REDC 7930)					Extended	Off-site	In-Commerce	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	REDC 7930	85	Off	1900	161,500	85	161,500	161,500
REDC 7930	CMR W9	85	Off	1410	119,850	85	119,850	119,850
CMR W9	HFEF	85	RL	810	68,850	85		68,850
IFEL	REDC 7930	15	On	2	30			0
IFEL	CMR W9	15	Off	1410	21,150	15	21,150	21,150
CMR W9	IFEL	15	RL	1410	21,150	15		21,150
Totals		139			404,630	295	**314,500**	392,600

Figure F-4. Alternative 3b Risk Miles

Alternative #3c (IMCL & REDC 7930)					Extended	Off-site	In-Commerce	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	IMCL	85	On	1	85			0
HFEF	REDC 7930	85	Off	1900	161,500	85	161,500	161,500
REDC 7930	HFEF	85	RL	1900	161,500	85		161,500
IFEL	IMCL	15	Off	1900	28,500	15	28,500	28,500
IMCL	IFEL	15	RL	1900	28,500	15		28,500
IFEL	REDC 7930	15	On	2	30			0
Totals		224			392,215	210	**202,000**	380,100

Figure F-5. Alternative 3c Risk Miles

Alternative #4a (INL)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	APEX-A	85	On	1	85			0
IFEL	APEX-A	15	Off	1900	28,500	15	28,500	28,500
APEX-A	IFEL	15	RL	1900	28,500	15		28,500
Totals		124			69,185	40	**40,500**	57,100

Figure F-6. Alternative 4a Risk Miles

Alternative #4b (ORNL)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	APEX-B	85	Off	1900	161,500	85	161,500	161,500
APEX-B	HFEF	85	RL	1900	161,500	85		161,500
IFEL	APEX-B	15	On	2	30			0
Totals		124			335,130	180	**173,500**	323,100

Figure F-7. Alternative 4b Risk Miles

Alternative #4c1 (LANL)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	APEX-C1	85	Off	810	68,850	85	68,850	68,850
APEX-C1	HFEF	85	RL	810	68,850	85		68,850
IFEL	APEX-C1	15	Off	1410	21,150	15	21,150	21,150
APEX-C1	IFEL	15	RL	1410	21,150	15		21,150
Totals		124			192,100	210	**102,000**	180,100

Figure F-8. Alternative 4c1 Risk Miles

Alternative #4c2 (PNNL)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	APEX-C2	85	Off	580	49,300	85	49,300	49,300
APEX-C2	HFEF	85	RL	580	49,300	85		49,300
IFEL	APEX-C2	15	Off	2390	35,850	15	35,850	35,850
APEX-C2	IFEL	15	RL	2390	35,850	15		35,850
Totals		124			182,400	210	**97,150**	170,400

Figure F-9. Alternative 4c2 Risk Miles

Alternative #4c3 (SNL)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	APEX-C3	85	Off	840	71,400	85	71,400	71,400
APEX-C3	HFEF	85	RL	840	71,400	85		71,400
IFEL	APEX-C3	15	Off	1380	20,700	15	20,700	20,700
APEX-C3	IFEL	15	RL	1380	20,700	15		20,700
Totals		124			196,300	210	**104,100**	184,300

Figure F-10. Alternative 4c3 Risk Miles

Alternative #4c4 (SRNL)					Extended	Off-site	Risk	Freight
From	To	# Shpmts	Type	Dist	Miles	Legs	Miles	Miles
ATR	HFEF	4	On	20	80			80
HFIR	IFEL	10	On	2	20			20
Other	HFEF	5	Off	1200	6,000	5	6,000	0
Other	IFEL	5	Off	1200	6,000	5	6,000	0
HFEF	APEX-C4	85	Off	2160	183,600	85	183,600	183,600
APEX-C4	HFEF	85	RL	2160	183,600	85		183,600
IFEL	APEX-C4	15	Off	360	5,400	15	5,400	5,400
APEX-C4	IFEL	15	RL	360	5,400	15		5,400
Totals		124			390,100	210	**201,000**	378,100

Figure F-11. Alternative 4c4 Risk Miles

Intra-APIEC Transportation

This criterion provides a quantitative measure for comparing the APIEC alternatives based on the types of mechanisms available to perform intra-APIEC transfers of specimens within or between the facilities involved at each site (i.e., from sample preparation to the examination instrument[s], between the shielded cells and non-shielded instrument spaces, and back to the prepared specimen storage). It evaluates these mechanisms based on an assigned point value for the mechanisms and the number of instances that mechanism is used within the alternative. Table F-1 provides a summary to be used for alternative scoring.

The totals were calculated by assigning values to the types of transfers to be performed. An intra-facility transfer using a Rabbit system received lower points with manual transfers moving within different areas at the same Lab receiving higher points. A lower point value is desirable as shown in Table F-1.

Table F-1. Summary of results for Intra-APIEC transportation analysis

Alt #	Description	Sample Prep to Shielded Exam Cells	Sample Prep to Non-Shielded Instrument Space	Return to Storage from Shielded Exam Cells	Totals
2	IMCL @ INL CMR W9 @ LANL RPL @ PNNL REDC 7930 @ ORNL SCF @ SRNL	2 @ 2 pts = 4 pts 1 @ 2 pts = 2 pts 1 @ 2 pts = 2 pts 2 @ 1 pt = 2 pts 1 @ 2 pts = 2 pts Subtotal: 12 pts	1 @ 2 pts = 2 pts N/A 1 @ 2 pts = 2 pts 1 @ 4 pts = 4 pts 1 @ 2 pts = 2 pts Subtotal = 10 pts	2 @ 2 pts = 4 pts 1 @ 2 pts = 2 pts 1 @ 2 pts = 2 pts 2 @ 1 pt = 2 pts 1 @ 2 pts = 2 pts Subtotal: 12 pts	34
3a	IMCL @ INL CMR W9 @ LANL	4 @ 2 pts = 8 pts 3 @ 2 pts = 6 pts Subtotal: 14 pts	2 @ 2 pts = 4 pts 2 @ 2 pts = 4 pts Subtotal: 8 pts	4 @ 2 pts = 8 pts 3 @ 2 pts = 6 pts Subtotal: 14 pts	36
3b	CMR W9 @ LANL REDC 7930 @ ORNL	3 @ 2 pts = 6 pts 4 @ 1 pts = 4 pts Subtotal: 10 pts	2 @ 2 pts = 4 pts 2 @ 4 pts = 8 pts Subtotal: 12 pts	3 @ 2 pts = 6 pts 4 @ 1 pts = 4 pts Subtotal: 10 pts	32
3c	IMCL @ INL REDC 7930 @ ORNL	3 @ 2 pts = 6 pts 4 @ 1 pts = 4 pts Subtotal: 10 pts	2 @ 2 pts = 4 pts 2 @ 4 pts = 8 pts Subtotal: 12 pts	3 @ 2 pts = 6 pts 4 @ 1 pts = 4 pts Subtotal: 10 pts	32
4a	APEX @ INL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
4b	APEX @ ORNL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22
4c	APEX @ LANL, PNNL, SNL, or SRNL	7 @ 1 pt = 7 pts	4 @ 2 pts = 8 pts	7 @ 1 pt = 7 pts	22

Mechanism Point Values:
Intra-Facility Rabbit: 1
Manual Transfer Using Shielded/Unshielded Transfer Device - Intra-Building: 2
Manual Transfer Using Shielded/Unshielded Transfer Device - Inter-Building (same site Area): 3
Manual Transfer Using Shielded/Unshielded Transfer Device – Intra-Site (same Lab): 4

Direct Experiment Cost

The Direct Experiment Cost criterion takes into consideration the staffing costs for sample receiving, preparation, specimen examination, results documentation, and waste processing and the transportation costs on an annual basis. The assumptions and summary data for the transportation portion of the Direct Experiment Costs for each alternative are discussed below.

Assumptions

1. All off-site transports are assumed to be in-commerce shipments regulated by DOT as Type B shipments. A DOT certified cask (equivalent to the GE2000) will be used for these shipments.
2. Shipments from ATR to HFEF, HFIR to IFEL, and all APIEC off-site shipments (after NDE/sizing/repackaging) require the use of a rental cask. Cost of the rental cask is based on GE2000 rental experience although GE indicating that it is no longer in the cask rental business.
3. The ORNL GE2000 cask is assumed to be unavailable to support HFIR to IFEL shipments due to its primary use for transferring HFIR fuel and the priority of that use.
4. Shipments from "other" irradiators to the NDE/sizing/repackaging capability are assumed to be paid for by others. University shipments are assumed to use the existing BRR Cask and shipping paid for by other programs. Shipments from commercial and/or international entities will be at their expense.
5. All experiments are assumed to be covered by the cask's Certificate of Compliance (CoC). That is, it is assumed that there are no CoC revisions required to be considered for this comparative analysis.
6. Shipments from ATR to HFEF are assumed to use the new haul road and will be out-of-commerce shipments. A DOT certified cask is assumed to be used so no Transportation Plan is required to be developed.
7. On-site shipments downstream of NDE/sizing/repackaging are assumed to be performed using existing casks (either Type A or Type B) that are available at the site at no cost.
8. A separate cask is assumed rented for each off-site shipment. For the distributed and consolidated alternatives, the portions of the sample to be examined at off-site facilities will be loaded into the same cask and sent in a circuit delivery route that minimizes the distance to be traveled.
9. All on-site shipments, and off-site shipments within 500 miles, are assumed to occur within the base 10-day rental period. Additional days will be added at a rate of 1 day per 500 miles of transport distance for off-site shipments greater than 500 miles.
10. Return of rented casks to the vendor after completion of the shipment is assumed to be covered by the rental fee.
11. Operations and RadCon support costs are assumed to cover both loading and unloading the casks ($6000 and $5000 at each end, respectively).
12. The rental for a Type B GE-2000 type cask is $75K for the first 10 days and $3K/day for days 11 thru 30.

Figure F-12 provides a summary of the experiment transportation costs for each alternative. Figures F-13 to F-19 provide additional detail information. Travel distances between DOE laboratory sites are provided in Figure F-20.

ESTIMATED ANNUAL TRANSPORTATION COSTS							
	Alt. 2	Alt. 3a	Alt. 3b	Alt. 3c	Alt. 4a	Alt. 4b	Alt. 4c (avg)
Cost Element							
On-Site Shipments							
Cask Rental	$1,050,000	$1,050,000	$1,050,000	$1,050,000	$1,050,000	$1,050,000	$1,050,000
Operations Support Costs	$1,368,000	$1,188,000	$348,000	$1,368,000	$1,188,000	$348,000	$168,000
RadCon Support Costs	$1,140,000	$990,000	$290,000	$1,140,000	$990,000	$290,000	$140,000
Freight Costs	$350	$350	$350	$350	$350	$350	$350
Off-Site Shipments							
Cask Rental	$7,500,000	$7,500,000	$7,500,000	$7,500,000	$1,125,000	$6,375,000	$7,500,000
Cask Rental - Additional Days	$8,100,000	$1,350,000	$3,540,000	$2,100,000	$315,000	$1,785,000	$1,372,500
Operations Support Costs	$3,060,000	$1,350,000	$1,770,000	$1,260,000	$240,000	$1,080,000	$1,260,000
RadCon Support Costs	$2,550,000	$1,125,000	$1,475,000	$1,050,000	$200,000	$900,000	$1,050,000
Freight Costs	$2,011,450	$698,250	$1,373,750	$1,330,000	$199,500	$1,130,500	$798,438
Total:	**$26,779,800**	**$15,251,600**	**$17,347,100**	**$16,798,350**	**$5,307,850**	**$12,958,850**	**$13,339,288**
Rank:	11	8	10	9	1	5	6

Figure F-12. Summary of Estimated Annual Transportation Costs

Alt. 2	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	114	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	228	Handling Event	6,000.00		$1,368,000
RadCon Support Costs	228	Handling Event	5,000.00		$1,140,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$3,558,350**
Off-Site Shipments	100	Shipment			
Cask Rental	100	Shipment	75,000.00		$ 7,500,000
Cask Rental - Additional Days	2,700	Days	3,000.00		$ 8,100,000
Operations Support Costs	510	Handling Event	6,000.00		$ 3,060,000
RadCon Support Costs	510	Handling Event	5,000.00		$ 2,550,000
Freight Costs	574,700	Miles	3.50		$ 2,011,450
				Sub-Total:	**$23,221,450**
Total					**$26,779,800**

Figure F-13. Estimated Alternative 2 Transportation Costs

Alt. 3a	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	99	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	198	Handling Event	6,000.00		$1,188,000
RadCon Support Costs	198	Handling Event	5,000.00		$990,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$3,228,350**
Off-Site Shipments	100	Shipment			
Cask Rental	100	Shipment	75,000.00		$ 7,500,000
Cask Rental - Additional Days	450	Days	3,000.00		$ 1,350,000
Operations Support Costs	225	Handling Event	6,000.00		$ 1,350,000
RadCon Support Costs	225	Handling Event	5,000.00		$ 1,125,000
Freight Costs	199,500	Miles	3.50		$ 698,250
				Sub-Total:	**$12,023,250**
Total					**$15,251,600**

Figure F-14. Estimated Alternative 3a Transportation Costs

Alt. 3b	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	29	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	58	Handling Event	6,000.00		$348,000
RadCon Support Costs	58	Handling Event	5,000.00		$290,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$1,688,350**
Off-Site Shipments	100	Shipment			
Cask Rental	100	Shipment	75,000.00		$ 7,500,000
Cask Rental - Additional Days	1,180	Days	3,000.00		$ 3,540,000
Operations Support Costs	295	Handling Event	6,000.00		$ 1,770,000
RadCon Support Costs	295	Handling Event	5,000.00		$ 1,475,000
Freight Costs	392,500	Miles	3.50		$ 1,373,750
				Sub-Total:	**$15,658,750**
Total					**$17,347,100**

Figure F-15. Estimated Alternative 3b Transportation Costs

Alt. 3c	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	114	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	228	Handling Event	6,000.00		$1,368,000
RadCon Support Costs	228	Handling Event	5,000.00		$1,140,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$3,558,350**
Off-Site Shipments	100	Shipment			
Cask Rental	100	Shipment	75,000.00		$ 7,500,000
Cask Rental - Additional Days	700	Days	3,000.00		$ 2,100,000
Operations Support Costs	210	Handling Event	6,000.00		$ 1,260,000
RadCon Support Costs	210	Handling Event	5,000.00		$ 1,050,000
Freight Costs	380,000	Miles	3.50		$ 1,330,000
				Sub-Total:	**$13,240,000**
Total					**$16,798,350**

Figure F-16. Estimated Alternative 3c Transportation Costs

Alt. 4a	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	99	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	198	Handling Event	6,000.00		$1,188,000
RadCon Support Costs	198	Handling Event	5,000.00		$990,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$3,228,350**
Off-Site Shipments	15	Shipment			
Cask Rental	15	Shipment	75,000.00		$ 1,125,000
Cask Rental - Additional Days	105	Days	3,000.00		$ 315,000
Operations Support Costs	40	Handling Event	6,000.00		$ 240,000
RadCon Support Costs	40	Handling Event	5,000.00		$ 200,000
Freight Costs	57,000	Miles	3.50		$ 199,500
				Sub-Total:	**$2,079,500**
Total					**$5,307,850**

Figure F-17. Estimated Alternative 4a Transportation Costs

Alt. 4b	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	29	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	58	Handling Event	6,000.00		$348,000
RadCon Support Costs	58	Handling Event	5,000.00		$290,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$1,688,350**
Off-Site Shipments	85	Shipment			
Cask Rental	85	Shipment	75,000.00		$ 6,375,000
Cask Rental - Additional Days	595	Days	3,000.00		$ 1,785,000
Operations Support Costs	180	Handling Event	6,000.00		$ 1,080,000
RadCon Support Costs	180	Handling Event	5,000.00		$ 900,000
Freight Costs	323,000	Miles	3.50		$ 1,130,500
				Sub-Total:	**$11,270,500**
Total					**$12,958,850**

Figure F-18. Estimated Alternative 4b Transportation Costs

Alt. 4c(Avg)	Annual Quantity or Amount	Units	Cost Per Unit ($)		Extended Cost ($)
On-Site Shipments	14	Shipment			
Cask Rental	14	Shipment	75,000.00		$1,050,000
Operations Support Costs	28	Handling Event	6,000.00		$168,000
RadCon Support Costs	28	Handling Event	5,000.00		$140,000
Freight Costs	100	Miles	3.50		$350
				Sub-Total:	**$1,358,350**
Off-Site Shipments	100	Shipment			
Cask Rental	100	Shipment	75,000.00		$ 7,500,000
Cask Rental - Additional Days	458	Days	3,000.00		$ 1,372,500
Operations Support Costs	210	Handling Event	6,000.00		$ 1,260,000
RadCon Support Costs	210	Handling Event	5,000.00		$ 1,050,000
Freight Costs	228,125	Miles	3.50		$ 798,438
				Sub-Total:	**$11,980,938**
Total					**$13,339,288**

Figure F-19. Estimated Alternative 4c (Avg) Transportation Costs

		ATR INL	HFEF INL	IMCL INL	APEX-A INL	CMR W9 LANL	APEX-C1 LANL	HFIR ORNL	IFEL ORNL	REDC 7930 ORNL	APEX-B ORNL	RPL PNNL	APEX-C2 PNNL	ACRR HCF SNL	APEX-C3 SNL	SCF SRNL	APEX-C4 SRNL
ATR	INL		20	20	20	825	825	1920	1920	1920	1920	600	600	860	860	2175	2175
HFEF	INL	20		1	1	810	810	1900	1900	1900	1900	580	580	840	840	2160	2160
IMCL	INL	20	1		1	810	810	1900	1900	1900	1900	580	580	840	840	2160	2160
APEX-A	INL	20	1	1		810	810	1900	1900	1900	1900	580	580	840	840	2160	2160
CMR W9	LANL	825	810	810	810		1	1410	1410	1410	1410	1240	1240	110	110	1590	1590
APEX-C1	LANL	825	810	810	810	1		1410	1410	1410	1410	1240	1240	110	110	1590	1590
HFIR	ORNL	1920	1900	1900	1900	1410	1410		2	1	1	2390	2390	1380	1380	360	360
IFEL	ORNL	1920	1900	1900	1900	1410	1410	2		2	2	2390	2390	1380	1380	360	360
REDC 7930	ORNL	1920	1900	1900	1900	1410	1410	1	2		1	2390	2390	1380	1380	360	360
APEX-B	ORNL	1920	1900	1900	1900	1410	1410	1	2	1		2390	2390	1380	1380	360	360
RPL	PNNL	600	580	580	580	1240	1240	2390	2390	2390	2390		1	1275	1275	2650	2650
APEX-C2	PNNL	600	580	580	580	1240	1240	2390	2390	2390	2390	1		1275	1275	2650	2650
ACRR HCF	SNL	860	840	840	840	110	110	1380	1380	1380	1380	1275	1275		1	1570	1570
APEX-C3	SNL	860	840	840	840	110	110	1380	1380	1380	1380	1275	1275	1		1570	1570
SCF	SRNL	2175	2160	2160	2160	1590	1590	360	360	360	360	2650	2650	1570	1570		1
APEX-C4	SRNL	2175	2160	2160	2160	1590	1590	360	360	360	360	2650	2650	1570	1570	1	

Figure F-20. Transportation Mileage between Select DOE Laboratories/Facilities

Risk to Public and Environment

To quantify the Risk to Public and Environment, the number of total off-site miles was calculated. It was assumed that the greater the mileage, the greater risk or potential for risk. Specifically, the risk is assumed to be traffic accidents that occur as a result of performing APIEC activities. The assumptions and summary mileage values for each alternative are provided below. The mileage for each alternative is shown in Figure F-21. These miles will be multiplied by the Waste Isolation Pilot Plant (WIPP) traffic incident rate (i.e., average number of traffic incidents per mile) and by 40 years to obtain the expected number of traffic incidents associated with each alternative's 40-year lifetime. The metric used for this criterion will be the expected number of traffic incident reductions from the worst case alternative (i.e., by definition the worst case alternative's metric value is "0").

Assumptions

1. Shipments of empty casks back to the origination point (i.e., cask renter) are assumed to occur for each shipment but do not contribute to public risk perception because the casks are not placarded as a radioactive shipment on this return leg. These legs do add additional miles and days for costing purposes.
2. Shipments of empty casks to and from the renter do not contribute to public risk perception because the casks are not placarded as a radioactive shipment on these legs. The cost of these transports is covered by the rental fee.

Perceived Public Risk Summary		
	Total Off-Site Miles	Rank
Alt 2	367,250	10
Alt 3a	121,500	5
Alt 3b	314,500	9
Alt 3c	202,000	8
Alt 4a	40,500	1
Alt 4b	173,500	6
Alt 4c1	102,000	3
Alt 4c2	97,150	2
Alt 4c3	104,100	4
Alt 4c4	201,000	7

Figure F-21. Summary of Annual Off-Site Mileage by Alternative