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*Selection of a Preferred Initial Access for the
Exploratory Studies Facility*

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This work was supported by the Yucca Mountain Site Characterization Project Office as part of the Civilian Radioactive Waste Management Program. This project is managed by the US Department of Energy, Yucca Mountain Site Characterization Project.

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TABLE OF CONTENTS

ABSTRACT.....1

A. INTRODUCTION.....2

B. MANAGEMENT PLAN AND DECISION PROCESS.....2

C. DEVELOPMENT OF QUESTIONS3

D. DATA USED IN EVALUATION4

E. WEIGHTING, RANKING AND SCORING6

F. DISCUSSION OF RESULTS.....8

G. CONCLUSIONS & RECOMMENDATIONS.....9

H. ACKNOWLEDGMENTS9

APPENDIX 1 (Structured Decision Process)9

APPENDIX 2 (Final Suitability Questions).....13

APPENDIX 3 (Applicability of the DAA to SPIA).....15

REFERENCES.....16

SELECTION OF A PREFERRED INITIAL ACCESS FOR THE EXPLORATORY STUDIES FACILITY

by

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ABSTRACT

An issue of interest to the Yucca Mountain Site Characterization Project Office (YMPO) has been selection of the preferred location for initial access to the Exploratory Studies Facility (ESF) in the event that the U.S. Department of Energy (DOE) elected to proceed with a phased approach to facility development. A task force to conduct an assessment and prepare a recommendation of the preferred initial location (north or south) for starting underground *in situ* tests at Yucca Mountain was initiated by YMPO to address this issue. The task force addressed geotechnical issues associated with the presence of disqualifying conditions at the site, the inability of the site to meet qualifying conditions, and the potential for unexpected geologic conditions at the site. The task force compared the north and south ramp accesses of the ESF to determine whether either access would be more likely to provide relevant information about potential site unsuitability. The task force did not address issues such as design time or construction costs.

Within the aforementioned context, a balanced evaluation of currently available geotechnical information and issues failed to provide a clear mandate for either ramp as the preferred initial ESF access. Neither access was clearly superior in providing geotechnical information to resolve site suitability issues. The task force therefore recommended that other appropriate programmatic factors, such as schedule, be used as a basis in determining the choice of a preferred, initial ESF access in the event of phased construction.

A. INTRODUCTION

An issue of interest to the Yucca Mountain Site Characterization Project Office (YMPO) has been selection of the preferred initial access to the ESF in the event that the U.S. Department of Energy (DOE) elected to proceed with a phased approach to facility development. A task force to conduct an assessment and prepare a recommendation of the preferred initial location (north or south) for starting underground *in situ* tests at Yucca Mountain was initiated by YMPO direction.^{1,2,3}

The task force was implemented as described in YMP/92-4, Selection of Preferred Initial Access (SPIA) for Exploratory Studies Facility Management Plan,⁴ and the SPIA Task Force Structured Decision Process (Appendix 1). The task force compared the north and south ramp accesses of the ESF to determine whether either access would be more likely to provide relevant information about potential site unsuitability. The task force did not address issues such as design time or construction costs.

B. MANAGEMENT PLAN AND DECISION PROCESS

A management plan, YMP/92-4, was written to guide the task force in developing a recommendation on this issue for the YMPO Deputy Project Manager. The task force consisted of senior geoscience technical staff selected for their experience, knowledge of the program, and familiarity with the issues. The management plan required creation and documentation of a decision process to aid in development of the recommendation. The management plan also required technical review of the final report in accordance with Quality Management Procedure (QMP) 06-04.

The decision process included five steps. First, the task force identified relevant reference information that encompassed (1) evaluations of the site suitability; (2) evaluations and information about relevant physical conditions at the site, with emphasis on geotechnical characteristics and in the context of relating the physical conditions and properties of the Yucca Mountain site to evaluations of site suitability, and (3) information and evaluations that described the specific physical conditions, character and properties of the Yucca Mountain site, with particular emphasis on the distribution and presence or absence of these attributes.

In the second step, the task force developed a list of questions (see Appendix 2) to be used in determining whether there were any significant differences in geotechnical characteristics between the north and south ramps. The questions were developed from the relevant reference information described above. All questions related the presence of disqualifying conditions at the site, the inability of the site to meet qualifying conditions, and the potential to encounter unexpected geologic conditions at the site to measurable or otherwise quantifiable physical attributes of the site. All questions addressed a common theme, namely, whether or not either access was preferred in obtaining information about the physical attributes of the site.

In the third step, information relevant to the expected geotechnical characteristics of the north and south ramp accesses was assembled.

Fourth, by consensus agreement, a Figure-of-Merit decision-aiding matrix was used to relate questions developed in step two to geotechnical characteristics determined in step three, thus ranking the north and south locations.

Finally, the task force considered the results of the Figure-of-Merit ranking, various sensitivities, the Project's current state of geotechnical knowledge, and other factors in developing a recommendation.

C. DEVELOPMENT OF QUESTIONS

The task force members identified reference materials to be examined as the basis for the development of questions for the evaluation. The group discussed the relevance of the references and members of the evaluation team were assigned responsibility to develop a set of questions that would be used to relate significant site suitability issues to measurable geotechnical attributes of the northern and southern areas of the site. The discussions identified the following internal reports that addressed suitability, related geotechnical attributes of the site, and characterization issues including: Early Site Suitability Evaluation (ESSE),^{5,6} Appendix J of the Design Acceptability Analysis (DAA),⁷ the Test Prioritization Task (TPT),⁸ Calico Hills Risk Benefit Analysis (CHRBA),⁹ Total System Performance Assessment report,¹⁰ Geophysics White Paper,¹¹ Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft,¹² and ESF Alternative Studies.¹³ The discussions also identified the Unsaturated Zone Peer Review Record¹⁴ as a source for perspectives on suitability issues and the attendant geotechnical attributes of the site. External documents such as the Nuclear Regulatory Commission (NRC) Site Characterization Analysis¹⁵ and the four Nuclear Waste Technical Review Board (NWTRB) Reports to Congress^{16,17,18,19} were identified; they were examined for suitability issues and the attendant geotechnical attributes of the site identified by independent oversight groups.

The questions that formed the basis for the evaluation represented a balanced consideration of the geotechnical issues important to the suitability of the Yucca Mountain site. The Figure of Merit decision-aiding process and the subsequent evaluations addressed topics of concern in existing project documentation (see Section D). In many cases, the focus on those concerns in this study was different from the focus in the existing documentation. None of the existing project documentation related to suitability has specifically examined differences between the northern and southern areas of Yucca Mountain. One existing project document, Appendix J of the Design Acceptability Analysis (DAA), does express a preference for an ESF location in the northern part of the site. An evaluation of the applicability of Appendix J of the Design Acceptability Analysis to this study is presented in Appendix 3.

Collectively, ninety-one preliminary questions were initially submitted by task force members. The evaluation team categorized these questions into eleven topical groups: fast flow paths, fault effects, Calico Hills hydrology, zeolitic/vitric facies changes, lateral extensions, spatial coverage, stratigraphy, chlorine-36, (geologic) surprises, infiltration/recharge, and rock quality.

A smaller number of questions were then developed for each topic by summarizing the ninety-one preliminary questions in a common format and stating them in terms of specific physical features or phenomena that could be observed or described. This list of topical questions was then further reduced to a final list of thirteen questions (Appendix 2) that formed the basis for the evaluation.

The result was a set of relatively complex questions that reflected a number of technical issues. Formulation of the evaluation questions at such a level of complexity was judged necessary to avoid the potential for "double voting" for one alternative based on the existence of several questions focused on only slightly different aspects of the same general topic. The evaluation team dedicated substantial time to discussion of the final questions in an effort to assure that all members had essentially the same understanding of the issues involved in each question, despite the apparent complexity.

D. DATA USED IN EVALUATION

The task force members assembled information relevant to the expected geotechnical characteristics of the north and south ramp accesses. This included information that described the specific physical conditions, character and properties of the Yucca Mountain site. Particular emphasis was placed on the distribution (including location, presence or absence) of these attributes of the site. The information addressed the character of the site both within the conceptual perimeter drift boundary (CPDB) and external to the CPDB.

The task force made the following key assumptions:

1. Both ramps would ultimately be constructed, producing data from both the north and south areas, as well as the main potential repository block. (This was consistent with the findings of the ESF Alternatives Study.)
2. The ESF testing program and facility configurations were not fixed and would be adapted to address significant geotechnical features encountered in either ramp. (A ramp-specific sequence of prioritized site characterization testing aimed at providing the most critical information for early site qualification and or disqualification must be developed.)
3. The SBT program would be conducted as currently planned, providing a real control essential in interpretation of ESF data. (The task force strongly concluded that early surface-based drilling at both ends of the potential repository block should be a YMPO priority.)

A limited set of physical conditions and properties of the site were considered to be relevant to the evaluation, as expressed in the thirteen questions developed by the task force. These group into four categories: (1) near-surface moisture distribution; (2) structural features, including both faulting and fracture sets; (3) stratigraphic variability; and (4) moisture distribution and characteristics within and below the potential repository host rock.

Near-surface moisture distribution results from the combined effects of climate,

topography, and near-surface stratigraphy. Existing data indicated somewhat greater precipitation in the northern reaches of Yucca Mountain than to the south, though the difference between the design locations for the ramps was judged by the task force to be minor and possibly insignificant.^{20,21} The southern ramp appeared, on the basis of information examined during the evaluation, to pass beneath a more varied topographic profile, i.e., a greater number of channels and slopes. No large differences in the expected moisture content in the Paintbrush non-welded unit as a function of latitude were identified, although the thickness and stratigraphic variability of the unit appeared greater in the vicinity of the north ramp.²²

The number, lateral frequency, and displacement of faults appeared significantly greater in the vicinity of the southern ramp, and this ramp was predicted to intersect a segment of the Solitario Canyon fault.^{23,24} The intensity of fracturing was assumed by the task force to be greater in the south than in the north, although locally intense fracturing was expected in the north as well, such as in Drill Hole Wash. Isolating the characteristics and effects related to a single fault was deemed to be more feasible at the northern location.

The topic of stratigraphic variability was dominated by the spatial distribution of the zeolitic and vitric facies of the Calico Hills tuff. Information available to the task force indicated that only the vitric facies was present in the southeastern part of the exploration area, whereas only the zeolitic facies was likely to be available in the north.^{25,26}

Questions related to determining *in situ* moisture distributions (particularly with regard to chlorine-36 analyses) integrated stratigraphy and structure. The opportunity to sample from and near faults appeared greater in the south. However, with respect to the Calico Hills tuff, the vitric facies present in the south was considered potentially incapable (due to mechanical properties) of supporting fractures. Accordingly, the task force generally considered that preferential flow pathways in the Calico Hills were more likely to exist in the north where the Calico Hills was zeolitic.

E. WEIGHTING, RANKING AND SCORING

The task force evaluated the final thirteen questions using a Figure-of-Merit process. Questions were weighted in the following manner. First, there was a discussion period to ensure that each member had a common understanding of each question. Each voting member of the task force was then allotted a total of thirteen votes (equal to the number of questions) to be cast according to their estimation of the importance of each question. Votes could be cast in any manner as long as the total number of votes cast by any individual did not exceed thirteen. The aggregated votes received by each question (i.e. the total votes summed for all members) then represented the question's relative weight.

Task force members cast from zero to three votes for each question. The most heavily weighted questions were numbers 5, 12, 9, and 3 which addressed (1) high *in situ* water saturations at the TSw/Chn boundary; (2) testing of potential for fracture flow in nonwelded intervals; (3) the geometry, mechanical, and geochemical properties of the Calico Hills nonwelded unit; and (4) high *in situ* water saturations at the TCw/Ptn or PTn/TSw1 boundary. Questions 10, 11, and 13 (addressing potential repository effects on Calico Hills hydrologic or geochemical properties, area available for the potential repository, and excavation drift stability within the TSw2 unit) were considered of minimal importance by a majority of the group.

As a sensitivity exercise to test the initial weighting scheme, each member also ranked the questions from one to thirteen in order of relative importance. Individual results were summed and the questions re-ranked on an aggregate basis. The relative importance of questions according to this scheme was consistent with the previous ranking with question 5 ranking highest and questions 11 and 13 ranking lowest.

Scoring of the north and south ramp alignments was then conducted. For each of the thirteen questions, members were asked to determine whether either ramp was preferred, whether both the north and south ramps were equally relevant, or whether neither ramp would provide relevant suitability information. A score of one was allocated if the area was preferred or equal in providing relevant information. Zero was allocated if the area was not expected to provide relevant geotechnical information.

Scoring produced a matrix of one or zero values that were summed and then multiplied by the aforementioned question weights (or ranks) to determine the final preference for either the north or south ramp. The base case aggregate results, indicating a small preference for the south ramp, were as follows:

Question	Weighting	North Ramp Score	South Ramp Score	Weighted North Ramp	Weighted South Ramp
1	8	4	6	32	48
2	6	4	5	24	30
3	10	6	4	60	40
4	7	6	5	42	35
5	12	4	5	48	60
6	7	4	6	28	42
7	9	2	6	18	54
8	4	4	5	16	20
9	11	2	4	22	44
10	3	3	2	9	6
11	3	1	7	3	21
12	11	4	4	44	44
13	0	1	1	0	0
Total		45 (43%)	60 (57%)	346 (44%)	444 (56%)

The following sensitivities were conducted to examine the effects of weighting, ranking, and individual voting patterns on the final outcome:

1. The effects of weighting were eliminated by simply summing the unweighted votes for the north and south ramps; this resulted in a 57 percent to 43 percent vote for the south ramp.
2. All questions relating to Calico Hills characteristics were deleted by altering their weight to a value of zero; this resulted in a 53 percent to 47 percent vote for the south ramp.
3. The weighting developed by each individual was applied to the total votes cast for each question. Raw scores varied from 405 to 457 (an average of 436 votes or 56 percent) for the south ramp and 313 to 358 (an average of 340 or 44 percent) for the north ramp.
4. One at a time, individuals were removed from the voting and weighted votes were recalculated. Results ranged from a 53 percent to a 58 percent vote for the south ramp, depending upon the individual removed from the voting.
5. An alternate weighting scheme (based on ranking the questions in order of relative importance) produced a 55 percent to 45 percent vote for the south ramp.
6. Ranking developed by each individual was applied to the votes cast by that individual. Overall, this sensitivity produced a raw score of 431 (56 percent) for the south and 343 (44 percent) for the north.

Thus, the Figure-of-Merit process resulted in a small but consistent vote in favor of the south ramp as the initial, preferred ESF access.

F. DISCUSSION OF RESULTS

Given previous discussions about suitability issues, results of earlier evaluations (including Appendix J of the Design Acceptability Analysis), and the potential for continuous preferential flow paths in the north, the Figure-of-Merit results prompted extensive discussion. After consideration of the following points, the task force concluded that a clear geotechnical basis did not exist to select either ramp as the preferred initial ESF access.

First, the most important (highest weighted) questions in the Figure-of-Merit evaluations focused on fracture flow and relevant properties; the task force considered the likelihood for preferential flow paths, based on current geotechnical data, to be higher in the north. However, the Figure-of-Merit scoring produced a small preference for the south ramp based on a perceived potential to sample increased fault and fracture density and diversity, along with access to more stratigraphy. Thus the Figure-of-Merit evaluations were more heavily influenced by an interest in gaining insights into an area of greater structural and stratigraphic complexity, and the ability to address the associated local uncertainties, than in locating potential preferential flow paths.

Discussions of the Figure-of-Merit results (1) highlighted a general lack of subsurface data and consequential high uncertainty associated with current geotechnical knowledge across the entire potential repository block and (2) emphasized that limits to accessible stratigraphy in the north could be partially relieved if current constraints to stand-off distance of the excavation from the water table were relaxed. (Relaxation of the stand-off constraint would require a defensible performance impact calculation for impacts of facility construction on determining the necessary stand-off from the water table.) Thus, the Figure-of-Merit voting spread was not considered significant and no clear preference was indicated.

Second, the task force concluded that no single feature in either area was likely to provide clear evidence to resolve either a potential disqualifying or qualifying factor. Moreover, the group considered that resolution of site suitability issues would require a comprehensive evaluation of data from both areas, north and south, and that this evaluation was not likely to be completed before both ramps had been constructed. Thus, neither access alone was likely to provide uniquely diagnostic, early information on site suitability.

Third, it was generally held that initial excavation in the north would better integrate with existing and planned (near-term) surface-based testing (SBT) activities, but that excavation in the south would more likely provide unique information that could not be obtained as part of the planned SBT program.^{27,28,29}

Fourth, the task force unanimously believed that the initial excavation location, north or south, was not nearly as critical to site characterization as a Project commitment to proceed with excavation as expeditiously as possible at either end of the potential repository block. Since both ramps would eventually be constructed, a general lack of data in the overall potential repository area was considered far more important in resolution of site suitability issues at this early

stage of site characterization than the choice of initial ESF access.

Within the aforementioned context, a balanced evaluation of currently available geotechnical information and issues failed to provide a clear mandate for either ramp as the preferred initial ESF access. Neither access was clearly superior in providing geotechnical information to resolve site suitability issues, including the presence of disqualifying conditions, an inability of the site to meet qualifying conditions, or the potential for unexpected geologic conditions at the site. The task force therefore recommended that other appropriate programmatic factors, such as schedule, be used as a basis in determining the choice of a preferred, initial ESF access in the event of phased construction.

G. CONCLUSIONS AND RECOMMENDATIONS

The task force concluded that, based on geotechnical factors, there was no clear preference for either the north or the south ramp as the initial Exploratory Studies Facility access; neither access was clearly superior in providing geotechnical information to resolve site suitability issues (10 CFR Part 960).³⁰ Moreover, the task force unanimously believed that the initial excavation location, north or south, was not nearly as critical to site characterization as was a commitment to proceed with excavation as expeditiously as possible, at either end of the potential repository block. Information from underground excavation was considered essential in resolving fundamental geotechnical issues and in reducing uncertainty by providing data to test current conceptual models.

Although a Figure-of-Merit decision-aiding process resulted in a small apparent preference for the south ramp, consideration of the general lack of data in the potential repository area and consequential high uncertainty in structural, stratigraphic, and hydrologic models at this early stage of site characterization led to a conclusion that the voting spread was not significant. In addition, the task force concluded that no single feature in either area was likely to provide clear evidence towards resolution of potential site suitability issues and that site suitability issues were not likely to be resolved before both ramps are constructed.

The task force therefore recommended that other appropriate programmatic factors, such as schedule, be used as a basis in determining the choice of a preferred, initial ESF were in the event of phased construction.

H. ACKNOWLEDGMENTS

This work was supported by the Yucca Mountain Site Characterization Office as part of the Civilian Radioactive Waste Management Program. This project is managed by the U.S. Department of Energy, Yucca Mountain Site Characterization Project.

APPENDIX 1: SPIA Task Force Structured Decision Process

The task force will compare the north and south ramp accesses of the ESF to

determine whether either access is more likely to provide relevant information about potential unsuitability of the site. The task force will address geotechnical issues associated with: the presence of disqualifying conditions at the site; the inability of the site to meet qualifying conditions; and the potential for unexpected geologic conditions at the site. The task force will not address issues such as design time or construction costs. An underlying assumption of the task force is that the testing program and facility configuration will be adapted to address the significance of the geotechnical features encountered in either ramp. Specifically, the task force agrees that the presence or absence of a test in either of the ramps will not be used as a discriminator.

The task force investigations will address three types of information in a Figure-of-Merit decision aiding methodology. It will address suitability criteria that have been and can be used to evaluate the site. The second type of information to be examined addresses the relationship between physical conditions at the site and evaluations of the suitability of the site. The third type of information describes the specific physical conditions, character and properties of the Yucca Mountain Site.

The decision process encompasses the following five steps:

1. Identify the relevant reference information. This information will include documentation known by and available to the members of the task force that addresses the three facets of this task force investigation:
 - a) Evaluations about the suitability of the site, including the presence of disqualifying conditions at the site; the inability of the site to meet qualifying conditions; and the potential for unexpected geologic conditions at the site,
 - b) Evaluations and information about relevant physical conditions at the site, with emphasis on geotechnical conditions, in the context of relating the physical conditions and properties of the Yucca Mountain Site to evaluations of the suitability of the site, and
 - c) Information and evaluations that describe the specific physical conditions, character and properties of the Yucca Mountain Site, with particular emphasis on the distribution, presence or absence of these attributes of the site.

The focus of the relevant reference information will be on published information. The task force will, if necessary, prepare or have prepared additional material, such as maps and cross sections. The task force will consider on a case by case basis the use of relevant unpublished information; it is intended that such information be used only in a corroborative fashion. If such unpublished information should prove crucial to the conclusions of the task force, a technical review of the information will be requested.

2. Develop a list of questions to be used to ascertain whether there is an expected, significant difference between the north and south ramp accesses in the likelihood to provide information to answer these questions. The

questions will be developed from the relevant reference information described in steps 1(a) and 1(b) above. The objective of the task force in developing these questions is to relate the presence of disqualifying conditions at the site, the inability of the site to meet qualifying conditions, and the potential to encounter unexpected geologic conditions at the site to technical issues, including, measurable or otherwise quantifiable physical attributes of the site. The questions will address specific physical conditions, character and properties of the Yucca Mountain Site, the distribution, presence or absence of these attributes of the site, and whether there is an expected significant difference between the north and south ramp site locations. The questions will be phrased in the context of determining whether there is a preference for either the north or south ramp access in the likelihood to provide information to answer the question.

The group will discuss suggested questions from the members of the task force. The voting members of the task force will signify agreement, by signature, with the set of questions developed. If agreement cannot be reached, it will be so noted and a minority position prepared.

These questions will form the basis for the Figure-of-Merit approach to the evaluation of the ramp accesses (see discussion in step 4). Clearly, there may be a hierarchy of importance within the questions that should be addressed by the task force. Typically, relative importance is addressed in a Figure-of-Merit ranking through the assignment of weights to the questions. The task force will investigate weighting of the criteria in the following manner. There will be a discussion period wherein presentations about the relative importance of the individual questions can be made to the assembled task force by members of the task force. Each voting member of the task force will be allotted a number of votes equal to the number of agreed upon questions. By anonymous ballot, each voting member will allocate a number of votes to each question. The results will be tabulated and normalized to arrive at the ranking. The voting members of the task force will signify agreement, by signature, with the ranking developed. If agreement cannot be reached, it will be so noted and a minority position prepared. Additionally, the task force will investigate the sensitivity of the conclusions of the study to the chosen weighting by evaluating the ramps with no weighting of the questions.

3. The task force members will assemble information relevant to the expected geotechnical characteristics of the north and south ramp accesses. This will include evaluations of information that describes the specific physical conditions, character and properties of the Yucca Mountain Site. Particular emphasis will be placed on the distribution and location, encompassing presence or absence, of these attributes of the site. The information will address the character of the site both within the conceptual perimeter drift boundary (CPDB) and external to the CPDB. Members of the task force will discuss this information to facilitate a common understanding of the information.
4. Evaluate and rank the north and south ramp characteristics on the basis of physical conditions. The questions developed in step 2 will be used in a

Figure-of-Merit decision aiding process to accomplish this objective. The choice of a Figure-of-Merit approach was discussed by the task force and its use represents a consensus of the group. The Figure-of-Merit approach was selected by the task force to provide a methodology that was formal and traceable and consistent with the expected complexity of the task. The task force recognized that more sophisticated decision aiding methodologies often offer more rigor and traceability through increased formality and the use of common factors for comparison. This is often required when dissimilar entities must be compared. For the purposes of this task force, the physical attributes under comparison will be reduced to a common basis in terms of their relationships to the suitability of the site. All of the questions to be used to evaluate the north and south ramp accesses will address a common theme, namely, whether or not there is a preference for either access to obtain information about the physical attributes of the site. Furthermore, most, if not all, of the information to be considered by the task force will be from other published studies. For these reasons, a Figure-of-Merit approach to aid the decision was determined to be consistent with the expected scope and objectives of the study.

The Figure-of-Merit decision aiding evaluation will proceed by evaluating for each question in turn whether or not there is a preference for either the north or south ramp access in the likelihood to provide information to answer the question. The point assigning scheme will consist of three options. For each question, (1) the evaluator may assign one point to either the north or south access if it is concluded that one of the accesses is important to addressing the question and whether it is possible to discriminate between them; (2) the evaluator may assign one point to both the north and south ramp access if it is concluded that both are equally important to addressing the question; or (3) the evaluator may assign no points to both the north and the south ramp accesses if it is concluded that neither are important to addressing the question. The ranking of the accesses against the questions will be performed by multiplying the weighting factors for each question (see step 3) by the total points assigned to that question and summing for all questions. The sensitivity of the ranking to the weighting will be investigated.

5. Evaluate the results of the ranking and produce a recommendation about whether or not either access is preferred to provide information about potential unsuitability of the site. The recommendation will consider sensitivity, minority opinions, and assumed facility modifications necessary to access geotechnical information. Document the decision when complete, producing either a consensus report or majority and minority reports. The documentation will be in the form of a white paper to be submitted to the DOE for their review. The voting members of the task force will signify agreement, by signature, with the white paper developed. If agreement cannot be reached, it will be so noted and a minority position prepared. All of the records of the task force will be submitted in a formal record package.

APPENDIX 2: Final Suitability Questions

Final version of the questions to be used in the north-south ramp evaluation:

1. Will the north or south ramp provide better opportunity to evaluate more laterally extensive exposures of the Topopah Spring member (especially thermal/mechanical unit TSw2), sufficient to allow characterization of spatial variability of hydrologic properties related to fracture density and aperture?
2. Will the areas north or south of the potential repository block provide greater likelihood of obtaining information regarding hydrologic effects of unexpected formation heterogeneity or structural features, such as faults or shear zones that exhibit no surface expression?
3. Will the north or south access provide better opportunity to observe and sample (including chlorine-36 and tritium) in zones of potentially high saturation (including topographic effects on infiltration) associated with stratigraphic contacts in the lower Tiva Canyon member and the Paintbrush nonwelded unit, updip from mapped faults, in order to verify conditions that are predicted alternatively to cause aerially pervasive channelized flow downward into the Topopah Spring member or to cause lateral diversion of flow to fault zones?
4. Will the north or south access provide better opportunity to observe, monitor and sample (including chlorine-36 and tritium) (perhaps episodically) percolating water in the Topopah Spring member, within and updip from mapped faults and beneath overlying zones of potentially high saturation?
5. Will the north or south access provide better opportunity to observe and sample (including chlorine-36 and tritium) within and beneath zones of potentially high saturation associated with stratigraphic contacts in the lower Topopah Spring member and the Calico Hills tuff, in order to test whether channelized flow occurs beneath the potential repository?
6. Will the north or south access provide better opportunity to observe differences in fault or fracture patterns, persistence, and properties within stratigraphically continuous welded and nonwelded units?
7. Will the north or south access provide better opportunity to observe and measure fault and fracture characteristics, and to characterize and sample moisture, in the vitric Calico Hills tuff?
8. Will the north or south ramp provide a better opportunity to observe fault displacement, distributed faulting and rupture of datable fracture infillings that may indicate the timing or extent of future faulting which might cause the direct failure of canisters due to fault displacement or possible changes in groundwater depth or flow patterns?
9. Will the north or south ramp provide better information to characterize the

physical boundaries of the Calico Hills barrier, especially the nature of the vitric to zeolitized transition, structural and lithologic features, and chemical or physical processes affecting flow or causing lower retardation, in that unit?

10. Will the north or south ramp provide better data to permit detection and characterization of potential changes in physical properties, geochemistry, or mineralogy of the Calico Hills, such as dehydration and rehydration behavior of zeolites including adsorptive potential and volume changes, due to repository heat and stress effects.
11. Will the north or south ramp provide a better opportunity to obtain information regarding faulting and other structural features that may affect the area available for the repository (including potential extensions and abandonments)?
12. Will the north or south ramp provide a better opportunity to observe and sample exposures that may help to resolve the question of whether open and connected fractures systems can exist/persist in the softer, generally nonwelded stratigraphic intervals at Yucca Mountain, and to detect direct evidence regarding flow and the interaction of fractures and matrix?
13. Will the north or south ramp provide a better opportunity to obtain information regarding the rock quality or excavation drift stability to be anticipated within the Topopah Spring member in the main repository region?

APPENDIX 3: Applicability of Appendix J of the Design Acceptability Analysis to the SPIA Study

Appendix J of the Design Acceptability Analysis (DAA), expresses a preference for an ESF location in the northern part of the site. The recommendations of that study are not applicable to the conclusions of this (the SPIA) study. The DAA examined aspects of regulatory compliance for the ESF Title I design supporting the Site Characterization Plan (SCP).³¹ The DAA and this study addressed very different questions and the facilities examined in the two studies are also very different. The facility examined in this study was developed as a result of the ESF Alternatives Study. The ESF Alternatives Study was done to address, in a comprehensive manner, a number of issues related to ESF design including the issues related to waste isolation impacts that were addressed in Appendix J of the DAA, as well as other issues such as interference and representativeness.

In Appendix J of the DAA, the DOE reconsidered the five locations of the original ESF location siting study (all of which were in the northern half of the study area) for impacts to waste isolation. The DAA concluded that differences among the five locations were not significant to waste isolation under current conditions. However, the DAA also concluded that, under certain types of future conditions, locations toward the northeast would be more likely to have ground water flow times less than 10,000 years in local zones of flux concentration. Under those types of conditions, reliance upon natural barriers or physical processes, such as geochemical retardation, may be necessary. A northern area facility was recommended because it could have more utility, owing to a shorter distance to the water table in the north, and could provide access to potentially important geochemical information.

The DAA and the SPIA study looked at different issues, so a comparison of the results of the studies must be done with care. The recommendation of the DAA for a northern location of the ESF did not strictly consider the suitability of the site; rather, it focused on differences related to construction and operations impacts on suitability. There also were differences in the facility configurations. The facility examined in the DAA had two shafts in close proximity, essentially at a single point in the site area. There was a single test level, and extrapolation of data across the site was required. The question of whether or not there were differences between the north and south areas regarding early acquisition of information to determine the suitability of the site was not addressed in the DAA.

The SPIA study examined potential differences between the north and south areas of a facility that has ramp accesses at both ends, drifting across the block in both directions, and excavations running the length of the block below the potential repository horizon in the Calico Hills unit. The question of interest for the SPIA study was whether or not there was an overriding geotechnical issue related to suitability of the site that could be resolved earlier or in a more timely fashion through the use of information obtained from one access location or the other. The SPIA study found that there was not a clear geotechnical preference for either the north or south access location to address, early in the program, questions of site suitability.

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- 1 Memorandum, Gertz to Dyer, "Request to Initiate Task to Conduct an Assessment and Prepare a Recommendation of the First Location (North or South) for Initiating Underground In Situ Tests of Yucca Mountain," Dated February 24, 1992.
 - 2 Letter, Gertz to Nelson, "Technical Direction to Technical and Management Support Services (T&MSS) - Development of the Management Plan: Assessment and Recommendation of the First Location (North or South) for Initiating Underground In Situ Tests of Yucca Mountain," Dated March 27, 1992.
 - 3 Letter, Gertz to Distribution, "Technical Direction to Yucca Mountain Site Characterization Project (YMP) Participants - Participation in the Effort to Conduct an Assessment and Prepare a Recommendation of the First Location (North or South) for Initiating Underground In Situ Tests of Yucca Mountain," Dated March 27, 1992.
 - 4 DOE (U. S. Department of Energy), 1992. Selection of Preferred Initial Access for Exploratory Studies Facilities Plan, Revision 0, YMP/92-4, Yucca Mountain Site Characterization Project, Las Vegas, NV.
 - 5 Younker, J. L. et al, 1992. Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada, Yucca Mountain Site Characterization Project, Las Vegas, NV.
 - 6 Younker, J. L. et al, 1992. Report of the Peer Review Panel on the Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada, Yucca Mountain Site Characterization Project, Las Vegas, NV.
 - 7 DOE (U. S. Department of Energy), 1989. Design Acceptability Analysis (DAA), Appendix J, YMP-89-3823, Yucca Mountain Site Characterization Project, Las Vegas, NV.
 - 8 Mattson, S. R. et al, 1991. Testing Priorities Report at Yucca Mountain: Recommended Early Tests to Detect Potentially Unsuitable Conditions for a Nuclear Waste Repository, Yucca Mountain Site Characterization Project, Las Vegas, NV.
 - 9 DOE (U. S. Department of Energy), 1991. Risk/Benefit Analysis of Alternative Strategies for Characterizing the Calico Hills Unit at Yucca Mountain, Revision 0, Review Record Memorandum 90/3, 2 volumes, Yucca Mountain Project Office, Las Vegas, NV.
 - 10 Barnard, R. W., M. L. Wilson, H. A. Dockery, J. H. Gauthier, P. G. Kaplan, R. R. Eaton, F. W. Bingham, and T. H. Robey, 1991. An Initial Total-System Performance Assessment for Yucca Mountain, SAND 91-2795, Sandia National Laboratories, Albuquerque, NM.
 - 11 Oliver, H. W., E. L. Hardin, & P. H. Nelson, 1990. Status of Data, Major Results, and Plans for Geophysical Activities, Yucca Mountain Project, Yucca Mountain Site Characterization Project, Las Vegas, NV.
 - 12 DOE (U. S. Department of Energy), 1990. Technical Assessment Review (TAR), Review Record Memorandum, Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft, Yucca Mountain Project Office, Las Vegas, NV.
 - 13 SNL (Sandia National Laboratories), 1991. Exploratory Studies Facility Alternatives Study (ESFAS), SAND91-0025, Albuquerque, NM.
 - 14 Freeze, R. A. et al, 1991. Unsaturated Zone Hydrology Peer Review Record Memorandum,

Yucca Mountain Site Characterization Project, Las Vegas, NV.

- 15 NRC (Nuclear Regulatory Commission), 1989. Nuclear Regulatory Commission's Site Characterization Analysis (SCA) of the DOE's Site Characterization Plan, Yucca Mountain Site, NV, NUREG-1347.
- 16 NWTRB (Nuclear Waste Technical Review Board), 1990. First Report to the U.S. Congress and the U.S. Secretary of Energy, Arlington, VA.
- 17 NWTRB (Nuclear Waste Technical Review Board), 1990. Second Report to the U.S. Congress and the U.S. Secretary of Energy, Arlington, VA.
- 18 NWTRB (Nuclear Waste Technical Review Board), 1991. Third Report to the U.S. Congress and the U.S. Secretary of Energy, Arlington, VA.
- 19 NWTRB (Nuclear Waste Technical Review Board), 1991. Fourth Report to the U.S. Congress and the U.S. Secretary of Energy, Arlington, VA.
- 20 T&MSS (Technical and Management Support Services), 1991. Exploratory Studies Facility Phasing of Underground Construction and Design Activities, November 5, 1991, presented to DOE project management and participant Technical Project Officers, Las Vegas, NV.
- 21 RSN (Raytheon Services Nevada), 1991. Preliminary Siting Analysis - Revised South Ramp Portal and Optional Shaft Siting Requirements, Las Vegas, NV.
- 22 Kaplan, P. G., 1992. Uncertainty and Sensitivity Results for Pre-waste-Emplacement Groundwater Travel Time, High Level Waste Management, Proceedings of the Third International Conference, Las Vegas, Nevada, April 12-16, 1992, LaGrange Park. IL: American Nuclear Society, Inc., 2:1643-1646.
- 23 Scott, R. B. and J. Bonk, 1984. Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections, Map USGS-OFR-84-494, Open-File Report, U. S. Geological Survey .
- 24 Scott, R. B., 1990 Tectonic Setting of Yucca Mountain, Southwest Nevada, Basin and Range Extensional Tectonics Near the Latitude of Las Vegas, Nevada, Wernicke, B. P. ed., Geological Society of America Memoir 176, Boulder, CO, pp. 251-282.
- 25 Ortiz, T. S., R. L. Williams. F. B. Nimick. B. C. Whittet, and D. L. South, 1985. A Three-dimensional Model of Reference Thermal/Mechanical and Hydrological Stratigraphy at Yucca Mountain, Southern Nevada, Sandia Report SAND84-1076, Sandia National Laboratories, Albuquerque, NM.
- 26 Broxton, D. E., R. G. Warren, R. C. Hagman and G. Leudemann, 1986. Chemistry of Diagenetically Altered Tuffs at a Potential Nuclear Waste Repository, Yucca Mountain, Nye County, Nevada, LA-10802-MS, Los Alamos National Laboratory, Los Alamos, NM.
- 27 Dyer, J. R., 1991. Update on Surface-Based Testing, a presentation to the NWTRB (Nuclear Waste Technical Review Board) on preliminary results from unsaturated zone infiltration studies, December 7-8, 1991, Arlington, VA.
- 28 Broxton, D. E., 1991. Internal memorandum from D. E. Broxton to E. Springer, September 19, 1991, Final Submittal, Test Plan Package 91-5 - Pre Title II Design Studies, Planned ESF Tests, Los Alamos National Laboratory, Los Alamos, NM.

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- 29 DOE (U. S. Department of Energy), 1991. Exploratory Studies Facility Design Requirements, Appendix B, YMP/CC-0013, Revs. 5/31/91, 7/1/91, 7/29/91, Yucca Mountain Project Office, Las Vegas, NV.
- 30 10 CFR Part 960 (Code of Federal Regulation) 1984. Title 10, Energy, Part 960, General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, U. S. Government Printing Office, Washington, D. C.
- 31 DOE (U. S. Department of Energy), 1991. Site Characterization Program Baseline, YMP/CM-0011, Yucca Mountain Site Characterization Project, Las Vegas, NV.