EDA Evaluation Process

Presentation to:
Nuclear Waste Technical Review Board (NWTRB)

Presentation by:
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Yucca Mountain Project

Requirements for the LADS Decision Process

- **Compatible with a conceptual design process**
  - **Encourage brainstorming, new ideas**
  - **Develop design concepts that meet general requirements**
  - **Allow designs to change and evolve with additional analysis**
- **Readily incorporates judgments as well as calculations**
- **Uses consensus of team, not single individual**
- **Relies on consistent set of objectives; alternatives can be modified to better meet objectives**
- **Provides flexibility to DOE to consider M&O *recommendation*–as well as other perspectives–to arrive at their *selection***

LADS Decision Analysis Team

Name	Affiliation	Role
Kevin Coppersmith	Geomatrix	facilitation
Thomas Cotton	JK Research	methodology, implementation
Steve Hora	Univ. Hawaii, Hilo	methodology
Allin Cornell	Stanford Univ.	methodology
Peter Morris	Applied Decision Analysis	review

LADS Process

The LADS Decision Analysis team developed a process that facilitates conceptual design activities and has the following attributes:

- **Identifies objectives (criteria) and uses as guides in developing design concepts**
- **Uses workshops and interactions attended by observers to brainstorm, develop, and evaluate alternative ideas and perspectives**
- **Uses consensus decision process with LADS core team as decision-makers, using both project-developed information and engineering judgment**
- **Provides documented basis for judgments and evaluations**

Key Process Issues Decided by License Application Design Integration Group

LADIG: Representatives from management

Process Issues Addressed:

- **Decision methodology: less structured approach consistent with conceptual design and DOE flexibility**
- **Phase II evaluation criteria and measures**
- **Desired product: ranking of EDAs by criterion; <u>not</u> rolled-up decision using MUA**
- **M&O provides documented recommendation**

LADS Process Steps

- **Phase I evaluation of Design Alternatives and Design Features (DA/DFs)**
- **Enhanced Design Alternative (EDA) development**
  - **January workshop**
- **EDA evaluation**
  - **March workshop**
  - **Phase II evaluation criteria**
- **EDA comparative evaluation**
  - **Ranking against each criterion**
  - **Design recommendation**

EDA Evaluation Process

- **Eight candidate EDAs from workshop refined to set of five that captures the diversity**
- **Design descriptions and analyses developed by lead design engineers**
- **EDA evaluation criteria developed by LADS core team, approved by LADIG**
- **Evaluations conducted by LADS core team and documented in report**

EDA Evaluation Criteria

- **Purpose is to identify a set of criteria to evaluate the EDAs that are consistent with the objectives of a repository design**
- **Criteria consist of multiple subcriteria evaluated on natural and constructed scales**
- **Because the ratings are not intended to be part of a formal utility analysis, they are not required to be:**
  - **Independent**
  - **Mutually exclusive**
  - **Comparable within criteria or across multiple criteria**

EDA Evaluation Criteria

(continued)

- **The role of the EDA evaluations is to provide a consistent set information and engineering judgments for each EDA**
- **The evaluations provide a basis for the pairwise comparisons to arrive at ranking within each criterion**
- **Numerical "scores" have no quantitative meaning; mathematical combinations of scores would be inappropriate and meaningless**

Enhanced Design Alternative (EDA) Evaluation Criteria

Criterion	Main Relevant Factors
Screening: meets regulatory requirements	▪ Peak dose within 10,000 years of 25 mrem/yr to the average member of a critical group at 20 km from the potential repository
Licensing probability/Safety	• Time to 25 mrem/yr dose • Level and timing of peak dose in 1 million years • Margin: Ratio of 25 mrem/yr to peak dose in 10,000 years • Degree of defense-in-depth • Uncertainties in postclosure performance and the ability to mitigate them by the time of possible LA • Engineering acceptance • Environmental considerations
Construction/Operations/ Maintenance	• Worker safety • Constructability • Operations • Maintainability • Handling logistics • Performance confirmation • Off-normal events
Flexibility	• Increased disposal capacity (87,000; 105,000 MTU) • Preclosure period (10 yr after emplacement; 100 yr; 300 yr) • Receipt of 5-yr old CSNF • Design changes (Hot « cold; blending; backfill) • Unanticipated natural features or findings
Cost/Schedule	• Time and costs (total and net present value) required for site characterization and licensing, construction, operations, monitoring, and closure

EDA Comparative Evaluations

- **Purpose:**
  - **To rank the EDAs against the four evaluation criteria**
  - **To arrive at a recommended design**
- **Ranking**
  - **Conducted by LADS core team**
  - **Method: pairwise comparisons between all EDAs against each evaluation criterion separately**
  - **Source of information: technical basis for the evaluations against the criteria; not just the scores**

EDA Ranking Against Criteria: Based on Pair-Wise Comparison

License Probability/Safety	Flexibility	Construction/Operations/ Maintenance	Cost
I	IIIa, IIIb	V	II, IIIa, IIIb, IV, V
II	V	IIIa	I
IIIb	II	II	
IIIa	IV	IIIb	
V	I	I	
IV		IV	

EDA Comparative Evaluations

(continued)

- **EDA Recommendation**
  - **No explicit value model, allowing for flexibility in DOE's selection process**
  - **Considered consistency in ranking across multiple criteria; ranking well in all criteria preferable to ranking highly in one or two and poorly in another**
  - **EDA II judged to provide reasonable balance**

EDA Comparative Evaluations

(continued)

- **Thought process in arriving at EDA II as recommended design**
  - **All five EDAs provide excellent performance; no discriminators**
  - **EDAs I and II provide the best licensing probability/safety, particularly with respect to uncertainties in coupled processes and waste package corrosion**
  - **Relative to C/O/M, EDA II is comparable to other EDAs, but EDA I has operational and preclosure safety issues related to substantially more drifts and more waste packages**

EDA Comparative Evaluations
(continued)

- **Thought process in arriving at EDA II as recommended design (continued)**
  - **EDA II is more flexible than EDA I in terms of possible additional capacity or changes in temperature goals; EDA II can achieve lower temperature goals with longer ventilation or other thermal management techniques**
  - **Cost associated with EDA II is comparable to other EDAs; significantly higher for EDA I**

Principal Results of EDA Analysis

Performance Categories		EDA I	EDA II	EDAs IIIa/IIIb	EDA IV	EDA V
Performance Factors	Margin	2,500	3,550	1,500	180,000	1,250
	Time to 25 mrem	290,000 years	310,000 years	290,000/ 310,000 years	100,000 years	300,000 years
	Peak Annual Dose	85 mrem	85 mrem	215/100 mrem	1,200 mrem	200 mrem
Licensing Probability/Safety Factors	Rock Temperatures	Always below 96ºC	>96ºC several m's into drift for hundreds of yrs.	>96ºC across most of repository	>96ºC across most of repository	>96ºC across essentially all of repository
	Waste Package Corrosion	Does not enter aggressive corrosion range	Does not enter aggressive corrosion range	Some WPs in aggressive corr. range for 1000s of years	Humid air corrosion of WPs begins as early as 100 years	Some WPs in aggressive corrosion range >10,000 years
Construction, Operations, and Maintenance Factors	Number of Waste Packages	15,903	10,039	10,213	10,213	10,039
	Length of Emplacement Drifts	132 km	54 km	55 km	60 km	54 km
	Key Construction, Operations, and Maintenance Issues	Operational impacts of more packages and longer drifts; blending	Blending; emplacement of backfill	Fabrication of dual corrosion-resistant material package in IIIb	Fabrication, welding, and handling thick WPs; empl. of backfill	Blending
Flexibility Factors	Emplacement area for 70,000 MTHM	1,400 acres	1,050 acres	740 acres	740 acres	420 acres
	Ability to Change to Lower Temperature	N/A	Requires longer ventilation	Requires changes in drift spacing	High temp. integral to WP performance	Requires changes in drift spacing
	Ability to Change to Higher Temperature	Requires development of larger packages and coupled models for PA	Requires devel. of coupled models for PA	N/A	N/A	N/A
Cost	Repository Life Cycle Cost	$25.1 billion	$20.6 billion	$20.1 billion/ $21.3 billion	$21.7 billion	$20.0 billion
	Net Present Value	$13.4 billion	$11.0 billion	$10.7 billion/ $11.4 billion	$11.3 billion	$10.8 billion

EDA Evaluation Process: Conclusions

- **Decision process compatible with conceptual design process: brainstorming, maximum flexibility for DOE**
- **Evaluation criteria reflect multiple objectives**
- **Design concepts continually evolved**
- **EDAs ranked against each criterion using pairwise comparisons**
- **Design concept recommended based on consistency across all criteria**