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Donna R. Mattson
Section Leader
U. S. Nuclear Regulatory Commission
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Washington, D.C. 20555

Dear Ms. Mattson:

Enclosed are Appendices A through J and Bibliography as submitted by the State of Utah to the Department of Energy as part of the comments package to the Draft Environmental Assessments for Davis and Lavender Canyon Sites.

Please feel free to contact us if you need additional information.

Very truly yours,

Rosa M. Naccarato

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Office Manager

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Encl. to ltr. to D. Mattson from R.M. Nascenta - 5/28/85

E.A. COMMENTS ON DAVIS AND LAVENDER CANYON SITES
SAN JUAN COUNTY, UTAH
1985

APPENDIX A -- Review and Analysis of High Level Nuclear Waste Issues for Gibson Dome in Southern Utah: Geohydrology, compiled by S.D. Willet and D.S. Chapman,

APPENDIX B -- Review and Evaluation of The Gibson Dome High Level Nuclear Waste Repository Environmental Assessment: Geohydrologic Issues, compiled by Christopher J. Duffy, Brad Hall, March 5, 1985

APPENDIX C -- Review of the Draft Environmental Assessment Documents, Lavender and Davis Canyon Sites, San Juan County, Utah, compiled by Jon Zeisloft, March 14, 1985

APPENDIX D -- Review of DOE-Sponsored Studies and Conclusions Associated with The Effect on Visual Quality of Siting A High-Level Nuclear Waste Repository in Utah, compiled by Michael Johnson, Jeff McCusker, Brent Jones, Duane McNamee, Cathy Jenn, Eugene Trobia, Utah Office of Planning and Budget with Utah Automated Geographic Reference Taskforce, January 1985

APPENDIX E -- Critique of Noise Impact Analysis in DOE Draft Environmental Assessment for Proposed Nuclear Waste Repository in Davis Canyon Utah, compiled by James D. Foch, Jr., March 14, 1985

APPENDIX F -- Critique of Noise Impact Analysis in DOE Draft Environmental Assessment for Proposed Nuclear Waste Repository in Davis Canyon Utah, compiled by James D. Foch, Jr., (Edited by J. Wittman and T. Ristau) March 14, 1985

APPENDIX G -- Reclamation Technical Report, compiled by R. Harden, S. Linner, K. Mutz, and T. Portle OGM, March 4, 1985

APPENDIX H -- Review of Radtran II Model compiled by Dr. D.M. Liverman, March 1985

APPENDIX I -- Comments on Coverage of Aesthetics in Davis Canyon Final Draft Environmental Assessment, compiled by William Blair, Jones & Jones, March 17, 1985

APPENDIX J -- Review and Assessment of Expected Impacts of the Proposed Nuclear Waste Repository Construction on Cultural and Paleontological Resources in the Gibson Dome Area of Southeastern Utah, compiled by La Mar W. Lindsay, James L. Dykman, David B. Madsen James H. Madsen Jr., Elizabeth Manion, Wilson G. Martin, and Gary Topping, April 1984

BIBLIOGRAPHY

APPENDIX A

APPENDIX A.

CONTENTS FOR REPORT NO. 3

1. Review and Analysis of High Level Nuclear Waste Issues
for
Gibson Dome in Southern Utah: Geohydrology

by

S. D. Willett and D. S. Chapman

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1. Review and Analysis of High Level Nuclear Waste Issues for Gibson Dome in Southern Utah: Hydrology.

by

S.D. Willett and D.S. Chapman

1.1.0 Introduction

The Department of Energy (DOE) is nearing completion of the present phase of its search for a high level nuclear waste repository. With the upcoming release of Statutory Environmental Assessments (SEA) for each of the potential sites, the preliminary site suitability assessments and the research which serves as their support will be presented. As these assessments serve as the basis for the decision as to which sites will continue to the next phase of study (site characterization), it is appropriate to review and critique the research involved in the preliminary studies.

This report presents a critique of the geohydrologic studies conducted or compiled by the DOE for assessment of the Davis Canyon and Lavender Canyon sites of southern Utah. The basis for our critique is principally the draft (Fifth Draft) version of the Environmental Assessments. The critique address principally the scientific approach and basic assumptions followed by DOE in the studies leading up to the conclusions given in the EA.

The indeterminant nature of geohydrologic systems makes groundwater problems inherently model dependent. The DOE studies of the Paradox Basin are no exception; essentually all conclusions are dependent on the conceptual models. This report therefore concentrates primarily on the underlying assumptions and factual support for these models. The principle source of information on DOE modeling is given in the First and Second Status Report on Regional Groundwater Flow Modeling for the Paradox Basin, Utah prepared by Intera consultants for the Office of Nuclear Waste Isolation of Battelle Memorial Institue (Intera, 1984a, 1984b).

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1.1.1 Introduction to Groundwater Modeling

Groundwater flow systems are among the most difficult geologic systems to understand in great detail. Unlike many other physical systems the quantities of interest (actual groundwater velocities and fluxes) are normally impossible to measure directly and measurable properties have such large spatial variation as to be very difficult to characterize exactly. Thus we are left to rely heavily on conceptual simplifications and models. The dangers inherent in this model reliance are well expressed by Bear (1979):

> "There is no need to elaborate on the fact that most real systems, and certainly the aquifer system considered here, are indeed complicated beyond our capability to describe them and to treat them exactly as they really are. The very passage from the microscopic level of treating flow through porous media to the macroscopic level of treating it as a continuum involves already a certain simplification of the real world. The porous medium continuum is inhomogeneous, anisotropic, etc., and further simplifications are necessary. These take the form of a set of assumptions which should not be forgotten whenever the model is being employed in the course of investigations."

Bear (1979) further gives some simple rules for judging the appropriateness of a model:

> "The choice of the most appropriate conceptual model for a given aquifer system...is dictated not only by the features of the aquifer itself (e.g., its geological properties), but also by the following criteria:
> a) it should be sufficiently simple so as to be amenable to mathematical treatment.
> b) it should not be too simple so as to exclude those features which are of interest to the investigation on hand.
> c) information should be available for calibrating the model."

It is in the context of these criteria that we critically examine the groundwater flow models constructed by DOE contractors (Intera 1984a, 1984b) for the flow system at the Davis Canyon site. Criterion (b) is addressed in Section 1.2.2 of this report dealing with

conceptual models. Criterion (c) is included in Section 1.3.3 on the appropriatenes or

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suitability of the data base used by DOE modelers.

1.2 Conceptutal aspects of modeling

1.2.1 Model Construction

In constructing a conceptual model of a groundwater system, one must consider a number of questions, including:

1) What is the nature of the fluid flow? What is the physics governing the fluid flow? Is it through the porous matrix of the rock or through secondary features such as fractures? Is the flow driven by density gradients or elevation gradients? Is it effectively isothermal?

2) What is the nature of the geologic media? This question is inherently linked to question (1) above, but goes beyond. Is the medium heterogeneous and/or anisotropic? If so, what determines the nature or scale of heterogeneity? Do laminations, bedding, facies changes, secondary diagenesis or deformation features have significant effect on flow properties?

3) What are the hydrologic boundary conditions imposed on the system? What are recharge-discharge rates to the system and how can they be treated?

4) How is this problem going to be solved? What is the mathematical expression for the processes in (1)? How will the geologic features in (2) be incorporated? What are the properties the model should predict and what is the desired resolution of these predicitons?

Each of these questions must be answered in any modeling effort. Each question is

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answered either explicitly or implicitly in every model simulation of a hydrologic system. The last question, namely how well does the model simulate the actual system and produce the desired output data, particularly should be judged against Bear's criterion (b) (Sec. 1.1).

1.2.2 DOE Modeling Effort

The goundwater flow model used by DOE contractors (Intera 1984a, 1984b) is constructed in two phases. First, a regional Darcy flux model is constructed. This model assumes Darcian flow of a constant density, constant viscosity fluid through anisotopic porous media. Geologic units are generally assumed homogeneous on a formation scale and secondary permeability features are averaged into the bulk permeability of each model unit. Predictable output data of the model are: average hydraulic head and average Darcy flux on the scale of the model discretization, which is specified as approximately five kilometers laterally and corresponds to formation thickness vertically. The second phase of the DOE modeling is considerably simpler, and is used to predict groundwater velocity. This calculation (model) uses the average Darcy flux, (output from the first phase model), as an input parameter and predicts the actual groundwater velocity as output data. Assumptions in this phase of the modeling include: (1) all fluid flow is through the primary (matrix) interstitial pores, and (2) the medium is homogeneous over the domain of the model (a single unit of the first phase model above).

1.2.3 Critique of modeling effort: (a) regional model, (b) velocity model

In this section we examine DOE's conceptualization of the geohydrologic system and judge its appropriateness. In particular, we consider evidence supporting or

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contradicting assumptions used in the modeling and assess the value of model predictive capabilities against the criteria given by Bear (Section 1.0). Data are considered here only for their importance in determining the appropriateness of assumptions used in the conceptualization; appropriateness or inadequacies of the data themselves are addressed later.

1.2.3 (a) Regional Model

At this point it is appropriate to ask what features of the actual system we are most interested in. The principle quantity required by the DOE siting guidelines is groundwater traveltimes or velocities for contaminent transport.

However, because the regional model is highly dependent on a number of basic assumptions, many of which are required because of the limited data base, the limitations of the model may preclude a meaningful estimate of these desired critical parameters. The greatest limitation of this model arises from its parameterization and predictive capabilities.

Because of its regional scale and coarse discretization, the model resolution is extremely limited. For example, variations in potentiometric surfaces with half wavelength less than five kilometers cannot be predicted and are not used during model calibration. The use of a coarse regional model thus has the effect of smoothing exisiting data. Smoothing of a potentiometric surface results in averaging of hydraulic gradients and Darcy fluxes. The same argument holds for physical properties of the media, e.g. hydraulic conductivity. The discretization thus limits the predictive capabilities of the model.

Output from the regional model are hydraulic heads and Darcy fluxes. These modeled fluxes are average fluxes, the averaging caused both by averaging of hydraulic conductivities within each model element and by smoothing of the potentiometric

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surfaces. The predictive capabilities of this model are limited to these average values of flux. This is independent of data constraints, that is, given infinite data the model can still predict only average flux values.

The regional model therefore is insufficient in meeting Bear's criterion (b) (Section 1.1.1): it is incapable of predicting those features which are of interest to the investigation at hand. To circumvent this problem and obtain groundwater velocities, DOE modelers undertook a second phase of modeling (Section 1.2.2), but it must be emphasized that this represents a second independent model with its own assumptions and errors.

In order to obtain error estimates and to investigate the influence of potential disturbances to the groundwater flow system, the DOE modelers have perturbed a number of model parameters and analyzed the resulting output. A sensitivity analysis was also made using an adjoint method. However, the error estimates and sensitivities obtained by these methods are of limited value since they represent error ranges of the model output parameters and not of the actual system. Since the model predicts average Darcy fluxes, parameter perturbation gives the probable range of values for the average Darcy flux, not the range of actual groundwater velocities. Variation in actual groundwater velocity is determined by both variation in actual Darcy flux and the input parameters of the velocity calculation model. Evaluating possible variation in the average Darcy flux, as done by DOE modelers, may give some indication of the variation in actual Darcy flux, but without consideration of the averaging involved in the regional model and the implication of the second phase modeling (calculation of actual velocities), these perturbation techniques cannot be used directly to evaluate expected variations in the actual groundwater velocity.

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1.2.3 Groundwater velocity model

The second phase of modeling done by DOE contractors (Intera 1984a, 1984b) consists of calculating actual groundwater velocities from the average flux across the model domain. The basic assumptions used by DOE in this conceptualization are: (1) the medium is completely homogeneous, and (2) flow is through the matrix porosity. The combination of these two assumptions allows the calculation of an average linear velocity as simply the average flux divided by the effective porosity (Freeze and Cherry, 1979). This is also the definition of groundwater velocity given in DOE's siting guidelines. But the validity of this calculation is limited. Technically, it is never valid, as it represents an average of a "statistically large number" of interstitial velocities. It is the actual interstitial velocities which generally dominate radionuclide transport velocities and so are of interest here. However, for practical purposes, the average linear velocity approaches actual velocities on a small scale and has a lower validity bound at the scale at which Darcy's Law is valid. This is shown graphically in Figure (1)

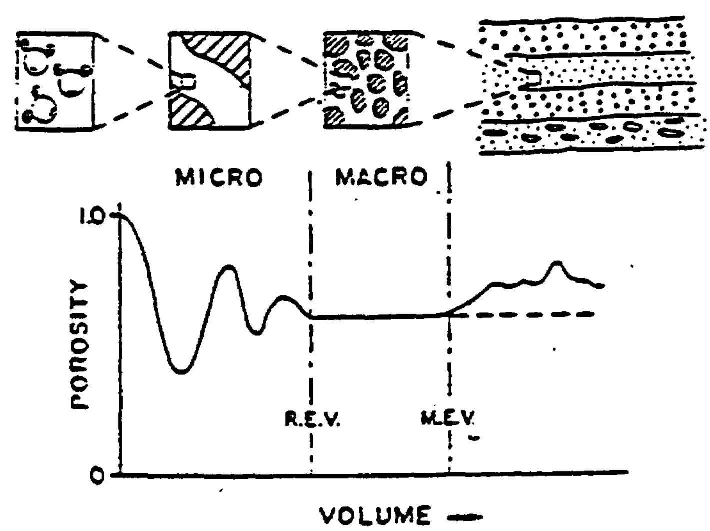

Figure 1. Conceptual representation of the macroscopic scale as applied to the description of a porous medium.

taken from Gillham and Cherry (1982). This leads to the concept of a representative

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elemental volume (REV) which represents the minimum volume for which the concept of linear average velocity is valid (Bear 1972).

In a perfectly homogeneous media, the linear average velocity remains an appropriate representation of the actual velocity field at any scale of analysis larger than the REV. However, in a medium with heterogeneous permeability, as the scale of analysis (model) increases and incorporates heterogeneites, additional averaging of the spatially varying velocity field must be done to obtain the appropriate average linear velocity. An average linear velocity can be obtained at any scale regardless of the degree of heterogeneity, provided the heterogeneities are properly averaged. However, the actual velocities within the modeled volume may vary signficantly (up to orders of magnitude) from this calculated average. The variance of the actual velocities about the average linear (or mean) velocity increases with the scale of the model. This is shown conceptually in Figure (2) (from Gillham and Cherry 1982) where the dispersivity

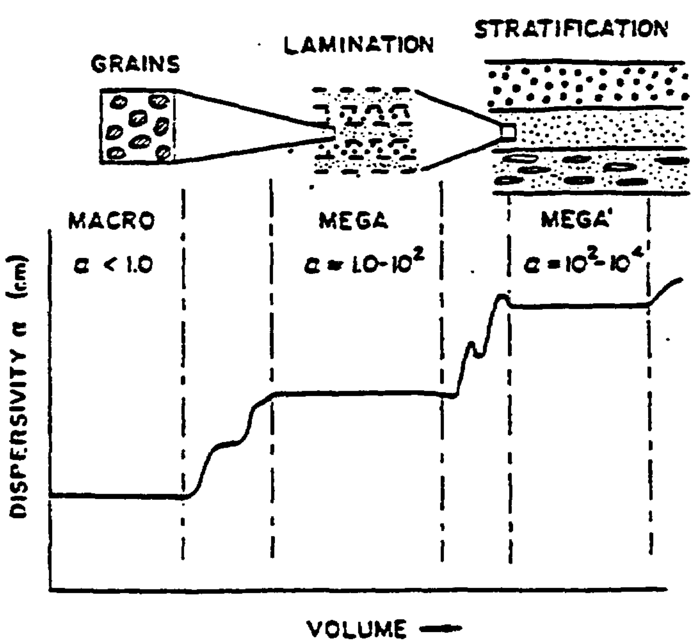

Figure 11. Conceptual representation of megascopic scale as applied to description of a geologic region.
(from Gillham and Cherry, 1982)

can be regarded as a measure of the variance about the mean velocity and the volume

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refers to the characteristic elemental volume of the model. The conceptual scales refer to variation in velocity due to permeability heterogeneities resulting from typical geologic features in a sedimentary formation. The Macro scale refers to variations of interstitial velocities over a volume of order 1 cm^3; the Mega scale represents variations on the scale of 1 to 10 cms, such as interbed laminations; the Mega scale refers to heterogeneities on the scale of 1 to 10 meters, such as bedding variations. It can be seen that using a representative model volume of 10 meters can result in an increasing velocity variance of several orders of magnitude. The representative model volume used by DOE modelers is on the order of a kilometer laterally (3 to 5 kilometers) and hundreds of meters vertically. This volume is large enough to include not only permeability heterogeneities resulting from lamination and bedding, but also larger scale lithologic variations such as facies changes. We should expect the resulting velocity field to have a correspondingly large variance. Thus in a region with large scale heterogeneities the average linear velocity is a poor estimate of the variable of interest: the actual groundwater velocity.

The above discussion is only semi-quantitative, and although the terms "mean" and "variance" are used, they do not necessarily imply a normal distribution of velocities. Although models do exist where velocity distributions are normal, this is not generally the case for larger scale geologic settings as demonstrated by Smith and Schwartz (1980, 1981) using a stochastic model. An important result of this work is that travel times may be skewed or multimodal resulting in significant mass transport at velocities significantly greater than the mean.

Examination of existing permeability data confirms that the Paradox Basin is, in fact, heterogeneous and flow behavior is, as described above, highly variable. ONWI 503 (Intera 1984a) gives distributions of permeability for the Honaker Trail, Paradox and Leadville formations. Each of these has four to five orders of magnitude variation in permeability and shows the common characteristic of heterogeneous formations: a log normal permeability distribution. Vertical variations in permeability are available only from the GD-1 borehole. Here again, permeability varies by four to five orders of magnitude (Thackston et al., 1984). This is acknowledged in the reports dealing with hydrologic properties (Thackston et al., 1984) but is not incorporated in the modeling.

The second assumption in the velocity calculation phase of the modeling is that flow occurs through the matrix porosity of each geologic unit. This allows the use of the effective porosity measurements made in the laboratory on GD-1 core samples. This assumption holds only so long as secondary permeability features have the same effective porosity as the rock matrix. The common exception to this assumption is the case of secondary permeability resulting from fracturing. A fracture network may have a porous media equivalent, i.e. obeys Darcy's Law, but the groundwater velocities are generally several orders of magnitude larger than for the same flux through a porous medium.

Fractures do occur in the GD-1 core in several formations. Principle among these is the Leadville Limestone. Comparison of the lab and field permeability tests indicate that the field tests yield permeabilities one to two orders of magnitude larger than the lab samples (Figure 3). The lab samples provide a measure of the matrix permeability, whereas the field drill stem tests give the permeability of the bulk rock including secondary features. The consistantly higher permeabilities obtained by the drill stem tests in the Leadville Limestone indicate that secondary permeability controls the groundwater flux through this unit. This was also noted by the contractors conducting the permeabilty tests for DOE (Thackston et al., 1984). The nature of the secondary permeability has not been studied, but examination of the GD-1 core log (Woodward Cylde Consultants, 1982) suggest that the Leadville is generally homogeneous and contains a number of widely spaced open fractures. The secondary permeability is likely the result of these fractures. If this is the case, using the matrix effective porosity to calculate groundwater velocities, as done by the DOE modelers, is clearly erroneous. Some fracture flow model is neccesary to calculate correct velocities from the assumed

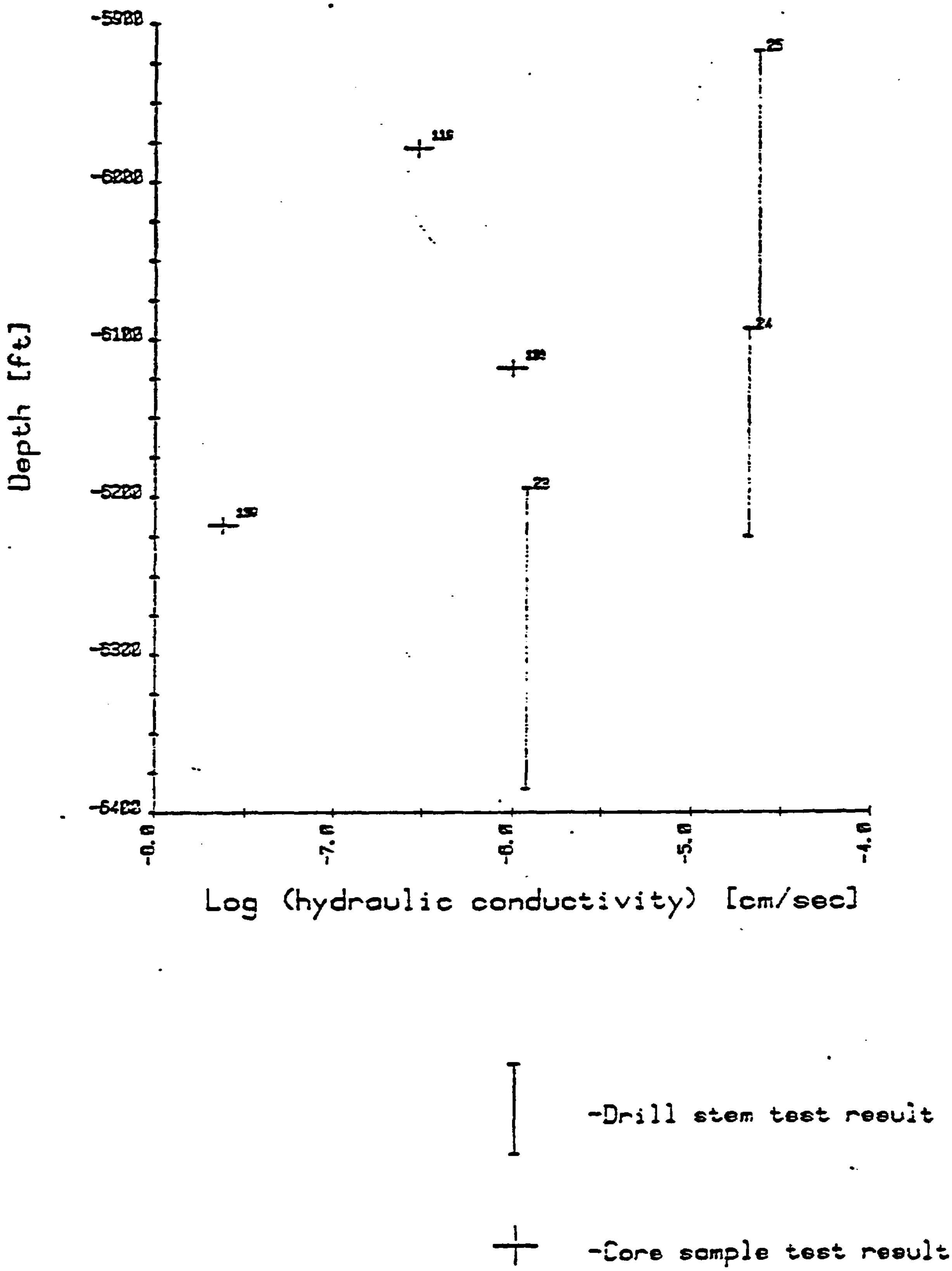

Figure 3: Hydraulic conductivity tests from GD-1.

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or modeled flux. For example, if we assume flow occurs through a set of horizontal planar fractures we can use a model given by Snow (1968) in which the permeability is a function of fracture density (N) and aperture (b):

$$K = \frac{Nb^3}{12} .$$

By estimating N from the GD-1 core log, b can be calculated from the in situ permeability test. This allows the calculation of actual velocities from the flux with effective porosity given as $n = Nb$.

As an example to illustrate the importance of this conceptual difference we can compare velocities calculated with the porous matrix model used by DOE modelers (Vp) and velocities calculated by the fracture model just described (V_f). Assuming a fracture density of $N=1m^{-1}$ (a more conservative estimate might be $0.1m^{-1}$) the ratio of velocities is $V_f/V_p=1700$. As this velocity is used to estimate groundwater travel times through the Leadville Limestone to the Colorado River, this estimate would have to be revised if the fracture model were used. Instead of travel times ranging from 12,000 to 110,000 years computed with a porous matrix model, the fracture model predicts a range of 7 to 65 years. Note that, despite the large difference in velocities and travel times, the average groundwater flux remains the same and so use of the fracture model would have no effect on the regional flux model. These calculated travel times for both models assume complete homogeneity of the formation between GD-1, the proposed repository, and the Colorado River, a questionable assumption made by the DOE modelers. It is our opinion that none of these estimates represent true travel times, but this example illustrates the importance of secondary fractures and the ambiguity of the data.

The evidence and importance of the fractures in the Leadville Limestone implies the need to investigate other possible zones in which secondary permeability is important. This is difficult since DOE contractors have not explicitly compiled data regarding secondary features such as fractures. A fracture log was run in the GD-1 borehole but the results were never used in the hydrologic analysis. Fractures were observed in the Honaker Trail and upper Paradox formation, but the hydrologic data are ambiguous as to their importance. This is in part due to drill stem tests in the Paradox being conducted over several interbeds simultaneously, a method which conceals the importance of secondary permeability effects in any individual bed.

The permeability data in the lower Paradox formation does show a large discrepency (two to three orders of magnitude) between core samples and borehole tests which may be indicative of secondary permeability. But these results are complicated by the effects of salt squeeze in the borehole tests.

The Pinkerton Trail and Molas formations also have potential for secondary permeability. No borehole permeability tests were obtained in these units at GD-1 because of unstable borehole conditions. These unstable conditions may have been related to fracturing. Matrix permeabilities were very low (10^{-4} md) at GD-1. However, the Elk Ridge Number 1 borehole lost circulation while drilling the Pinkerton Trail and had to be abandoned (Thackton et al., 1984), implying very high local permeability, probably the result of fracturing. Two values of Molas permeability (location unspecified), probably from drill stem tests, gave values more than four orders of magnitude larger (Intera 1984a). Hanshaw and Hill (1969) suggested that the Pinkerton Trail had significant permeability. If this suggested permeability were secondary, it would not have been detected at GD-1.

1.2.4 Summary of Critique of Conceptual Model

DOE modelers have adopted a hierarchical approach to modeling of the groundwater flow system of the Paradox Basin. At this initial stage of research they present a large regional scale model. As our understanding of the system increases and more data are obtained, this model can be refined. This is a sound scientific approach. However, it has a drawback in that initial models may not yield any useful information directly. While useful for setting up refined models, the results of initial regional models do not give estimates of the final results, e.g. local groundwater flow paths and travel times.

The regional groundwater flux model presented by DOE contractors is, at best, capable of predicting regional groundwater fluxes. It should in no way be interpreted as offering estimates of groundwater velocities. Any uncertainties associated with the model, or system perturbations analyzed with the model result in corresponding uncertainties or effects on the regional groundwater flux. Any estimates of confidence are also with respect to calculated regional flux, not groundwater velocity.

Groundwater velocities are modeled as flow through the matrix porosity of a homogeneous porous medium. Given the observation that heterogeneity increases with model scale and the extremely large scale of the DOE model, we should not expect the homogeneity assumption to hold. This is supported by observed variance in permeability measurements. The model also neglects the nature of secondary permeability features such as fractures, which provide high velocity flow paths without increasing regional fluxes. These shortcomings introduce uncertainties in the velocity calculations which are so large as to overwhelm any uncertainties in the regional flux model and undermine any confidence in the calculated groundwater velocities and travel times.

1.3 Data Adequacy

A formidable obstacle to the modeling of the groundwater flow system of the Paradox Basin is the inadequacy of the available data. As Bear (1979) stated (sec. 1.1), sufficient data should be available for calibrating a model. As discussed in section 1.2, DOE contractors have proposed two models: a regional groundwater flux model incorporating existing regional data and a second model (perhaps better called a hypothesis) to directly calculate velocities. Their second model/hypothesis is based only

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on assumptions, not data. The data used in the regional model and in support of the velocity calculation hypothesis are discussed in the following two sections respectively.

1.3.1 Data Available for Regional Model

Examination of the available hydrologic data for the Paradox Basin indicates why modeling to date has been restricted to large scale regional models. Data consist mainly of drill stem tests conducted in petroleum exploration wells irregularly scattered throughout the geologic setting. The data coverage is so coarse as to preclude modeling on a smaller scale, without making an excessive number of unjustifiable assumptions and interpolations.

Potentiometric surfaces

Potentiometric surfaces are interpolated from available data from exploration wells in the region. This interpolation is done regionally and so results in a regionally smoothed surface. This removes any possibility of interpreting or detecting features of the flow system other than large regional trends. Since these potentiometric surfaces are used for calibrating the flow models, these models will not predict any small scale features which may exist. These surfaces are not definitive even on a regional scale. Large regions are totally without data, the most significant being south and west of the GD-1 borehole, including both Davis and Lavender Canyon sites. A statistical analysis of the existing data, such as kriging or conditional simulation, might yield a less generalized potentiometric surface and would give some idea of the uncertainty in the interpolated surface, particularly in areas with poor data coverage such as at the proposed sites.

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Permeability

Permeability data are also obtained largely from drill stem tests in exploration wells. Sufficient data are available in most units to conclude that most formations have heterogeneous permeability structure. For example, 60 permeability measurements in the Leadville Limestone give a range of values over 5 orders of magnitude and show a log-normal distribution.

The emphasis on analysis of the permeability data, however, has minimized the evidence for heterogenity by concentrating on obtaining regional average values. No spatial distribution analysis was presented or incorporated. For example, although spatial distribution of permeability of at least the Permian units is available in the published literature (Jobin, 1962), a single average permeability was used in models to characterize the entire unit. Formations with large variation in permeability such as the Elephant Canyon formation, the Paradox formation and the Leadville Limestone are assigned a single value, assumed characteristic of the average value. Their assumed average values are often less than the mean of the available data, the result of heavy weighting of the GD-1 data. Throughout ONWI-503 (Intera, 1984a), one encounters references to "characteristic regional values" or the exclusion of data as being "non-representative of the average value" and the neglect of heterogeneities as having a negligable effect on regional average permeabilities.

The same approach is taken in obtaining permeability measurements at GD-1. In spite of acknowledging intra-formation heterogeneous conditions, no attempt is made to characterize the heterogeneity (Thackston et al., 1984). Instead, the investigators attempt to obtain average permeabilities over some interval. The average values obtained may be appropriate for regional modeling, but are inappropriate for more localized modeling. In addition, much useful information is lost. For example, drill stem tests and long term shut in tests conducted directly below salt cycle 6 were applied over a 200 foot interval that included all of salt cycles 7 and 8, and 3 interbeds. These tests

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gave only the average permeability of the 3 interbeds, making it impossible to differentiate flow velocites within the individual beds. The loss of information with respect to permeability variance precludes the option of using a probabilistic model for groundwater velocity or transport predictions.

1.3.2 Average Regional Model

While some of these averaging practices may significantly affect the regional model results, they certainly impose strong limitations on the interpolation of the model results to more localized flow. In particular, spatial variations of permeability could change even regional flux direction and magnitude. On a local scale, spatial variation could drastically change fluxes, even several orders of magnitude. We conclude that the combination of permeability averaging for model input parameters and smoothed potentiometric surface data for model calibration results in an averaged model output. This may not be inappropriate, if the desired result is a model of the average regional flux. But extreme caution must be used, if these results are to be interpolated to a local scale.

1.3.3 Data for Velocity Calculation Model

As discussed in section 1.2 of this report it is absolutely not appropriate to calculate groundwater velocities directly from regional fluxes, unless the medium is completely homogeneous, a condition which is refuted by all available data. It might have been possible to estimate actual groundwater velocities from the regional fluxes by one of two methods: (1)If site specific data had been obtained (3 to 5 boreholes within 5 km of the site would be sufficient for a crude estimate, including detailed permeability tests, fracture assessments and, preferably, tracer tests between wells) small scale flow modeling would be possible. Furthermore, if the regional model were properly calibrated to site conditions, it could be used to determine boundary conditions for detailed deterministic flux and velocity modeling. (2) If permeability studies at GD-1 and throughout the study region had been conducted in sufficient detail to estimate permeability distributions and spatial correlations, a stochastic model could be used to statistically estimate velocity ranges and associated uncertainty. However, this would likely require site-specific data to estimate effects of secondary permeability.

In view of the above considerations we conclude that there are no data appropriate for site specific groundwater velocity calculations.

1.3.4 Summary of Data Analysis and Appropriateness

The acquisition, analysis and interpretation of hydrologic data needed for groundwater flow modeling is characterized by an approach which is misguided. The approach taken by DOE contractors in obtaining and analyzing important hydrologic parameters, such as hydraulic head and permeabilities, has consisted of an attempt to obtain regional average values. While these average values may be useful in determining regional fluxes, they have little or no importance in determining local flow velocities. The acquisition and use of these average values results in the loss of pertinent information and obscures the actual problems of determining local flow velocities.

The adequacy of the data base in the Paradox Basin has not been addressed in detail in this report. The adequacy of a data base is dependent on its intended use. If the object of the study is to obtain estimates of the average regional flux, the data base may be sufficient. If the object of the study is to obtain estimates of groundwater travel times from the proposed repository to a point not more than ten kilometers distant, the database is extremely inadequate. We might recall once again, Bear's (1979) criteria for an appropriate model (section 1.1): "data should be available for calibrating the model."

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When the only data available are regional average values, a model can at best predict regional averages. Since no data exist for actual groundwater velocities or the features which determine them, model predicted velocities and travel times remain pure speculation.

Meaningful deterministic models of groundwater velocity in the immediate vicinity of a proposed site could only be obtained with the use of site specific data. Detailed knowledge of local scale permeabilities, fracture systems, and hydraulic heads are necessary for parameter input, and model calibration for even crude estimates of local scale flow.

Alternatively, a probabilistic model could be used, if parameter frequency distributions and spatial correlation were determined. However, this would also likely require site specific data for model verification. Assessment of secondary permeability could further require additional data in the vicinity of the site for statistical validation.

1.4 Assessment Against the Guidelines

The DOE's "General Guidelines for Recommendation of Sites for Nuclear Waste Repositories" provides a framework in which to assess the suitability of a proposed site for characterization and development as a repository. At the present decision point (site nomination as suitable for characterization), an assessment is required of all postclosure guidelines, including geohydrology, as to the suitability of the site for site characterization. This assessment must include a preliminary estimate as to the likelyhood that a qualifying or disqualifying condition will be found. These assessments and the evidence in their support are given in the Environmental Assessment and its supporting documents. The following section discusses and critiques the assessment against the geohydrology guideline (guideline 10 CFR 960.4-2-1) made by the DOE. Although reference is made to the Davis Canyon EA, the same comments generally hold

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for Lavender Canyon since the assessments are based on the same data and models.

1.4.1 Geohydrology Guidelines

The basic conclusions reached by the DOE in the Davis Canyon EA is that the qualifying condition is likely to be met. This conclusion is based on the calculated travel times based on the modeling done by Intera and WCC. Section 2 and 3 of this report have shown the fallacy in calculating travel times from a regional model utilizing a regional data base. For the reasons discussed in the previous section the travel times presented in the EA must be regarded as purely speculative. At best, these travel times represent regional averages. Sound scientific reasoning, based on an understanding of the features and processes which determine groundwater travel times, would indicate that the use of average values is not a conservative approach. It is our opinion that the guidelines support this position by incorporating "groundwater travel time along any path" as a favorable or adverse condition, rather than average groundwater travel time.

It could be argued that travel time alone does not determine the importance of a potential flow path; the magnitude of the flux must also be considered. Therefore, it is appropriate to use average parameter values to obtain sufficient flux for significant radionuclide transport to occur. This is not neccessarily correct. Fluid flow takes the path of least resistance. It flows preferentially toward and through high permeability zones or fractures, giving larger fluxes at these higher velocities.

It could also be argued that the qualifying condition will be met, based on the long travel time within salt cycle 6 (minimum of 4,000 years, E.A. section 6.3.1.1.2). However, given the difficulty in calculating flow velocities in salt, and the unknown potential for dissolution, tectonic or human intrusion, it is important that the entire hydrologic system be well understood and alternative potential flow paths considered.

It is our conclusion that without more specific, localized groundwater velocity

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modeling of the site, the qualifying condition cannot be assessed.

Favorable and Potentially Adverse Conditions

Favorable Condition (1): The conclusion that travel times to the accessable environment are more than 10,000 years is based on the lack of dissolution features and the results of regional flow modeling. The inadequacy of the flow models is the main point of this report. Dissolution is often a local phenomenon and without data from the site, the hypothesis is without a factual basis.

Favorable Condition (2): The favorable conclusion found is largely based on the lack of adverse data, rather than the existence of supportive data or modeling. The "worst case" assumption used to assess the effect of a rise in water table level is applied to the regional model and so gives an assessment of the effect on average hydraulic gradient rather than local velocities.

Favorable Condition (3): The complexity of the geohydrologic system is being underestimated. It has not been demonstrated that meaningful models can be successfully applied. The "success" of regional models is only in fitting a small amount of potentiometric surface data with a model which is by no means unique. Modeling done thus far is straightforward due to the excessive simplifying assumptions used. It is a far more difficult task to construct a model which reflects reality in sufficient detail to accurately predict groundwater travel times. These difficulties have not been addressed and this is one of the major ommisions of the EA.

Favorable Condition (4): This condition is likely to be found. It should be noted, however, that if the Leadville Limestone is a fractured aquifer and thus provides a high velocity travel path to the accessible environment as some data suggest, the downward gradient is actually an adverse condition as it directs transport toward this high velocity travel path.

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Potentially Adverse Conditions: We find no major disagreements with the assessments found by DOE.

Disqualifying Condition: As discussed, travel times to the accessible environment have not been adequately assessed. However, it seems likely that salt cycle 6 will contain the waste for at least 1,000 years, provided the disturbed zone remains small and the repository is located in the middle of the unit.

1.5 Summary and Conclusions

1. The regional model given by DOE as the principle support for their geohydrologic system assessment is capable of predicting only average regional fluxes. It cannot be used for direct calculation of groundwater velocity or travel time.

2. Groundwater velocities and travel times are calculated from the regional fluxes by assuming flow through the primary porosity of a homogeneous medium. These assumptions are refuted by all available data. Theoretical considerations suggest that use of these assumptions could result in overestimating travel times by several orders of magnitude.

3. Fractures exist in the geologic setting in the vicinity of the site as shown at GD-1. These features have not been properly incorporated in the hydrologic modeling, resulting in overestimations of groundwater travel time.

4. Data used in regional modeling are highly averaged and interpolated resulting in loss of information and resolution.

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5. No data exist for deterministic groundwater velocity calculations from the proposed site to the accessible environment. Data available for probabalistic velocity estimates are not used or have been lost through averaging.

6. Because of (a) the inappropriateness of the conceptual models, (b) the use of invalid assumptions, and (c) the inadequacy of the data, no meaningful estimates of groundwater travel time have been obtained. As DOE's assessment of the site suitability against the geohydrology guideline is based on their travel times, we cannot concur with their assessment. Inadequate studies have been conducted at this time to make a meaningful assessment of the site suitability for repository development or full site characterization.

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APPENDIX B

Appendix B

REVIEW AND EVALUATION OF THE GIBSON DOME HIGH LEVEL NUCLEAR WASTE REPOSITORY ENVIRONMENTAL ASSESSMENT: GEOHYDROLOGIC ISSUES

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March 5, 1985

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background/Authorization

This report is meant to provide a technical review and evaluation of Department of Energy documents concerning groundwater, radionuclide travel time and monitoring issues relative to siting a high level nuclear waste repository in the Gibson Dome area in Southern Utah. In so doing we have, during a relatively short period of time, examined in detail the Department of Energy Guidelines concerning high level nuclear waste disposal (1983) including revisions (1984), and each draft of the Environmental Assessments for Davis and Lavender Canyon, up to and including the final draft (dated Dec., 1984). In addition, a large body of supporting DOE documents and relevant published research literature was carefully examined and incorporated into this report.

Our approach to the review and evaluation process has been to examine the assumptions analysis procedures, conclusions and supporting data regarding groundwater, radionuclide travel time and monitoring issues for the Davis and Lavender Canyon Environmental Assessments, and to provide an independent appraisal of the DOE approach and assessment of these issues.

This work is carried out under a contract with the State of Utah Office of Planning and Budget (Contract No. 85-0205).

2.0 REVIEW AND EVALUATION OF GROUNDWATER ISSUES

2.1 Summary of Groundwater Issues

In general, our most serious concern about the groundwater issues in the Davis and Lavender Canyon Environmental Assessments has to do with the very minimal effort that has been made to date to characterize hydraulic conditions in the region surrounding the proposed repositories and along expected travel paths. It seems remarkable that the siting procedure has come so far based on a single observation well in the impacted area. It appears that no other proposed repository site has this little information on which to make quantitative assessments. In our estimation, part of the problem stems from the mistaken view that, because the flat-lying hydrostratigraphic units of the Colorado Plateau can be identified and correlated over large distances, hydraulic properties can be inferred or extrapolated over large distances (1-10's of km) as well, and therefore additional field data are unnecessary or redundant. In other words, because a satisfactory geologic model is available for the western Paradox Basin, the hydraulic model is also "realistic" and well-defined. It is our opinion that because of the large degree of spatial variability of hydraulic properties evident in the regional data base and in GD-1, and the likelihood of the existence of discrete hydraulic features (such as joints, fractures and dissolution conduits), that hydraulic characterization in the impacted area is premature. We feel that, at present, the data base available for the Gibson Dome sites is inadequate to make quantitative predictions and assessments about the hydrologic performance of these sites.

A second concern we have is with regard to the use and application of groundwater model predictions as a substitute for "hard field data" in the region surrounding the proposed repository. It is our opinion that the use of sophisticated models with a generic data base does not constitute a "realistic" prediction of performance. Here again we feel that the only way to make quantitative and reliable assessments of hydrologic performance (velocity and travel time) is on the strength of reliable field data and supported by verifiable model studies. Model results provide no substitute for field data.

A third major concern has to do with the post closure monitoring program. Because of the sparcity of proposed observation characterization wells, the corresponding uncertainty in the location of "expected travel paths," and the potential for significant fluid flow in discrete hydraulic features, there would be little assurance that a contaminant release would ever be detected by the proposed post closure monitoring system. Additional drilling in the region down gradient from the repository is the only way to better define "expected flowpaths" and improve chances of intercepting contaminant releases. Again we would emphasize that model results are not a suitable substitute.

A final overall concern has to do with the inadequacies of the DOE guidelines on which the Davis and Lavender Canyon environmental assessments were made. The major problem associated with the guidelines as we see it, has to do with a lack of any criteria within the document (Nov. 18, 1983) quantifying the amount of hydraulic field data which would be recognized as a "minimum" for site description and evaluation. In the present situation one borehole and model results from a generic data base are available.

Most groundwater hydrologists/hydrogeologists would not feel comfortable making site evaluations based on this amount of data, however, the DOE guidelines direct that this be done (DOE Guidelines, p. 11):

> If the existing data for a site are not adequate to substantiate such evaluations, then an evaluation shall be based on the potential of the site to meet the qualifying condition of a guideline, using appropriate and technically, conservative assumptions. That is, the DOE will use assumptions that realistically approximate the parameters or conditions considered to exist, or expected to exist or occur in the future, at such site.

2.2 Hydraulic Properties of Hydrostratigraphic Units

An early comprehensive regional study of the hydrodynamics of the Paradox Basin can be found in Hanshaw and Hill (1969). The hydrogeologic interpretations of these authors seem to provide the basic conceptual framework on which subsequent studies have been based. Huntoon (1979) and Weir et al (1983) provide additional valuable interpretations of the hydrogeology of the western Paradox Basin. The three hydrostratigraphic units defined in the Environmental Assessments of Davis and Lavender Canyon and described in ONWI 290 and 491 are the same as those suggested by Hanshaw and Hill (1969) with slight modifications. However, the description of the three hydrostratigraphic units in the Environmental Assessments rely almost totally on the data from GD-1, a single borehole located several miles from either repository site. Because the hydraulic conductivity and porosity of the consolidated hydrostratigraphic units of the Colorado Plateau are likely the result of secondary, fracturing, faulting and solution, we can expect large blocks of low hydraulic conductivity in the region (Huntoon, p. 45, 1979), interspersed with zones of higher hydraulic conductivity. A single borehole would not be considered representative of regional aquifer properties under almost any field situation, but especially not here where the fluid transport properties were developed subsequent to deposition and burial. Evidence for secondary permeability and porosity is found in data from GD-1. Laboratory measurements on cores of the rock matrix are consistantly lower than the drill stem tests (Figure 3-38, Davis Canyon E.A.). The drill stem tests are effectively measuring the total permeability (and porosity), which apparently is controlled by jointing, fracturing and/or dissolution. The reliance of the environmental assessment on data from a single borehole, is not in our opinion good hydrogeologic judgment.

There is an overall failure in the E.A.'s to recognize that presently, the only way to make realistic or conservative estimates of the hydrologic performance of the potential repository, is from a statistical analysis of the regional data base (Table 3-11, Davis Canyon, Table 3-11, Lavender Canyon, in fifth draft, July 27, 1984, not provided in final draft). Hydraulic conductivity data for a single observation well (such as GD-1) could fall anywhere within a 6 order of magnitude range (see Fig. 3-38, p. 3-139, David Canyon E.A.). This is obviously inappropriate for assigning velocities or travel time over the entire the impacted area. A statistical methodology incorporating regional data statistics for hydraulic conductivity and porosity would be an appropriate approach to preliminary velocity--travel time estimation. Using regional data for hydraulic conductivity and porosity would not underestimate the quality of data derived from petroleum exploration. This is discussed in greater detail in Section 3.3.

The second point of concern regarding the hydraulic data base has to do with the statement in both the Davis (p. 6-80) and Lavender

Canyon (p. 6-87) E.A. that "geologic correlation between boreholes spaced as much as 32 kilometers (20 miles) apart is an acceptable practice with a fairly high confidence level in this particular setting" (in Assumptions and Data Uncertainties).

Although the unique geology of the Colorado Plateau is such that geologic correlation over large distances is possible, the context of the above statement in the text should not be construed to mean that geologic correlation and the correlation of hydraulic properties (porosity, hydraulic conductivity) over large distances are the same, as is done in the E.A.'s and in the groundwater modeling study (ONWI/TR32/TR17, 1983, 1984). It is safe to say that each of the hydrostratigraphic units in the Gibson Dome area are subject to several orders of magnitude change in hydraulic conductivity, even over relatively short distances between boreholes (say 10-100 meters). Again, the E.A. does not discuss uncertainties in data or processes using any recognized framework of risk and/or statistical analysis.

A third point of general concern is that the Environmental Assessments make no attempt to resolve the potential impact of discrete hydraulic features such as fractures, faults, joints and dissolution conduits. The potential of these features to dominate the rate of groundwater flow and contaminant transport along expected flowpaths would seem to be extremely significant in this geologic environment. Neglecting the possibility of flow in discrete hydraulic features, and estimating velocities based on the matrix permeability and porosity of the consolidated rocks will drastically underestimate the velocity and overestimate the travel time of contaminants in the impacted hydrogeologic zones.

Specific Comments: The Pinkerton Trail Formation, the upper-most formation of the lower hydrostratigraphic, unit is suggested to be an aquitard in both E.A.'s Although the hydraulic conductivity for the Pinkerton Trail Formation is low in GD-1, on a regional basis Hanshaw and Hill (1969) refer to it as the Pinkerton Trail Aquifer, a limestone characterized by low potentiometric gradients. Also, the Elk Ridge drill hole apparently lost circulation of drilling fluid in this unit and it became necessary to abandon the hole. This would indicate that at least locally, the Pinkerton Trail Formation would not serve as an aquitard.

The assumption is made that the middle hydrostratigraphic unit is impermeable with the conclusion that essentially no groundwater moves through the middle hydrostratigraphic unit. This assumption is not necessarily supported by regional data or even with the data from GD-1, where the hydraulic conductivity ranges between 10^{-5} cm/sec and 10^{-10} cm/sec (Fig. 3-38, Davis Canyon E.A.). Obviously these would be considered low values of hydraulic conductivity, however, they do not suggest impermeability. The question of impermeability of the salt is probably not nearly as important as is the question of availability of flowing groundwater. Just because large blocks of salt exist is not conclusive evidence that the unit is effectively impermeable.

Also the permeability or impermeability of salt is primarily based on the use of water as the fluid. What would be the magnitude of vapor transport of water and/or volatile radionuclides in the presence of large thermal gradients likely to exist within the repository horizon? Does the salt provide an effective barrier to gas flow and subsequent condensation in adjacent (cooler) strata? Petroleum reservoir analysts should be able to comment/quantify this notion. Volatilization and transport of organic chemicals at shallow waste disposal sites can be a serious local air quality problem under some conditions, and thermal gradients involved are many times less. We found no reference or specific calculations dealing with this question.

2.3 Regional Potentiometric Surfaces

General Comment: Regional potentiometric surface maps for each of the important hydrostratigraphic units in the Paradox Basin were orginally presented by Hanshaw and Hill (1969). In this study the potentiometric contours were constructed by interpolation of point data from widely spaced (1-10's of miles) oil and gas exploration wells. The authors of this study, recognizing the uncertainty in the contoured potentiometric surfaces, confined their interpretations of the hydrodynamics of the Paradox Basin to large scale conceptualizations of the flow paths, aquifer interconnections and boundaries of the system. Weir et al. (1983) also provides large scale potentiometric contour maps of these units using somewhat more recent data, and they also confined their interpretation to the large scale aspects of the flow system.

These approaches are quite useful for establishing the regional hydrologic framework such as boundary conditions, recharge and discharge areas, generalized flow directions, etc., however it does not provide the detailed hydraulic head data necessary for estimating the direction and magnitude of local velocities associated with potential contaminant transport from a waste repository. With the exception of GD-1, essentially no hydraulic head data exist between the potential repositories and the accessible environment (Colorado River). In addition plans to collect this data are largely inadequate since the site characterization plan (see Chapter 4) suggests that drilling will not be performed or will be performed in a limited way within the national park boundaries, which comprise most of the expected travel path from the sites.

Having carefully read the first and second status reports (ONWI/E512-02900/TR-32 . . ./TR-17, 1983, 1984) concerning regional groundwater flow modeling, it is apparent that simulated hydraulic head contours will be substituted for actual field data in the region to the west of the repository sites. It seems reasonable to point out here that model results are no substitute for field data, and performance estimates based on modeling results without field data for model verification are essentially meaningless. This is discussed in a following section in more detail.

Specific Comments: The E.A.'s for Davis and Lavender Canyon sites go to great lengths to argue that the upper and lower hydrostratigraphic units are hydraulically isolated by the middle unit (taken to be impermeable except at the Shay Graben and Lockhart Basin). Other authors provide differing interpretations of the relative interconnection of these strata (Hanshaw and Hill, 1969, p. 285): "The potentiometric surfaces of Mississippian and Pennsylvanian (lower and middle hydrostratigraphic units respectively) aquifer systems (their Figs. 2, 5, 6, 7) are quite similar in their major aspects. Because Mississippian strata crop out in very few places and over limited areal extent, we suggested previously that this aquifer (Leadville) receives most of its recharge from cross-formational flow from overlying strata." The above situation could be occurring in the region surrounding the Davis and Lavender Canyon sites given the higher potentiometric level in the upper hydrostratigraphic unit, and that the water quality of the Leadville limestone (lower unit) is apparently similar to the Paradox (middle unit) at GD-1. However, this could also be the result of chemical diffusion processes. Weir et al. (1983) suggest that diffuse vertical leakage from the lower hydrostratigraphic unit might possibly account for the unexplained portion of the groundwater budget flowing to the Colorado River from the upper hydrostratigraphic unit. However, they state that little direct evidence is available at present.

The hydraulic gradient used to estimate the movement of water through the salt strata (Table 3-14, p. 3-144, Davis Canyon E.A.) is based on freshwater potentiometric heads, uncorrected for density gradients. A dense fluid, such as a brine, overlying a less dense fluid, creates natural density gradients which should not be neglected in calculating hydraulic head. Neglecting density gradients between the middle hydrostratigraphic unit (salt strata) and the lower hydrostratigraphic unit may drastically underestimate the vertical flow through this zone, and overestimate the travel time.

Davis Canyon 3-132 and Lavender Canyon 3-139: "Potentiometric levels within the Paradox Formation interbeds do not create a consistent areal pattern in the bedded salt area of the western Paradox Basin." This statement in both E.A.'s is misleading and is not consistent with what has been found by other authors (Hanshaw and Hill, 1969) who have constructed regional potentiometric maps of the Paradox. As stated earlier, the potentiometric maps of Hanshaw and Hill demonstrates the similarilty between contours in the Honaker Trail, Paradox and Mississippian Leadville formation, further illustrating their consistency and potential interconnection. The above interpretation that potentiometric levels are not consistent in the Paradox is primarily based on what was found at a single well GD-1, and neglects the regional evidence that flow in the Paradox is under hydrodynamic conditions (i.e. a regionally consistent slope to the potentiometric surface).

Another indication of the problem encountered when trying to make local interpretations of sparse data can be observed by comparing the difference in potentiometric surface maps developed by different authors for the region near the repository. Figure 2.1, after Hanshaw and Hill (1969), shows that the repository is located on or near a ridge of the 4400 foot contour line. Figure 2.2 from both the Lavender and Davis Canyon Environmental Assessments shows the repository on a relatively straight section of the 4400 foot contour line. This demonstrates the arbitrary nature of potentiometric maps in regions where essentially no data are available.

2.4 Recharge/Discharge

The assumptions concerning recharge and discharge patterns in the upper, middle and lower hydrostratigraphic units of the Davis and Lavender Canyons environmental assessments and supporting documents appear to be quite arbitrary in nature (i.e., not based on a significant body of field data), and always take a position that is not conservative with respect to developing a conceptual hydrogeologic model of flowpaths and velocities. For example, "significant recharge to or discharge from the middle and lower hydrostratigraphic units does not appear to occur in the Davis (Lavender) Canyon candidate area, except possibly where the normal stratigraphic sequence has been disrupted such as in Lockhart Basin and Shay

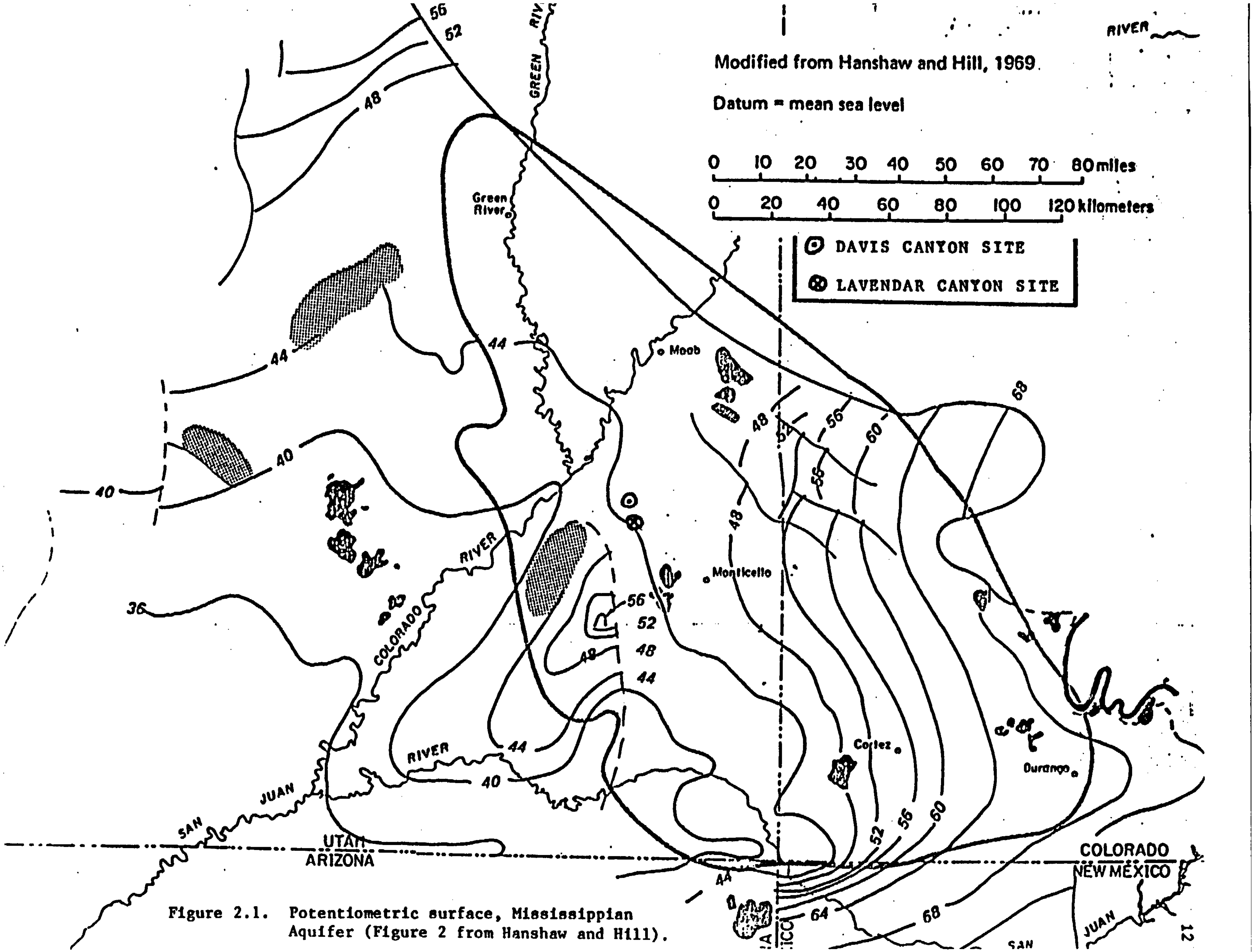


Figure 2.1. Potentiometric surface, Mississippian Aquifer (Figure 2 from Hanshaw and Hill).

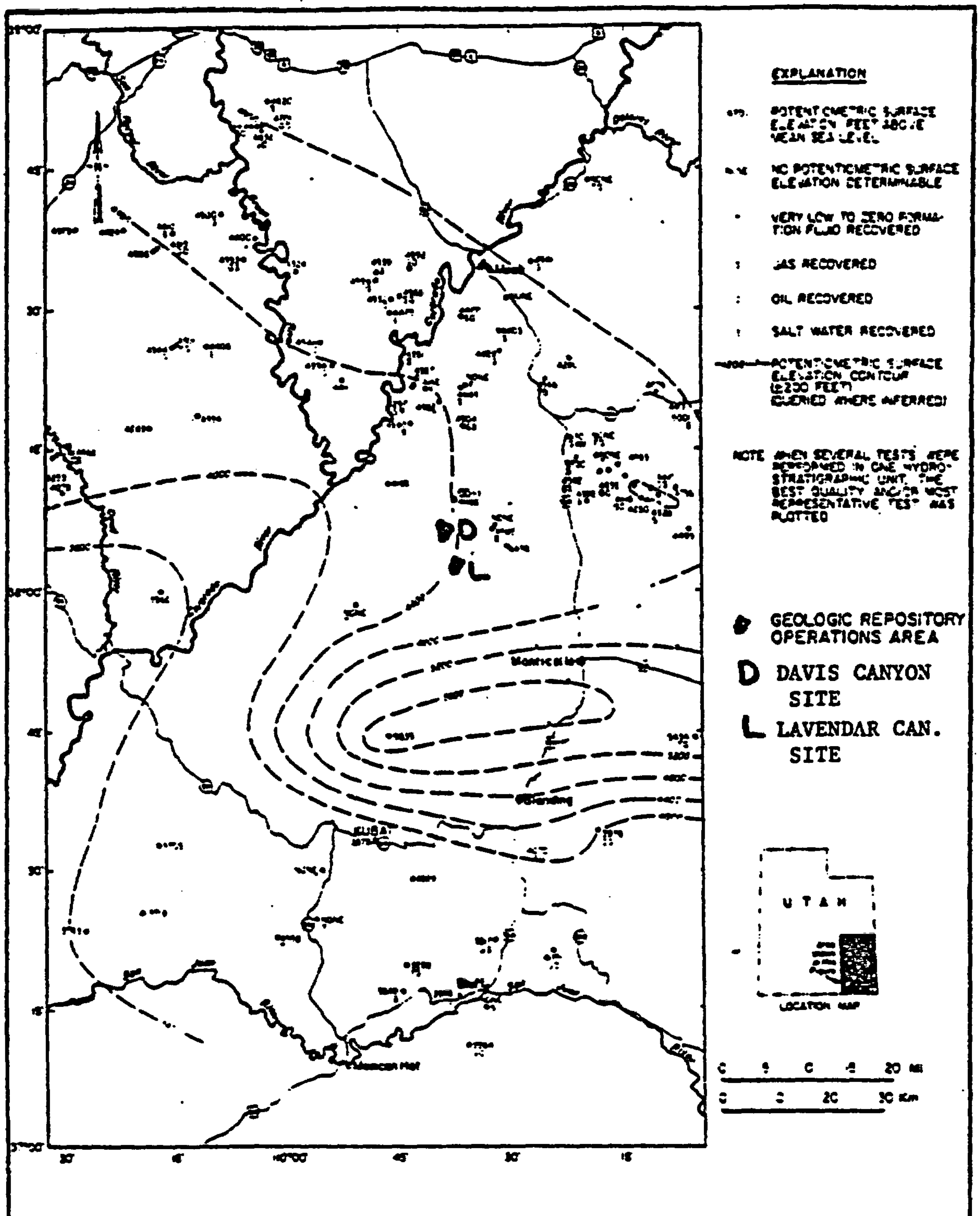


Figure 2.2.

Potentiometric Surface, Lower Hydrostratigraphic Unit

Figure 3-40

Graben" (Davis Canyon EA, 3-142). This statement largely ignores the possibility of diffuse vertical upward leakage from the lower hydrostratigraphic unit proposed by Weir et al. (1983). The following excerpt from Weir et al. (p. 45) provides a more "conservative" conceptual model of recharge and discharge.

> All large hydrologic systems include recharge areas, areas of lateral movement (such as the Paradox basin), and discharge areas. Recharge areas for the lower ground-water system are remote (east and north) from the study area; likewise, conspicuous (my emphasis) discharge areas are outside the study area. Marble and Grand Canyons, southwest of Paradox basin, comprise two such discharge areas for the lower ground-water system or its regional equivalent. In these canyons, ground water discharges from the Redwall Limestone, which is approximately the same age as the Leadville Limestone equivalent. However, not all water recharging the lower Paleozoic aquifer in the region is discharged from the Redwall Limestone into the Colorado River. Areas undoubtedly exist along the regional flow paths where water can migrate upward into younger rocks from the aquifer and its equivalent strata. Hydraulic potential for upward leakage exists almost everywhere in the area (my emphasis). Hydraulic heads are sufficient to raise fluid at least as high as lower saturated, permeable units of the upper ground-water system. Virtually all rocks can transmit some water, although the thick salt deposits of the Paradox depositional basin probably come as close to zero hydraulic conductivity as any natural sedimentary layers. Conceivably, the slope on the potentiometric surface of the lower ground-water system might be maintained through infinitesimally small, but widespread upward discharge; thus, the system would function without any conspicuous discharge to the surface directly from the system. ...
>
> ...Near the Colorado River, between its confluences with the Delores and Green Rivers, the predominant potential is for upward leakage from the lower ground-water system (fig. 9); that is, potentiometric heads for the lower system are 100 to 200 m higher than water-level heads in the main saturated zone of the upper system. However, no direct evidence exists of any actual leakage, upward or downward, through the confining beds of salt and adjacent confining beds from these potentials. Possible upward or downwater leakage depends on vertical potentiometric gradient in any specific locality.

Other nonconservative assumptions and statements concerning site performance were also found. Davis Canyon 3-132, Lavender Canyon 3-139: The following argument is offered as evidence of no recharge from the upper hydrostratigraphic to the lower unit. "Because the potentiometric surface of the upper hydrostratigraphic unit appears to be higher than the lower unit at the site (actually GD-1), and considering the extensive thick sequence of evaporite beds, hydraulic interconnection is probably restricted between the upper and lower units."

The argument that, because the potentiometric surface of the upper hydrostratigraphic unit is above the lower unit, flow is restricted does not follow. This actually would indicate that there exists a potential for vertical downward flow. Just because there is little evidence of salt disturbance at GD-1 does not restrict significant connection elsewhere. The following from Weir et al. (1983, p. 46) provides a more conservative assessment.

> Throughout most of the Moab-Monticello area, potentiometric head in the lower ground-water system is lower than the potentiometric head in the upper ground-water system (fig. 9 and pl. 2); thus potential for some downward leakage from the upper to lower system does exist.

Even at GD-1 the similarity of water quality between the middle and lower hydrostratigraphic units may also support the idea that slow, vertical downward flow presently exists at GD-1 through the entire sequence.

2.5 Groundwater Modeling

The groundwater modeling effort (ONWI/512-02900/TR-17 and ONWI/512-02900/TR-32) is referred to in both the Davis and Lavender Canyon E.A.'s with the following brief statement,

> Preliminary numerical modeling of the groundwater flow system was performed for the region surrounding the candidate area (Dunbar and Thackston, 1984, pp. 1-3). The basic conclusions from the study at this time are that the groundwater flow system conceptual model is realistic and that additional data are needed to adequately quantify the flow system parameters, especially transmissivities, hydraulic conductivities, recharge amounts, and potentiometric levels.

This statement is apparently presented simply to satisfy the requirement in the technical guidelines concerning the ability to model the site. They state that their conceptual model is 'realistic' but that additional data are required to quantify the system. In our opinion the model effort presented here is an attempt to justify many of the unsubstantiated assumptions about the nature of groundwater flow made earlier in the E.A.'s and supporting documents. The model results are not based on sufficient, or in many areas, any data on which to justify their claim that the model result is realistic.

A scientific approach to modeling would be to use an appropriate physical model of a system along with available information and data about the system to provide an understanding about how the system performs. The engineering approach to modeling is to apply this understanding along with a satisfactory data base, to provide the best available answer to the particular engineering problem at hand. The model study of the Paradox Basin performed by the Intera group does not satisfy either of these approaches. Restrictive assumptions are made at the outset, in many cases unsupported by field evidence or sufficient data, which are favorable to the view, that the Davis and Lavender Canyon sites are suitable for waste isolation. The model study then sets about to 'prove' that these assumptions are "realistic" even though no data exists to calibrate and verify their conceptual model in the region of critical concern.

On page 6 of the first status report the authors state their purpose is to predict groundwater flow and travel times to the biosphere and "to define confidence limits on this prediction." This is an almost unbelievable statement considering the almost total lack of data within the Gibson Dome area.

In our opinion, the groundwater model study implemented by the Intera group should not be viewed as having the capacity to predict anything. Its real value would have been as a screening model to test the viability of their basic assumptions, however, very little of this was done. Their approach has been to make restrictive assumptions concerning aquifer interconnnections and boundary conditions, input a generic data base (since hard data is essentially unavailable), and then call model output a prediction. I will include the following quotes from an editorial by Mary Anderson on groundwater modeling (Anderson, 1983).

> "It is also tempting to consider using models to judge the suitability of proposed waste sites, e.g., hazardous waste sites. A generic data base might be used for this type of modeling because it would be too costly and time-consuming to collect site-specific data for many different sites. The rationale is that it will be simpler to input model parameters from a generic data base and allow the model to calculate an array of numbers purportedly representing the concentration (or velocity--our statement) of contaminants in groundwater at any point in the subsurface. This type of modeling is valid only if it is recognized that models fashioned in this way are merely preliminary screening tools. Models that rely on a generic data base cannot be expected to produce results that are accurate for any specific site. Generic modeling can be a hazardous game because when the numbers from a computer output are plotted up in three-dimensional color graphics, it's easy to loose site of all the assumptions that went into the modeling effort. One tends to forget that "the Emperor has no clothes."
>
> It is clear that models must be used in conjunction with field studies and good hydrogeological field sense. In fact, field studies to help resolve the questions about dispersion and chemical reactions in the subsurface are in progress and in planning. Until the results of these studies are analyzed and accepted, the promotion of ground-water models for contaminant transport applications should be viewed with caution. Let's consider the experience of others:

'What were the scientific underpinnings of the National Environmental Protection Act that allowed it to demand scientific analyses that were not possible at that time, or maybe never possible? Why did the scientific community not refuse to collaborate with requests that were patently impossible? The legal or the administrative requirement to carry out modeling studies did, however, seduce many engineers and scientists, this reviewer included, to try to do the best they could under the situation. In retrospect, this was a great error because we have allowed air and surface water models to be adopted and be required (in some cases, models are even mentioned by name in the Federal Register), without regard to measuring the ambient environment before predicting effects of man-induced impacts. The engineering and scientific community are expected to perform analyses and prediction without a proper scientific data base.[1] (Rogers, 1983.)'

Some may disagree with a philosophy which implies that a "proper scientific data base" is required to make engineering decisions. Sometimes it is necessary to make decisions without complete data. Models can help in decision-making provided that the assumptions inherent in the model and the degree of uncertainty in the parameters used in the model are fully recognized."

3.0 REVIEW AND EVALUATION OF RADIONUCLIDE TRAVEL TIME/MONITORING ISSUES

3.1 Summary

This chapter describes the comments and concerns we have as to the pre and post closure site monitoring plans, and the methods used to calculate travel time and its variability. The Environmental Assessment clearly states that flowpaths are expected to be in a northwesterly to southwesterly direction from the repository. Several of the proposed site characterization wells are far removed from any expected flowpath, thus these wells give little information other than regional geohydraulic characteristics. Proposed monitoring along expected flowpaths is clearly inadequate.

Travel time calculations are based on bulk matrix permeability and porosity values, while contaminant travel paths will likely be in joints, fractures, and along dissolution surfaces. The travel times quoted in the E.A. are thus not conservative, and virtually ignore the impact of discrete hydraulic features. Also, the issues of the variability of expected travel time is not addressed in the E.A.

3.2 Assumptions and Framework for 10,000 Year Travel Time Criteria

According to the Department of Energy's Siting Guidelines (May 1984) for High Level Nuclear Waste Disposal, one of the important characteristics of the geohydrologic setting which demonstrates the compatibility of a given site for waste containment and isolation is (960.4-2-1 Geohydrology, PZ):

(1) Site conditions such that the pre-waste-emplacement ground-water travel time along any path of likely radionuclide travel from

the disturbed zone to the accessible environment would be more than 10,000 years.

In this same document the DOE outlines the types of information they expect to be included as evidence for subsequent evaluations of the site including travel time (Appendix IV, p. 7, Guidelines). In addition to the data listed below the DOE will also "supplement this information" with the following: a) conservative assumptions or extrapolations of regional data, b) conceptual models (I assume this to mean numerical models), and c) analyses of uncertainties in data.

Geohydrologic data base:

(1) Location and estimated hydraulic properties of aquifers, confining units and aquitards.

(2) Potential areas and modes of recharge and discharge for aquifers.

(3) Regional potentiometric surfaces of aquifers.

(4) Likely flowpaths from the repository to locations in the accessible environment, as based on regional data.

(5) Preliminary estimates of ground-water travel times along likely flow paths from the repository to locations in the expected accessible environment.

We have serious concerns about two particular aspects of these guidelines concerning the framework for assessing site geohydrology.

(1) The guidelines, inadvertently or not, encourage the use of numerical models with generic data as a substitute for hard field data. As discussed earlier, model results in regions where no data are available (such as over the 1000 km^2 region adjacent to the Gibson Dome site) can be used to produce any desirable answer. It is impossible to assess the level of

uncertainty in these areas and thus the concept of conservatism cannot be followed either. Model results are very useful in regions where field evidence (data) exists and can thus be verified. But in our estimation, model simulated potentiometric contours and velocities are no substitute for real data since they cannot be verified.

(2) A second general concern involves the lack of any statement or qualification concerning what amount of hydraulic field data constitues a minimum allowable data base for site characterization.

For example: Can a single observation well and corresponding hydraulic head, porosity and hydraulic conductivity data, over a 1000 square km region encompassing "expected travel paths," satisfy the requirements of the guidelines with respect to evidence? If so, then the guidelines are essentially meaningless since any site of that size would have low conductivity zones.

In our opinion the questions concerning a minimum allowable data base and the use of model results as a substitute for real data are not adequately defined in the guidelines or in the environmental assessments of Davis and Lavender Canyons.

3.3 Data Availability/Needs

The data base presently available for calculating travel times consists of the following items:

(1) The GD-1 borehole; porosity and hydraulic conductivity data.

(2) Regional hydraulic conductivity and potentiometric level in ONWI-290, Vol. V, Appendices.

(3) Regional potentiometric contour maps as published by Hanshaw and Hill (1969), and more recently by Weir et al. (1983).

It appears that most of the data cited in ONWI-290 comes from wells drilled several miles to tens of miles north, east, and south of the repository location.

Expected flow paths from the repository location and the Accessible Environment (the Colorado River) can be estimated from regional potentiometric surface contour maps given in Hanshaw and Hill (1969), Weir et al. (1983) or from the INTERA modeling study. In both cases, flowpaths could be expected to travel within a zone encompassed by northwesterly to southwesterly directions from the repository location. Flowpaths within this zone are poorly represented by data cited in ONWI-290, and would indicate the need for additional hydraulic conductivity, porosity, and potentiometric surface data in the region between the Colorado River and the repository location.

Site characterization studies outlined in Chapter 4 of the Davis and Lavender Canyon EA's indicate that several deep boreholes will be drilled within a 3 miles radius of the repository location, as well as boreholes in the Lockhart Basin (∿15 miles N of the repository), Beef Basin (∿ 15 miles SW of the repository), and the Shay Graben (∿ 10 miles SE of the repository). With the exception of the Beef Basin boreholes (2 boreholes), and the boreholes drilled to the NW and SW of the immediate vicinity of the repository, all the site characterization boreholes lie outside of any possible flowpath from the proposed repositories.

Granted that wells drilled to the east, northeast and southeast of the potential repositories help to characterize the range of expected values of porosity and hydraulic conductivity for the region, however they do not identify possible anomalies along expected flowpaths, or possible trends in geohydraulic parameters between the repository and the accessible environment that would greatly effect travel times. Additional site characterization wells along "expected flowpaths" should be drilled to determine the variations and trends in geohydraulic parameters along possible flowpaths.

A sensitive issue is whether site characterization drilling should be carried out within the Canyonlands National Park directly west of the repository location. In our opinion, since flowpaths likely would flow across the southerly boundary of the park, additional boreholes along these flowpaths will be necessary. Section 4.3.3.3 (p. 4-141) in the fifth draft (dated June 5, 1984) of both EA's propose that 2 boreholes be drilled within the park boundaries directly west of the proposed repositories "if unanticipated conditions are encountered or the boreholes outside of the park do not provide data to adequately characterize the site area." This section was deleted from the final version and thus based on the final draft there does not seem to be any plan to drill within the park. It is our opinion that, if drilling activities cannot be carried out within the park boundaries due to aesthetic or environmental reasons, then the assessment of hydrogeologic performance will be inadequate to determine site suitability as a waste repository.

In summary, the number of proposed boreholes (47) is more than adequate for regional hydrogeologic characterization but does not address the problem of travel time determination along flowpaths. The regional data base will provide a good estimate of the likely flowpaths, and once these are established additional data along the expected travel paths is necessary to quantify travel time.

3.4 Travel Time Estimation/Uncertainty Evaluation

First of all, it is our opinion that the Department of Energy (DOE) guideline concerning the 10,000 year travel time to the accessible environment may not be appropriate for high level nuclear wastes subject to dispersive/diffusive mixing processes. These dispersive/diffusive processes may make the initial arrival time of a contaminant much quicker than the arrival time of a contaminant that is traveling at the average fluid velocity. This concern is best summarized by Grisak et al. (1978)

> "It should be emphasized that arrival times using the average velocity may be misleading or irrelevant in the case of contaminants which exceed permissible levels at very low concentrations. In such cases the entire dispersed breakthrough curve is much more significant. In fact in some cases the first measurable arrival may represent excessive contamination."

It seems likely that for cases of flow and transport in discrete hydraulic features, such as fractures, joints and dissolution conduits, the above concern will be every more critical.

A serious criticism we have concerning the Environmental Assessment for both the Davis and Lavender Canyon sites is that there is no consistent quantitative framework established by the DOE or its consultants for estimating travel time. The travel times quoted in the EA (Section 6.3.1.1.2) are based on rules of thumb or "best guess" of the hydraulic properties of the hydrostratigraphic units (Table 3-15, Lavender Canyon and Table 3-14 Davis Canyon). A consistent framework of travel time estimation takes into account the variability of the hydraulic properties and the correlation of these properties.

The data needs for estimating the travel time are:

(1) Vertical and horizontal hydraulic gradients: Vertical hydraulic gradients can be determined from one well. Horizontal hydraulic

gradients require at least three wells to establish the plane of the potentiometric surface. Figure 3-40 in both the Davis Canyon and Lavender Canyon EA's show potentiometric surface contours in the vicinity of the repository. The problem with these maps is that potentiometric surface data between the repository and the Colorado River is nonexistent. Thus there is no data to substantiate the DOE's travel time analysis along the expected flowpaths.

(2) A hydraulic conductivity-porosity relationships needs to be established from field data to assess travel time variability. Since travel time is a direct function of hydraulic conductivity and porosity, the variability of travel time is related to the variability and covariability of these parameters. Collins (1976) shows with the modified Kozeny equation, hydraulic conductivity is proportional to the cube of the porosity. Thus, a small increase in porosity will give a much larger increase in hydraulic conductivity.

(3) Due to the effect of anisotropy in a fractured porous media, the direction of the hydraulic gradient may not be the same as the flow direction. This factor could affect the delineation of "expected flowpaths" to the biosphere. This aspect needs to be quantified by field studies.

To illustrate the wide variability of calculated travel times, the following analysis was done based on the Darcian flow equation:

$$T = \frac{LP}{JK}$$

where T is the travel time, P is the porosity, J is the hydraulic gradient, and K is the hydraulic conductivity. For the Honaker Trail, Paradox, and Mississippian formations the following data sources were used:

(1) Flowpath lengths and hydraulic gradients were estimated from potentiometric surface maps given in Hanshaw and Hill (1969).

(2) Formation porosity was estimated from the laboratory effective porosity given in ONWI-491.

(3) Formation hydraulic conductivity was estimated from regional data given in ONWI-290, Volume V.

Statistical parameters and calculated travel time are defined on Tables 3-1 and 3-2, respectively. The travel times shown are calculated for 1) the arithmatic mean porosity and geometric mean hydraulic conductivity and 2) for values of these hydraulic parameters plus/minus one standard deviation from their respective means. The results show that the calculated travel times can vary over several orders of magnitude, depending on the choice of the values of the geohydraulic parameters. This analysis also indicates that travel times can be shown to be much less than the 10,000 year requirement simply by picking the geohydraulic parameters one standard deviation away from their respective means.

A "conservative" analysis would pick so called "worst case" parameters for its analysis. It is our opinion that the parameters used in the EA to calculate "worst case" travel times were arbitrarily chosen. As indicated by our simplified statistical analysis, it is likely that "worst case" travel times could be much less than 10,000 years.

The methods and data used in the EA to express variability of velocity and travel time are in our opinion inadequate. Methods such as First-order Uncertainty Analysis (Benjamin and Cornell 1970, pp. 180-186) or derived probability distributions are possible rational approaches to

Table 3-1. Statistics of geohydraulic parameters taken from ONWI-290, Vol. V.

	Length (m)	Gradient	$\bar{Y}$a	SY	$\bar{K}_G$b (m/d)	$K_{\bar{Y}+S_Y}$	$K_{\bar{Y}-S_Y}$	$\bar{P}$	SP	$\bar{P}+S_P$	$\bar{P}-S_P$
Honaker	$21.5(10^3)$	0.018	-5.8	2.4	$3.0(10^{-3})$	$3.3(10^{-2})$	$2.7(10^{-4})$	0.062	0.055	0.117	0.007
Paradox	$21.5(10^3)$	0.013	-6.2	2.0	$2.0(10^{-3})$	$1.5(10^{-2})$	$2.7(10^{-4})$	0.044	0.046	0.090	0.0001c
Mississippian	$21.5(10^3)$	0.005	-5.2	2.1	$5.5(10^{-3})$	$4.5(10^{-2})$	$7.1(10^{-4})$	0.14	0.02	0.16	0.12

a. $\bar{Y} = \frac{\Sigma \ln(Ki)}{n}$

b. $\bar{K}_G = e^{\bar{Y}}$

c. $S_P > \bar{P}$, use 0.0001 in calculations

Table 3-2. Travel time estimate in years.

Formation	$T_{\bar{K},\bar{P}}$	$T_{K+,P+}$	$T_{K-,P-}$	$T_{K+,P-}$	$T_{K-,P+}$
Honaker	72,000	12,000	90,000	70	1,500,000
Paradox	100,000	27,000	1,700	30	1,500,000
Mississipian	300,000	42,000	2,000,000	31,000	2,700,000

preliminary determine travel time variability. However, model sensitivity studies, supported by field data in the impacted area, would be the best ultimate approach.

3.5 Relation Between Modeling Effort and Travel Time

In our opinion the regional modeling effort of Intera (1983, 1984) will not produce the required resolution to estimate contaminant transport from the potential repository sites to the accessible environment. The large scale over which the numerical model averages hydraulic conductivity (order of km's) assures that a low value of hydraulic conductivity will result. In regions of consolidated rocks where permeability and porosity are secondary, most of the flow will likely occur in localized zones of higher conductivity, from dissolution, jointing or fracturing. These zones will be separated by large blocks of extremely low conductivity material. If the spacing of the higher conductivity zones is wide (say 100's of meters) this will assure that block averages for the numerical model will be small. With regard to travel times, the regional numerical model has the same problem. It will provide a small average block velocity and large travel time estimate. However, contaminant releases will move in the high conductivity zones, governed by the local higher velocity. Thus we can expect any estimate of travel time (or velocity) based on regional averages, or estimated from large scale numerical models (by inverse techniques) to overestimate the travel time for contaminant movement on a local scale. Estimating reliable travel times without the benefit of detailed field data is an almost impossible task.

3.6 Consequence of Joints, Fractures, and Faults

Groundwater flow in discrete hydraulic features such as joints, fractures, faults and dissolution conduits is likely an important mechanism of groundwater flow within the deep sedimentary rocks of the Paradox Basin. The drill stem permeability tests from GD-1 support this, indicating a hydraulic conductivity over 2 orders of magnitude greater than the laboratory rock matrix permeability (ONWI-491, Table 4-2). Travel time is thus greatly influenced by the total (matrix and fracture) rock permeability. The presence of these features will impact both site characterization studies and post closure monitoring.

For site characterization, the problem lies in assuring that a proper assessment of the fracture hydraulic characteristics and fracture frequency is made. The regional hydraulic conductivity data given in ONWI-290, Vol. V, show for the Mississippian formation the high value of hydraulic conductivity is 75,000 times greater than the low value, and for the Paradox formation the ratio of high/low hydraulic conductivity is 2,000. Given the low matrix permeability of the consolidated sedimentary rocks that make up these formations, the higher values are likely due to secondary fracture or dissolution permeability. The Davis Canyon EA page 3-131 states that fracturing is a minor influence in Paradox formation permeability. However, the regional and GD-1 permeability data seem to contradict this statement.

For post closure monitoring, the variety of possible flowpaths through the fracture network leads to a high probability that contaminant flowpaths will not be intercepted by a monitoring well. This topic will be addressed in greater detail in section 3.6 of this review.

The final comment here is that overall, the modeling approach taken by INTERA is appropriate for regional water balance assessment of the various aquifers that make up the Paradox Basin. However, in the case of travel time estimation of contaminants, a much finer resolution will be necessary. The EA does not adequately address this fact.

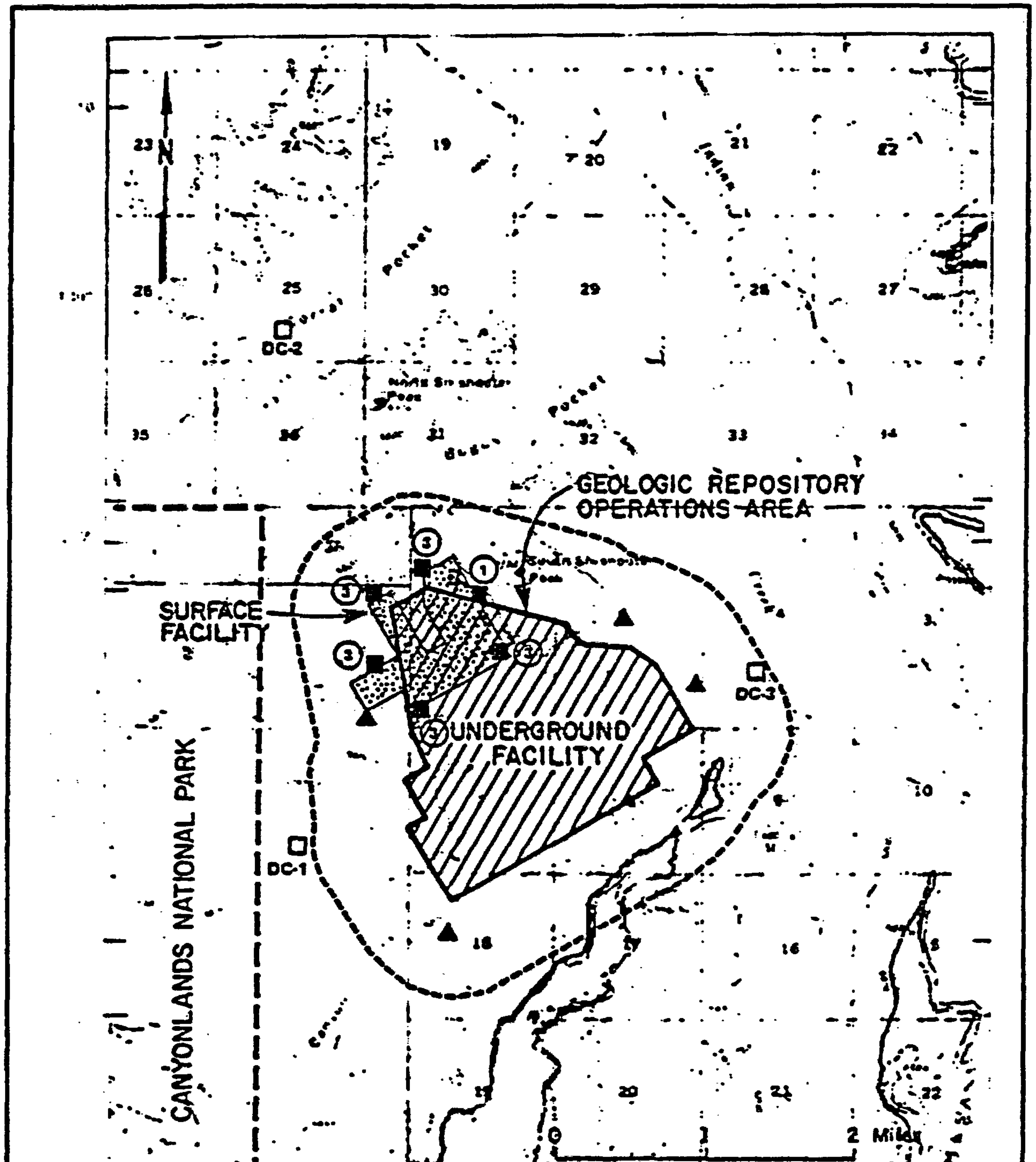
3.7 Post Closure Monitoring

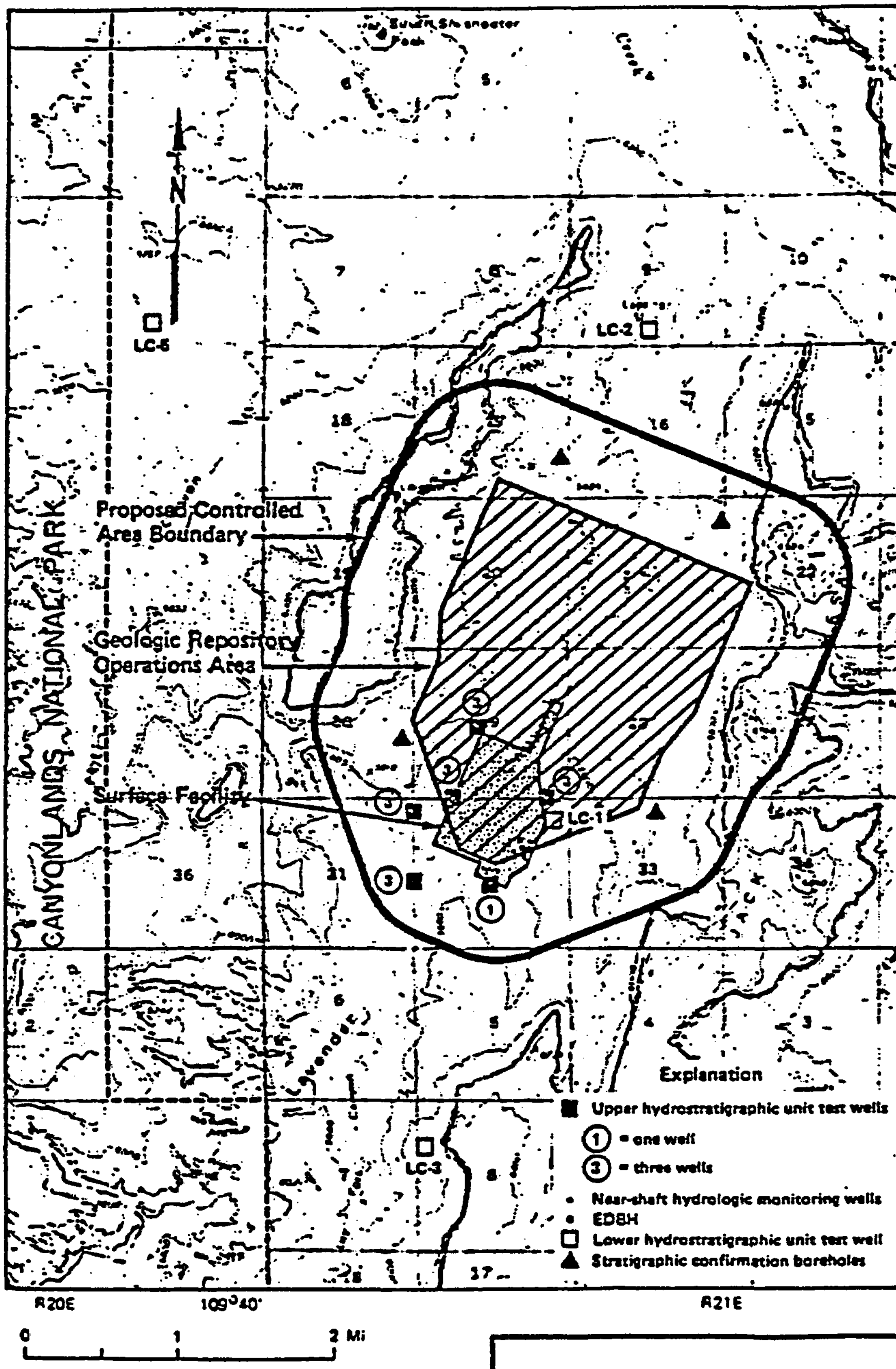
The EA indicates that the site characterization boreholes will also be used as monitoring wells during the post closure period. As was mentioned in the previous section, it seems likely that significant transport will occur within the fracture network of the rocks. The problem lies in assuring that the monitoring wells will intercept this contamination.

Flow is expected to be within a zone encompassed by flowpaths with a northwesterly to southwesterly direction from the proposed repositories. In the upper hydrostratigraphic unit, flow is expected to be more to the northwest and the flowpath is expected to be more to the southwest in the lower hydrostratigraphic unit. Referring to the enclosed figures from the 5th draft of the EA's, the following observations are made:

Lavender Canyon:

A. The lower hydrostratigraphic unit test wells leave wide gaps for contaminant flowpaths to the west and southwest of the repository. The sparcity of observation wells and uncertainty in precise flow directions provides little assurance that contaminant losses to the lower hydrostratigraphic units would ever be observed.


N
DC-2
GEOLOGIC REPOSITORY
OPERATIONS AREA
SURFACE
FACILITY
UNDERGROUND
FACILITY
DC-3
DC-1
CANYONLANDS NATIONAL PARK
0
1
2 Miles



Major Borehole Locations
Lavender Canyon

Figure 4-3

Davis Canyon:

A. Only two observation wells within the lower hydrostratigraphic unit are proposed to the west of the underground facility, which is clearly inadequate given the expected uncertainties in flow direction.

B. Shaft seal leaks or vertical flows into the upper hydrostratigraphic unit would be expected to move to the north or northwest from the repository. The upper hydrostratigraphic unit test wells are clustered more to the south and west of the Engineering Design Borehole. Thus the majority of the proposed monitoring wells are not along expected flowpaths.

4.0 CONCLUSIONS AND RECOMMENDATIONS

In general it is our conclusion that the Environmental Assessments and supporting documents for Davis and Lavender Canyon, given the present data base and knowledge of the hydrogeologic sytem, do not provide satisfactory evidence that 1) groundwater conditions within the three hydrostratigraphic units are favorable for successful isolation of High Level Nuclear Wastes and 2) expected radionuclide travel times are in excess of 10,000 years from the operations area to the accessible environment.

The following recommendations concerning site suitability as a repository, site and post closure monitoring, and contaminant travel time are based on our analysis given in the previous sections.

1. The proximity of the site to the Colorado River and its tributaries has major implications to the downstream water users dependent on the Colorado River for water supply. Contaminant leakage along undetected fracture networks, or the possibility of transportation spills, may render useless the sole water supply of major agricultural development and municipal users downstream. The human health and economic risks associated with placing a high level nuclear waste facility within the drainage of an important river system should be addressed in the guidelines and evaluated in EA's.
2. Inadequate data in the region of expected contaminant flowpaths to the biosphere introduces extreme levels of uncertainty in calculated travel times. The only way to reduce this uncertainty and develop confidence in the accuracy of calculated

travel times is to gather additional hydrogeological and geophysical data along expected flowlines. However presently, the data base is not adequate even to determine the location of "expected flow paths."

3. Incorporation into the DOE guidelines and the Environmental Assessment of the potential impact on system performance by discrete hydraulic features (joints, faults, fractures and dissolution conduits).
4. Incorporation of the problem of spatial variability of hydraulic properties as one component of the uncertainty in travel time calculations. Even in the presence of an "adequate" data base, the effect of spatial variations of hydraulic properties on contaminant transport will be a critical factor to site performance. This is not addressed in the E.A.'s.
5. Implementing in the guidelines and the environmental assessment the use of groundwater modeling as a screening tool rather than predictive tool. Model results should not be substituted for "hard data" in regions where inadequate data would make verification impossible.

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APPENDIX C

APPENDIX C

REVIEW OF THE
DRAFT ENVIRONMENTAL ASSESSMENT
DOCUMENTS
LAVENDER AND DAVIS CANYON SITES,
SAN JUAN COUNTY, UTAH

PREPARED FOR
STATE OF UTAH
HIGH LEVEL NUCLEAR WASTE OFFICE
BY

JON ZEISLOFT
CONSULTING GEOLOGIST

MARCH 14, 1985

TABLE OF CONTENTS

FIGURES

TABLES

PLATES
(in envelope)

I INTRODUCTION

This report is an appraisal of the Draft Environmental Assessments (DEA's) of Lavender and Davis Canyon Sites, in San Juan County, (DOE, 1984 a & b) Utah. It is an updating of my previous report (Zeisloft, 1984) which served as an appraisal of the fourth and fifth draft Working Papers of the Statutory Environmental Assessments. The subject DEA's were prepared by the U.S. Department of Energy (DOE) as part of the process of evaluating the suitability of sites for the development of high level nuclear waste repositories, per the Nuclear Waste Policy Act of 1982. The specific portions of the DEA's which I reviewed are these parts of Chapters 3 and 6 which fall within my areas of expertise (In a general way those areas are surface and subsurface stratigraphy and structure, as well as the occurrences of natural resources). Those DEA sections evaluated are 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.8; 6.2.1.3, 6.3.1.1, 6.3.1.3, 6.3.1.4, 6.3.1.5, 6.3.1.6, 6.3.1.7, 6.3.1.8 and 6.3.3.2.

The work has been done for the State of Utah, High Level Nuclear Waste Project Office. The objective has been to provide the state with a technical geologic basis on which to judge the EA's prepared by the DOE as well as a review of the DEA's based on my experience in the Paradox Basin. The project is located in the western portion of the Paradox Basin (Figure 1).

Following a discussion of the findings of my geologic work in the course of this study, I will review the DEA's relative to my findings and past experience. To close, my conclusions will be given.

II GEOLOGY

A. Surface Geology -

Introduction -

A moderately detailed (1 inch = 2000 feet) surface evaluation of the Lavender and Davis Canyon proposed repository sites was considered essential to the DEA evaluation. This was especially so since the conclusions on which the DEA's were based apparently were arrived at from the basis of regional geology, seismic studies (not available to the State of Utah), and remote sensing studies. This present study benefitted greatly by superb color air photos graciously loaned by the Monticello, Utah, office of the U.S. Bureau of Land Management (BLM). Those air photos (at a scale of approximately 1.8

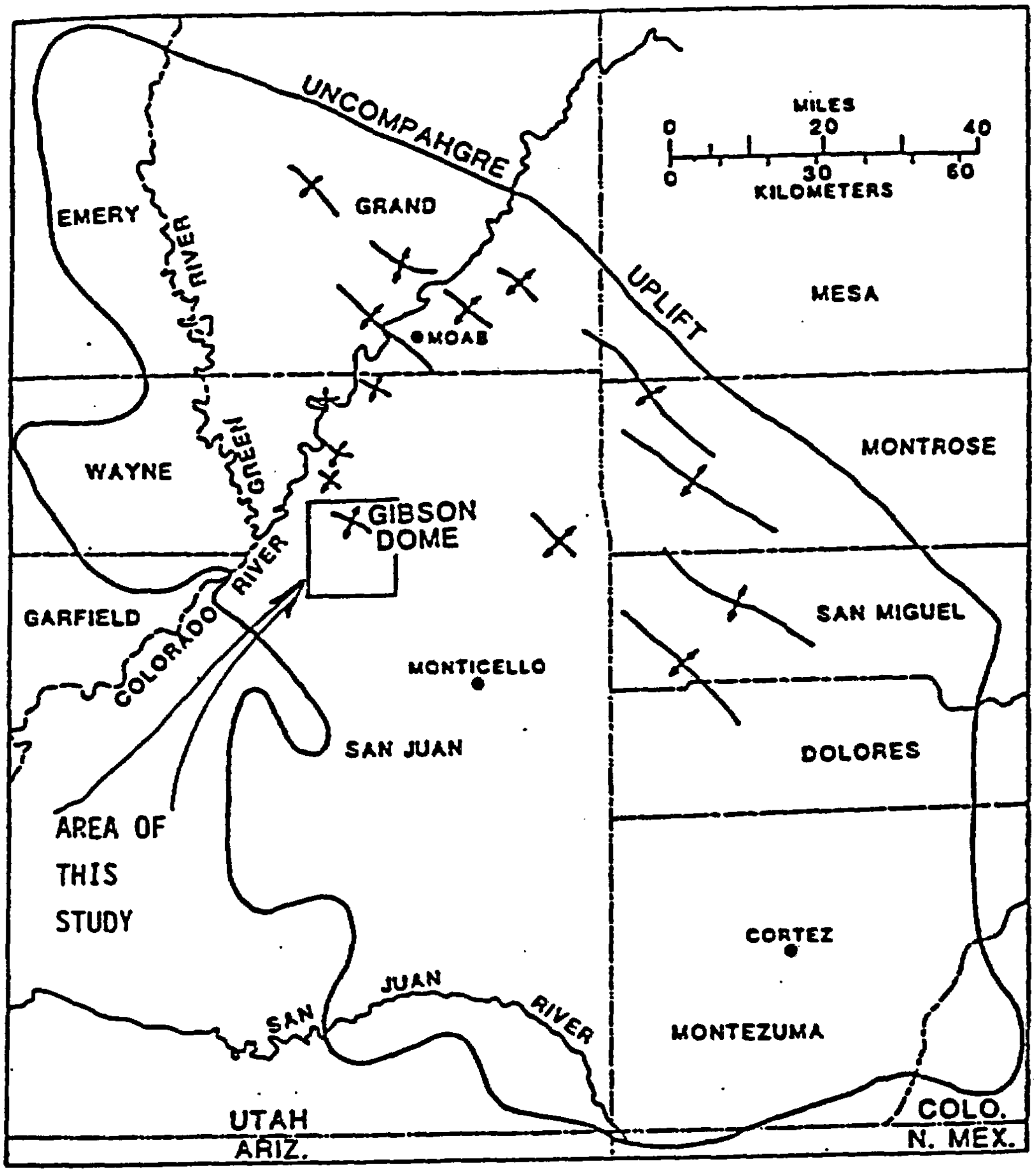


Figure 1. Index map of the Paradox Basin showing salt anticlines and limits of halite and potash in the Paradox Member of the Hermosa Formation. Modified from Hite, 1982.

inches = 1 mile) provided the basis for mapping formational contacts and structural features, via a magnifying stereoviewer and film overlays. Areas of approximately 11 square miles and 9 square miles were mapped at Davis and Lavender Canyons respectively. The geologic mapping data are presented as Plate 1.

Stratigraphy -

The stratigraphy of the area (Figure 2) has been amply described in the professional literature and will not be repeated in detail here. Very simply, bedrock strata exposed in the areas of detailed study ranged from the Cedar Mesa Formation of the Permian Cutler Group to the Triassic Kayenta Formation. The Cedar Mesa was exposed in the southern and/or western portions of the areas mapped, where erosion has exposed older rocks. The Organ Rock Formation is present over wide areas of the lower slopes of both areas, although widely masked by a thin veneer of colluvial and wind blown material (the mapping of which was not relevant to this evaluation). The Triassic Moenkopi Formation forms the narrow, upper slopes bordering all of the canyons. It is somewhat more resistant to erosion than the Cutler units beneath. Unconformably overlying the Moenkopi is the Moss Back member of the Triassic Chinle Formation. The Moss Back forms the prominent benches throughout the mapped areas; examples are the flat-topped features from which the North and South Six Shooter Peaks arise. Above the Chinle is the Triassic Wingate Formation which forms the spectacular vertical cliffs of the narrow ridges separating the canyons, as well as the Six Shooter Peaks themselves. The youngest unit present, excluding the Quaternary Alluvium, is the Triassic Kayenta Formation which is the resistant protection for the underlying Wingate. Quaternary age alluvium is present in the drainage bottoms. These distinctive stratigraphic units in an arid environment provide well exposed formational contacts.

Structural Geology -

The structural simplicity of the area (1-4° dips to the east and northeast) belies the stresses which the area must have undergone. All of the stratigraphic section is extensively jointed, although the jointing is more visible in the more competent units. The jointing readings shown on Plate 1 are each representative of several joint measurements taken over broad areas. It should be emphasized that the joints on Plate 1 do not depict even

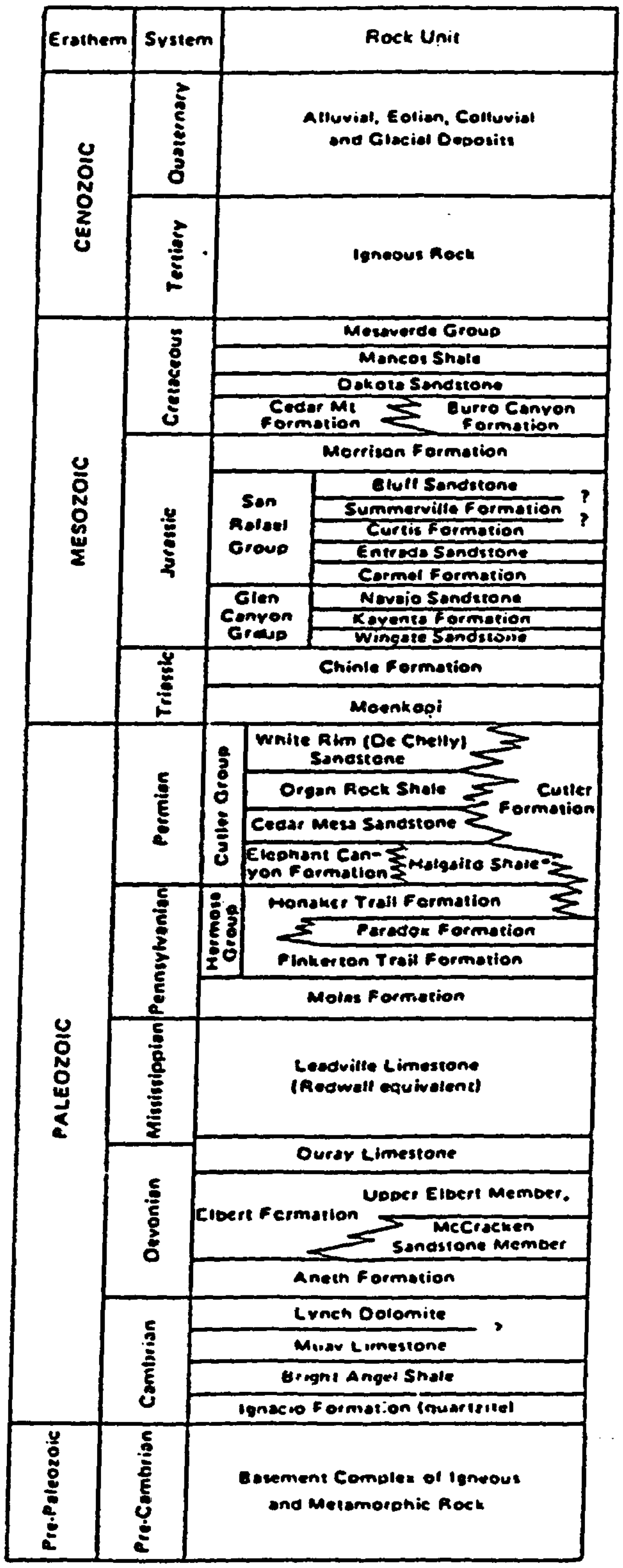


Figure 2. Stratigraphic column.

Modified from Woodward-Clyde Consultants, 1982.

joint set to the northwest. It is important to note that the jointing is prominent in outcrops immediately adjacent to, and within, the proposed repository surface facilities. Such jointing is well developed throughout the region, including areas of recharge, up-dip at higher elevations which typically receive more precipitation.

Photographs of typical jointing were obtained in the course of the field study. The field locations of the photographs are shown on Figure 3. Figures 4 through 7 depict the jointing. Figures 4-A and 5-A illustrate the serrate edges of the more resistant cliffs in the Davis Canyon area caused by jointing. In addition, the upper-left quadrant of Figure 4-A shows the pervasive nature of the jointing, and that the jointing does not occur only along the erosional edges of cliffs. Figure 4-B is a close-up of jointing in 4-A. The same joint-controlled, cliff-edge erosion occurs in the Lavender Canyon area as shown by Figure 6-A. An example of jointing further down in the section is shown by Figure 6-B. The existence of prominent joint sets elsewhere in the region is documented by Figure 7 which depicts joints to the southwest of the Davis Canyon site and east of the Lavender Canyon site.

The dominant northeast direction of joints measured in the project area is no coincidence. The primary structural grain over a large portion of the Candidate Area is northeasterly. The Colorado lineament, is a northeast trending fault zone through this portion of the Colorado Plateau which dates back to the Precambrian (Warner, 1978). Many regional structures can be related to crustal weakness resulting from the Colorado lineament, including the remarkably linear trend of the Colorado River just west and northwest of the study area, the left-lateral off-sets of the salt anticlines to the east (Hite, 1975), and Lockhart Fault bounding the northwest side of the Lockhart Basin dissolution collapse feature. The relationship of jointing to the circulation of water and subsequent erosion, on a regional basis, is evident in the distribution of drainages in and around the area (Plates 2-5) including Lavender and Davis Canyons. For examples, I call on the drainages on either side of Harts Draw and Indian Creek. The concept of canyon systems being determined by the arrangement of joints is well established in classical geomorphology (Lobeck, 1939 - especially pages 29 and 487); Lohman (1974) also discussed the erosional effect of jointing (pp. 63 and 79). Alternatively, Stokes (1964) makes a strong case for northeast-trending, wind-aligned incised stream patterns on the Colorado Plateau. This is a well documented and valid concept. In the study area perhaps both wind-aligned streams and jointing

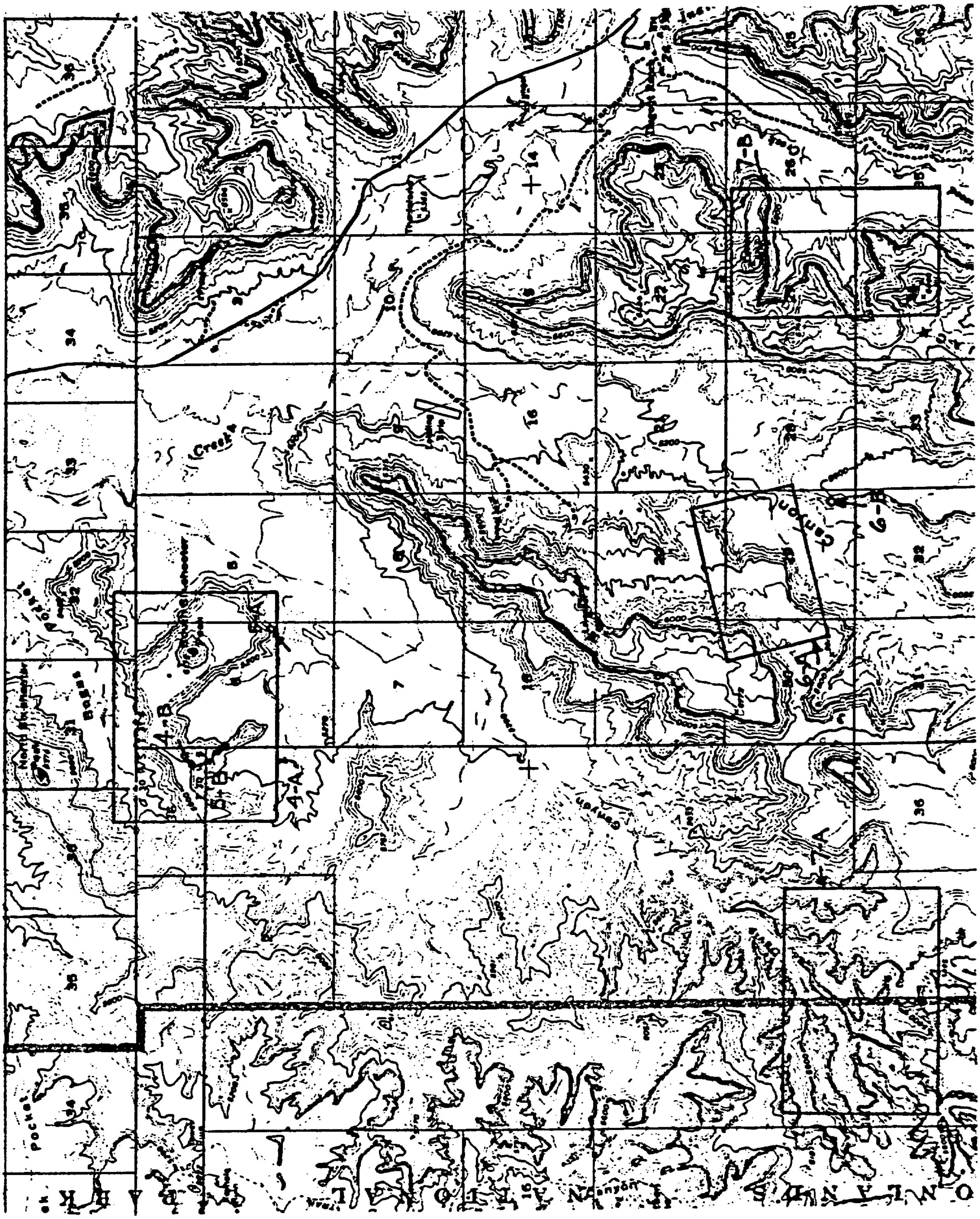
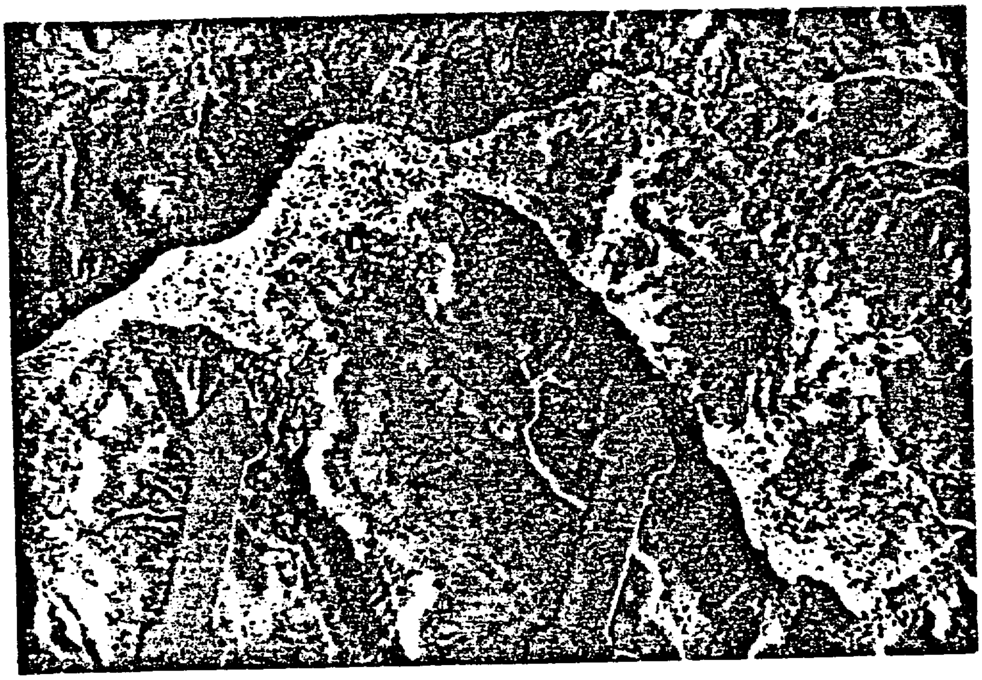
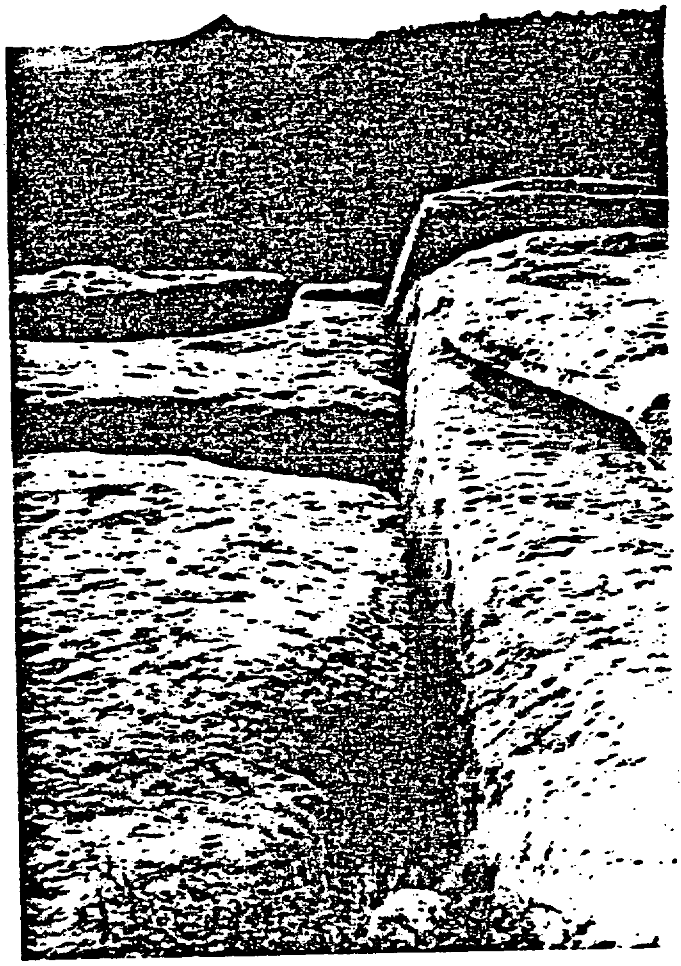


Figure 3. Photograph Location Map.



A. Enlarged portion of air photo used in surface mapping. Joints evident throughout South Six Shooter platform. Note especially recti-linear joint pattern in upper left quadrant of picture, and along the cliff edge (blue arrow).



B. Close up of jointing at cliff edge just beyond point of left arrow in photo A, above.

Figure 4. Davis Canyon jointing.

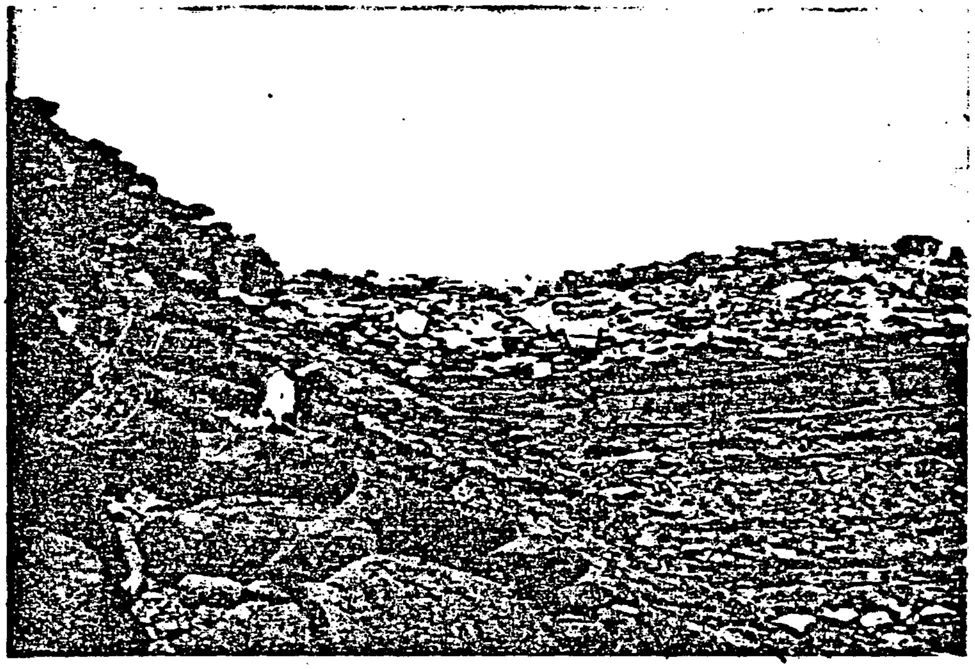


Figure 5. Davis Canyon jointing.

A. Prominent Moss Back jointing on skyline, on south end of South Six Shooter platform. Jointing is also evident in Moenkopi (mid-picture); and in the Organ Rock in foreground, although much rounded by erosion.

B. Prominent Moenkopi jointing on narrow ridge one mile west of South Six Shooter Peak.

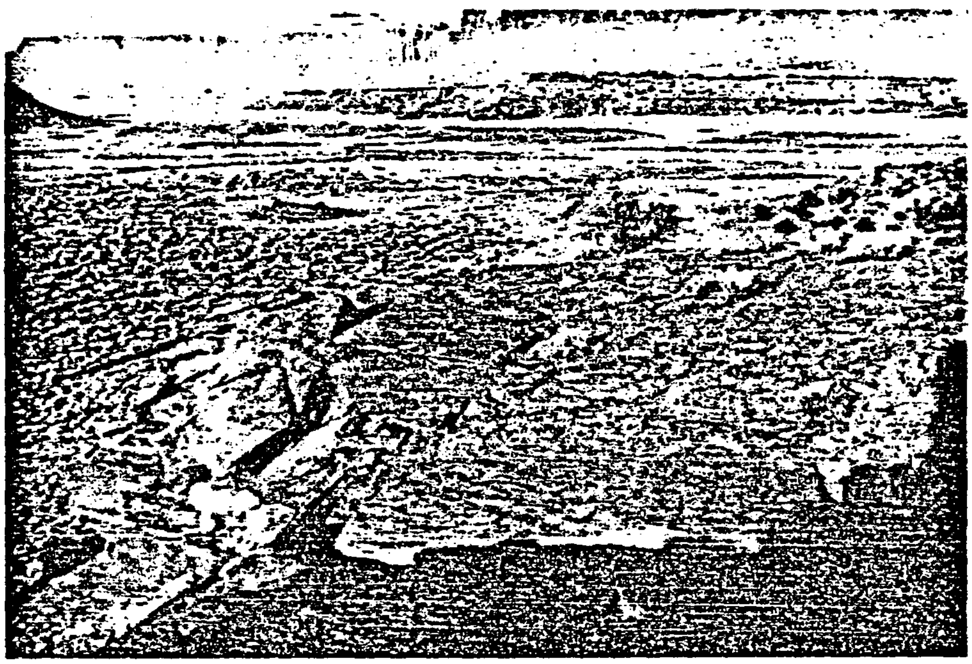
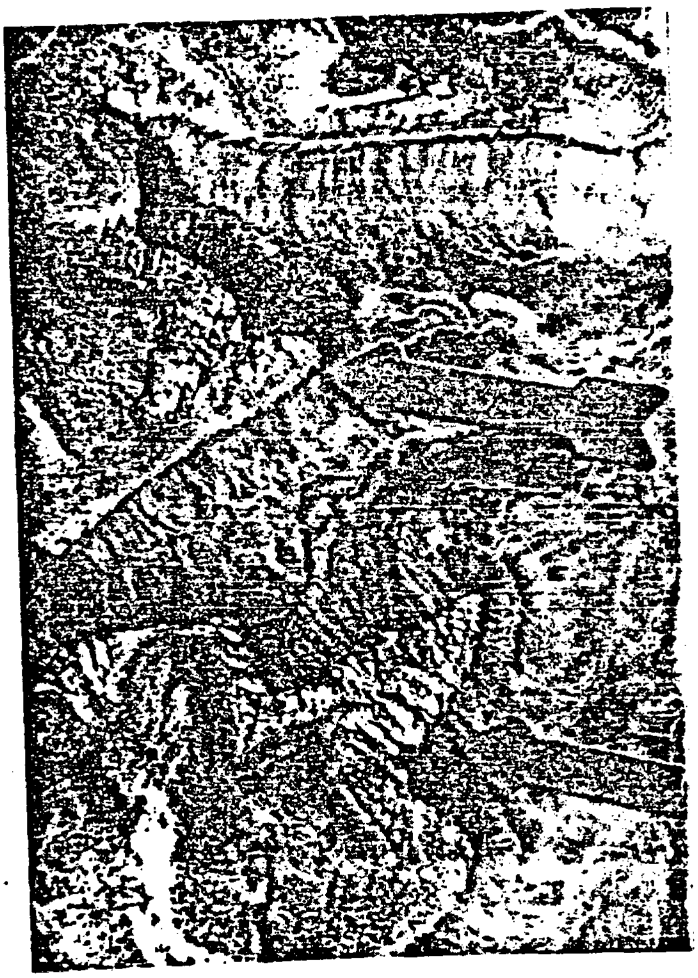


Figure 6. Lavender Canyon Jointing.

A. Enlarged portion of air photo used in surface mapping. Serrate edge of Moss Back cliff gives evidence of extensive jointing.

B. Rectangular joint-bounded blocks in upper-most Organ Rock along east side of proposed Lavender Canyon Site.



A. Cedar Mesa sandstone landforms which are controlled by jointing occur in the upper stretches of Davis Canyon.

B. Wingate sandstone erosion controlled by jointing in Cottonwood Canyon, 2 miles due east of the Proposed Lavender Canyon Site.

Figure 7. Nearby, regional examples of joint-controlled erosion. (Both enlarged from air photos used in surface mapping.)

have been responsible for developing the present prominent, northeast-oriented drainage pattern. With the dominant northeast joint direction, it is probable that both processes contributed to the resulting drainage pattern.

There are no surface faults mapped within the areas I studied (Plate 1) according to Detterman (1955), Hackman (1955) and Huntoon, and others (1982). During the course of my field studies, I recognized no faulting. I did, however, find two rocks, each 6-8 inches across, which suggest faulting.

The first was a nearly white, banded rock of all crystalline calcite. Such a lithology is typically deposited from solution in an open space, resulting in a vein filling. The second piece is also composed largely of coarsly crystalline calcite, with the addition of numerous angular chips of reddish brown chalcedony. The arrangement of the calcite and chalcedony strongly suggests recurrent movement (i.e., brecciation) during the formation of the rock. This rock also suggests that it originated as an open-space filling. Both rocks were found in Bogus Pocket (Plate 1), but neither was found in place.

Following my return from the field it became evident that sub-surface structural maps of McCleary (1983) show a northeast-trending fault coincident with North Six Shooter Peak in the Pinkerton Trail and older formations; that fault also appears on the isopach map of the Paradox Formation. Is it possible that the erosion of the northeast-trending Bogus Pocket is fault controlled? I believe that the surface expression of such a fault can be found by intensive field examination.

Surface observations give no evidence of salt dissolution in Lavender or Davis Canyon sites. Such evidence might include the collapse of a central area with faulting, or inward dipping of the surrounding strata, breccia pipes or bleaching of a broad area of generally reddish brown slopes and cliffs. By contrast, the dip of beds and their continuity was very uniform.

There was no evidence of land slide or slump activity in this arid area.

B. Subsurface Geology -

Introduction -

The character of the subsurface geological setting was established by traditional structural and isopach map methods based on geophysical logs of oil and gas exploration tests. A significant contribution to the project came from the files of the State of Utah, Oil, Gas and Mining Division. Those files provided copies of well logs (Table 1), the locations and elevations of the wells, drill stem test (DST) data, comments on hydrocarbon shows and well histories. To suppliment that data base the files of the Utah Geological and Mineralogical Survey provided a limited amount of additional information on DST's and hydrocarbon shows.

It must be noted here that the following subsurface maps were prepared from geophysical logs from only 17 oil and gas tests. By contrast, the Department of Energy's contractors had available the logs plus substantial additional data. Those data included seismic reflection surveys (copies of which the DOE claims they cannot provide to the State of Utah -- Memo: Zeisloft to Kefer, 12-05-84), structural maps prepared by Petroleum Information (experts in the area) and photogeologic interpretations. This study was severly hampered by not having access to that seismic information and to a lesser extent the other data. As a result Plates 2 through 5 must be considered interim interpretations which are reasonable based on the available data. They should be refined if and when Utah can acquire copies of DOE's seismic data and interpretations. As this report was being finalized, I received a draft copy of the geophysical interpretations (Kitcho, and others, 1984). Although it has been interesting to review those geophysical data, there are still short-comings. Specifically, the Kitcho (and others) report provides merely interpretations! For the State of Utah to evaluate the adequacy of the study, the raw data must be made available to enable a State geophysicist to review the quality of the data and the resulting interpretations.

Stratigraphy -

Of the formations present, the geometry of the total Paradox salt section and of salt cycle 6 were of primary importance. Plate 2 provides an isopach map of the total Paradox salt section. By my definition, that interval is the total thickness from the top of the uppermost salt cycle to the bottom of the lowest salt cycle. Since the study area is near the depositional edge of the saline basin the first salt encountered in drill holes varies across the area from salt cycle 2 to cycle 5 (Hite, 1960). Plate 2 clearly shows the excessively thick salt section which resulted in Gibson Dome. Salt cycle 6 individually exhibits an area of excessive thickness (Plate 3), but to a lesser degree than does the total Paradox salt interval shown on Plate 2. The linear zone of anomalously thick salt which constituted Gibson Dome (Plate 2)

TABLE 1... -- WELL CONTROL

(those wells which provided geophysical logs for stratigraphic correlation)

1.	Flying Diamond	Lockhart Gov't. #1-3	2100' FNL/ 509' FWL	Sect.3-29S-20E
2.	Humble/Carter	Rustler Dome #1	2000' FSL/ 820' FWL	4-29S-20E
3.	G.E. Kadane & Sons	Rustler Dome #1	330' FNL/ 330' FWL	15-29S-20E
4.	Damson Oil	Rector Fed. #1	2060' FSL/ 330' FWL	5-29S-21E
5.	Husky Oil	Husky Fed. #6-15	2439' FNL/2344' FWL	15-29S-21E
6.	Union/Pure	Horsehead Unit #1	1980' FSL/ 660' FWL	18-29S-21E
7.	Reynolds Mining Corp.	Gibson Dome #1	1670' FNL/ 275' FEL	35-29 1/2 S-20E
8.	Belco Petroleum	Gibson Dome - State #1	2310' FNL/2471' FEL	2-30S-20E
9.	Union/Pure	Lost Canyon - USA #1	730' FSL/1910' FEL	19-30S-20E
10.	Pan Am. Petrol./Trident	Beef Basin #5	1125' FNL/2005' FWL	32-30S-20E
11.	Woodward-Clyde	Gibson Dome #1	660' FEL/ 660' FSL	21-30S-21E
12.	Pan Am. Petroleum	Beef Basin #1	2425' FSL/1800' FWL	7-31S-20E
13.	Gulf Oil	Hart Point-Fed. #1	1980' FNL/1980' FWL	8-31S-22E
14.	Chorney Oil	Hart Point-Fed. #1	368' FWL/2203' FSL	22-31S-22E
15.	Champlin Petroleum	Dugout Ranch-Fed. #14-22	660' FSL/ 559' FWL	22-31S-22E
16.	Champlin Petroleum	Dugout Ranch #21-2	481' FNL/1994' FWL	2-32S-21E
17.	Placid Oil Co.	USA #DU-2	2041' FWL/1717' FSL	5-33S-21E

control close to Davis or Lavender Canyons it is reasonable to predict that Salt cycle 6 at those two proposed repository sites would be thinner (less than 200 feet thick) than was encountered in the DOE exploratory well GD-1 at Gibson Dome.

Structural Geology -

The structural configuration of the Candidate Area could be demonstrated by making a corrected-elevation contour map of any stratigraphic marker relative to sea level. The structure of that reliably identifiable horizon nearest to Salt cycle 6, and penetrated by the greatest number of drill holes would have the most value. To satisfy those requirements I chose the top of the Paradox Formation since it was penetrated in all wells used in this study (many oil and gas tests drilled only to the top of the salt). Plate 4 shows that the Paradox Formation structural configuration dips gently to the northeast closely following the trend of the Monument Upwarp. Anomalies on that surface are the Gibson and Rustler Domes. The strike of the structural contours at the Paradox Formation level closely parallel the depositional strike of the Paradox Basin and the strike of outcropping younger formations. The structural configuration on top of the Salt cycle 6 (Plate 5) is predictably similar to that of the top of the Paradox Formation.

C. Petroleum Exploration Data -

Information derived from drillholes of the petroleum exploration industry reveals that 56 drill stem tests (DST's) were run in 14 of the 17 wells used in this study (see Table 2). The majority of those DST's were positioned to test porosity in the Leadville limestone, which typically produced moderate quantities of salt water with minor gas shows indicative of moderately developed porosity. Ismay and Desert Creek DST's likewise produced water, but in much smaller quantities; a slight gas show from the Ismay was tested only in the Chorney, Hart Point well. Drill stem tests within the Paradox salt section generally produced small quantities of drilling mud. An exception to that, however, was in the Reynolds Mining, Gibson Dome #1 well where a test of the interbed between Salt cycles 13 and 14 produced 100 ft. of free oil plus 480 additional feet of hydrocarbon-bearing fluid. Subsequent production

TABLE 2 -- DRILL STEM TEST SUMMARY

WELL	FORMATION	DST (or other)	RECOVERY
Flying Diamond Lockhart Gov't. #1-3	mid-Leadville	4603 - 4665	3415' salt water
Humble/Carter Rustler Dome #1	top of Leadville	4193 - 4340	240' water cut mud
	upper Leadville	4200 - 4300	230' water cut mud
	mid Leadville	4334 - 4344	3730' black sulfer water
	Elbert	4905 - 5076	200' water cut mud
Kadane & Sons Rustler Dome #1	upper Leadville	4968 - 5013	1426' salt water; 2054' sulfer water
Husky Husky Fed. #1	salt cycles 2 and 3	4500 - 4687	90' drilling mud
	upper Leadville	7490 - 7675	453' gas cut mud; 420' slightly mud cut water
	mid Leadville	7667 - 7765	180' drilling mud 60' slightly gas and water cut mud
	mid Leadville	7775 - 7868	372' water cut mud 2271' very slightly gas cut water
	Elbert and McCracken	8214 - 8420	1083' water cut mud with a trace of gas
Union/Pure Horsehead Unit #1	Molas	6359 - 6420	30' drilling mud
	upper Leadville	6420 - 6540	60' drilling mud and 4000' black salt water
	Elbert and McCracken	7131 - 7256	95' drilling mud
Reynolds Gibson Dome #1	interbed between salt 13 & 14	3487 - 3525	Production tested through perforations 47.4 barrels of oil
	interbed between salt 13 & 14	3481 - 3537	130' gas cut mud 350' highly oil cut mud, 100' free oil (gassy)
	upper salt 14	3527 - 3534	20' drilling mud
	mid salt 18	4165 - 4226	35' drilling mud
	Pinkerton Trail	5089 - 5097	3' drilling mud
	lower Leadville	5955 - 5974	190' water
Woodward, Clyde Gibson Dome #1	unknown	17 successful DST's run	not reported
Belco Gibson Dome - State #1	Cane Creek zone (clastic interval beneath salt 21)	4903 - 4955	5' drilling mud
Union Lost Canyon - USA #1	interbed between salt 19 & 20	3742 - 3807	15' drilling mud
	Pinkerton Trail	4103 - 4173	10' drilling mud
	upper Leadville	4428 - 4528	1120' salty sulfer water
	Elbert	5070 - 5215	20' drilling mud
Pan Am/Trident Beef Basin #5		reported "no shows"	
Pan Am/Trident Beef Basin #1		reported "no commercial shows"	
Gulf Hart Point - Fed. #1	upper Ismay	4409 - 4503	30' drilling mud
	lower Ismay	4584 - 4666	30' drilling mud
	Interbed between salt 13 & 14	5731 - 5762	315' highly gas cut mud
	Pinkerton Trail	7150 - 7261	50' drilling mud
	Pinkerton Trail	7147 - 7261	40' drilling mud
	Pinkerton Trail and Molas	7186 - 7301	25' drilling mud
	upper Leadville	7495 - 7568	720' highly gas & water cut drill. mud
	mid Leadville	7608 - 7628	400' muddy salt water
Chorney Hart Point - Fed #1	upper Ismay	4270 - 4375	310' very slightly gas cut drill. mud
	lower Leadville	7458 - 7564	2250' brackish sour water
	lower Leadville	7480 - 7564	2200' salt water
Champlin Dugout Ranch - Fed. #14-22	upper Ismay	4342 - 4404	180' water cut drilling mud 253' water
Champlin Dugout Ranch - Fed. #21-2	upper and lower Ismay	2998 - 3134	556' water
Placid USA #DU-2	Ismay and Desert Creek	2389 - 2703	2703' sulfer water

testing of that interval, through perforated casing, produced 47.4 barrels of oil.

Although there is no commercial production of oil or gas in, or near, the Candidate Area, the number of DST's in the immediate area suggests that numerous oil and gas shows were encountered during drilling. The wide distribution of hydrocarbons in the Paradox Formation has been noted by Hite and Lohman (1973) who state:

> "Oil and petroleum gases, primarily methane, are found in the Paradox Member [Formation] by almost every well drilled in the Paradox basin."

Possibly the most significant bit of information to come out of the petroleum exploration records is from the Placid Oil, USA #DU-2. That drill-hole reported porosity in the form of cavernous limestone in the upper Leadville Formation. That anomalous porosity may be an example of the karst surface discussed under regional stratigraphy, above. An alternate interpretation of the Leadville porosity in the Placid Oil test, (located on the north boundary of the Shay Graben) calls on the dissolution of the carbonate material by solutions passing through the graben boundary fractures. In either case, such cavernous porosity, up the hydraulic gradient from the Candidate Area, must be viewed with concern as it may reflect a path and/or mechanism for getting ground water into the Paradox evaporite section.

Limonitic alteration seen on the surface exposures of the faulted blocks in the eastern extent of the Shay Graben further suggests anomalous fluid flow. The limonite is interpreted to be the result of recent oxygenated groundwater reacting with pyrite which had been deposited earlier in the fault-generated fracture porosity. Since much of the water tested from the Mississippian is sulferous, the present limonite may have once been pyrite generated by Mississippian fluids leaking via the graben system. The implication is that Mississippian water could have access to the Paradox salts via graben faulting, up-dip of the Lavender and Davis Canyon sites.

D. Salt Tectonics -

The Paradox Formation in the Paradox Basin is possibly best known as a result of the spectacular salt anticlines to the east of the Candidate Area.

salt flowage, and in many cases diapirism and dissolution. The salt moved episodically from late Pennsylvanian time at least through the Jurassic, in the more prominent anticlines. In some small areas such as at Onion Creek in Fischer Valley (Colman, 1983) and on the Meander Anticline on the Colorado River the evaporities are still moving.

In the area of this study the nearest salt anticline is Gibson Dome (Figure 1). It is only a slight swelling of the salt with no diapirism. In the immediate areas of Lavender and Davis Canyons there appears to be no surface evidence of salt flowage, diapirism or collapse.

E. Discussion of fracture porosity and permeability -

The significance of water circulating in fractured (jointed) rocks is a key issue to geologic characterization of the proposed repository sites. Fracture porosity as defined by the American Geological Institute (1957) is the "porosity resulting from the presence of openings produced by the breaking or shattering of an otherwise less pervious rock". The cause of rock fractures have been largely attributed to shear or tension forces acting on a given region. An alternative theory is that joints are caused by material fatique and ensuing failure resulting from cyclic earth tides. Hodgson (1961) gives a good accounting of these three theories and concludes that no one theory can account for all jointing. Blanchet (1957), although disavowing any attempt at theoretical rock mecanics, feels that joints can be attributed to material fatigue of small stresses throughout millions of years (rhythmic stress occurs 4 half-cycles per day, 1460 times per year, 1 ½ billion times per million years) by earth tides. Past work on fluid flow in fractures has been done in many fields, including petroleum geology, engineering geology, hydrothermal systems involving metals mineralization and geothermal resources, hydrodynamics and pure research. From these varied studies, we can extract a basic understanding of the importance of fracture porosity and of the degree to which fractures contribute to ground water movement.

Drummond (1964), Daniel (1954), Murray (1968), Stearns and Friedman (1972) and Wilkinson (1953) among many others, give descriptive discussions of fractured petroleum reservoirs. Harris, and others (1960), and Hodgson (1961) provide discussions of fractured sedimentary rocks on a regional scale. The role of dilatancy in the generation of fractures and the movement of fluids is discussed by Mead (1925). Laboratory and theoretical treatments of fluid flow in fractured rocks are provided by Jones (1975), Nelson and Handin (1977) and by Norton and Knapp (1977). Important studies relating the frequency and apertures in joints are those by Snow (1968 and 1970).

The fact that a substantial volume of petroleum is produced from fracture reservoirs demonstrates that fractures are open and retain significant permeability at great depths. Stearns and Friedman (1972) contend that "since most rocks are fractured in the subsurface, fractures influence the productivity of nearly all reservoirs". Daniel (1954) compares three fracture reservoirs in Iraq and Qatar. The highly productive Ain Zalah field produces from joints in an extremely tight limestone of little porosity and practically no permeability. Evidents strongly suggests (Drummond, 1964) that production in the upper pay zone; which is tight, is derived via fractures from a 2000 ft. deeper pay zone. The oil does not originate in the water-wet upper pay zone. During production, of wells penetrating only the upper pay zone, flowing of any one well quickly influences the pressure in nearby wells indicating efficient interconnection by fractures.

In the Dukhan field, relatively normal limestones produce from pore space averaging 16% in the upper and 21% in the lower units. While this porosity provides a good reservoir, permeability varies from nil to 4 darcys (averaging 15 - 30 md in the upper and 40 - 75 md in the lower unit). Productivity is undoubtly enhanced by joint permeability (Daniel, 1954, p. 813) where joints are open to an average width a little greater than average pore diameter. Due to the gentleness of the structure, joints at Dukhan play only a minor role.

In the Spraberry formation of West Texas (Wilkinson, 1953), jointing is common in cores of the reservoir rock. That reservoir exhibits average proosity of 8% and an average permeability of only 0.5 millidarcy. Thus the joints are interpreted to serve as "feeder lines" conducting oil to the well bore; commercial wells are not present where fracture permeability is absent.

The importance of joints to certain sites of petroleum production is evident from oil fields developed in basement igneous and metamorphic rocks (Landes, and others 1960; and McNaughton, 1953) from which production would be impossible were it not for permeable fractures.

The location and frequency of joints of often asked with regard to petroleum exploration. From the literature of that industry come the following important observations. Drummond (1964) identifies "tectonic fracture porosity" as that developed by the release of stress due to folding, and "cryptic fracture porosity" as that developed in the absence of folding of the rock section. Both types of porosity are present where the joints are open under tension. This is an important consideration since the Gibson Dome area seems to be under tension as evidenced by The Grabens, to the immediate west.

Drummond further states that, all other factors being equal, a thin bed will develop more joints than will a thick bed. During my field work in the area I observed that thinner units were clearly more jointed than were the thicker unit. Harris, and others (1960) in a very analytical study of surface fractures found that "the concentration of deformational fractures was in approximate inverse proportion to the thickness ...".

A third point of Drummond is that since joint development involves highly localized stress release in individual beds, the relative strength of the individual bed is the key factor to joint development within it (assuming all other things are equal). Stated another way, joint development of a given bed is in relation to the competency of that bed relative to the competency of the beds above and below it. Harris and others (1960, p. 1860), through field observations, came to the same conclusion. Drummond (1964) presents an example from the Middle East. There, in the Naft Khaneh/Naft-i-shah field, the Kalhur Limestone is quite thin, but does represent a reservoir with good fracture permeability. In this field the thin carbonate is overlain and underlain by anhydrite, clearly of lower competence than the intervening limestone.

This relative competency factor of joint development can be directly related to the nuclear waste isolation in Paradox salt 6. Since salt is characterized by extremely low permeability it has been felt by everyone that for ground water to have access to the buried waste in salt 6, it would have to do so via the carbonate and clastic interbeds. The interbeds above and below salt 6, each bounded by a thick incompetent salt unit, are perfectly analogous to Drummond's Kalhur Limestone bounded by anhydrite beds. Thus, based on relative thickness and relative competency the interbeds above and below salt 6 are very likely to be fractured. Presuming that pressure and hydrologic gradient anomalies develop as a result of repository activities, the fractured interbeds would provide access of groundwater to salt 6 and the contained radioactive waste.

Fracture permeability in igneous and metamorphic rocks has been studied

(Norton and Knapp, 1977) relative to mass transport in hydrothermal systems. There mineral distributions are related to fluid flow along fractures and by aqueous diffusion away from fractures. Permeability in fractured crystalline rock is treated by Brace (1980) where numerous in situ and laboratory values are compared. His study is exceptional in that it is based on a large number of pump tests of real rock situations. Although slanted toward crystalline rocks, some important conclusions were developed by Brace, many of which probably also characterize carbonate and evaporite rocks. These are:

1. At a particular site, permeability varies by over 4 orders of magnitude within a given depth interval;

2. Below 500 ft in depth there was no systematic variation of permeability with depth; and

3. At nearly every site some portion of the rock has a permeability of 1-100 md. In various wells this relatively permeable zone was present down to 9900 ft..

Brace's work identified major differences between laboratory and in situ permeability measurements. These differences are explained by joints in a rock mass not usually sampled for laboratory measurement, but whose flow paths are many times more significant than those of a smaller laboratory sample. The importance of this finding is that the size and extent of a sample (a core versus several cubic miles) must be known to properly interpret a measurement of permeability. Brace's finding that permeability does not decrease with depth is critical to evaluating the potential impact of jointing at the Lavender and Davis Canyon sites.

Laboratory tests of fracture flow in carbonate rocks (Jones, 1975) were carried out to characterize decreasing fracture permeability under conditions representing depletion of reservoirs at depths greater thatn 2000 ft.. The findings of this study can be related to the concerns of nuclear waste isolation in a jointed environment. It found that fracture permeability is greatly reduced as confining pressure is increased. Stated another way, the reduction of reservoir fluid pressure will result in an increase of net over burden pressure. Secondly, Jones (1975) found that fractures in dense carbonates do not completely heal, despite reduction in fracture opening, even at 20,000 psi confining pressure. At a nominal 3000 ft. repository depth, and a rock overburden increase of 1 psi per foot of depth, the rock overburden pressure on joints will be 3000 psi. Net overburden pressure in psi is the reservoir depth in feet minus the reservoir fluid pressure, which closely approximates hydrostatic head to that depth (approximately 0.43 psi per foot of depth). Thus the confining pressure on joints at 3000' will be approximately 1700 psi, far less than the 20,000 psi which even then failed to heal fractures in dense carbonates. The implication is that joints should be open to fluid movement at the depth of the proposed repository.

If we add additional conditions to those with which Jones worked, we have the possibility of increased permeability. Thermal expansion and uplift resulting from thermal energy release of buried nuclear waste will create a dilated zone, characterized by a tendency to widen joint openings. Mead (1925) and McNaughton (1953) indicate that such a dilated zone is characterized by low fluid pressures. The low pressures would create local pressure gradient anomalies with the resulting tendency to "suck in" (McNaughton, 1953) fluids from surrounding areas of normal, but relatively higher, pressures. In the case of the nuclear waste isolation in salt beds, this inflow of water to a dilated zone would probably initiate dissolution. Even though thermal energy eminating from the buried waste would decrease after several decades (as we have been told by the DOE) it can be envisioned that fluid channels would be established allowing probable continued circulation, dissolution and eventual catastrophic collapse of the repository area.

A dilatent zone would also be created by the development of a breccia pipe. If such a structural feature were propegated upward from beneath the Paradox salt section at the repository site (as they are elsewhere on the Colorado Plateau) a low pressure area would be developed which would drawn-in fluids from surrounding rocks resulting in dissolution.

Snow (1970) presents an excellent mathmatical treatment of fracture permeability, supporting it with fracture permeability derived from pump tests. Fracture permeability is obviously related to the frequency and the open width of a fracture. Daniel (1954) reports that in cores of the Ain Zalah and Kirkuk producing zones of the Middle East joint widths of 1/10 to 1/5 mm (1/250 - 1/125 inch) can be seen. The following example of productivity as related to fractures is given by Daniel:

> "The writer has seen in another field a core taken in solid anhydrite with 100% recovery, during the taking of which the well came in and flowed at the rate of 7000 barrels [294,000 gal.] per day of saturated brine. Upon pulling the core, it was seen that about

one foot length in the midst of it was cut by three intersecting fractures, two being parallel and about 25 mm (1 inch) apart and the third transverse to these. Their width did not exceed about 1/5 mm (1/125 inch)."

The confirmation of the magnitude of fracture widths comes form several references. Van Golf-Racht (1982), as cited in Kirkland (1984), "reports average fracture width as determined from the study of 1110 thin sections of carbonates as 0.08 mm" of those fractures studied 24% reveal an average width of 0.10 mm. Van Golf-Racht concluded that "a reasonable estimate of 'closed fractures' would be 0.01 mm". By experimental methods Gibson (1948) as cited in Daniel (1954) has shown "that a single fracture 1 mm (1/25 inch) wide crossing a well [bore] can produce at the rate of 7,000 - 10,000 barrels of oil per day".

By mathmatical evaluation Baker (1955) and Elkins (1953) have determined the permeability for specific size fractures. For instance, Baker has calculated that "a single fracture 0.01 inch (0.25 mm) wide has the equivilent permeability of 454 ft. (188 m) of unfractured rock with a uniform permeability of 10 md; an 0.05-in-wide (1.27 mm) fracture is equivalent to 568 ft (173 m) of rock with a permeability of 1000 md." In evaluationg the Spraberry fracture-production of West Texas, Elkins found that, based on pressure-buildup data, the average formation permeability of 16 md could be provided by fractures 0.28 mm (0.0011 in) wide spaced 10 cm apart. These values compare well with fractures measured in Spraberry cores at 0.002 in.

In light of the above examples of fracture fluid productivity and fracture permeability, it is well within the realm of possibility to have permeable fractures at repository depth, in the Lavender and Davis Canyon proposed repository sites. The possibility is enhanced when we consider the disrupted pressure and hydrologic regime that would result from the mining and waste emplacement.

III Review of Draft Environmental Assessments -

A. Introduction -

In the following part of this report the geologic aspects of the DEA's will be discussed relative to the findings of this study and my experience in the Paradox Basin. Since the geology at the two proposed sites is very similar, my comments will apply to both Davis and Lavender Canyon sites; comments which pertain to only one site will be so stated. For the convenience of all readers, these comments will follow the format of the DEA's. First I will discuss the geologic aspects of the site, Chapter 3, and secondly the adequacy of that information to meeting the siting guidelines, Chapter 6.

B. Review of Geologic Conditions -

3.2 - GEOLOGIC CONDITIONS -

3.2.1 Regional Geology - This introductory statement is adequately covered.

3.2.2 Geomorphology - This statement is adequately covered.

3.2.2.1 Physiography - The preparation of the DEA's has overlooked the obvious joint-controlled drainage which I have discussed above. This aspect should have been considered with regard to the manner in which erosion along jointing has modified the physiography of the area via a prominent northeast-trending orientation of the drainages.

3.2.2.2 Erosion - As mentioned in 3.2.2.1 above, the presence and influence of jointing was completely overlooked.

3.2.2.3 Paleoclimate - This section seems adequately covered.

3.2.3 Stratigraphy -

3.2.3.1 Regional Stratigraphic History of the Paradox Basin - This descriptive overview section is reasonably adequate with the following exceptions. I take exception to the references to isopach maps developed by McCleary (1984). There is no way to evaluate the accuracy of those statements under the present posture of the DOE which does not allow them to provide to the State of Utah copies of the seismic data which contributed to the generation of those isopach maps. Secondly, the DEA's mention the karst topography developed on the upper Leadville (DOE, 1984 b, pg. 3-12) but then fail to discuss the implication (either here, under Site-specific Stratigraphy - 3.2.3.2 or under Dissolution - 3.2.5.6) that the karst zone could have on increasing permeability at that zone, and providing access of groundwater to the repository itself.

3.2.3.2 Site Specific Stratigraphy - The DEA statement (paragraph 2) that

"The subsurface stratigraphy .... appears consistent and easily traceable for tens of kilometers surrounding the site" is at the same time true and very naive. Indeed, the gross formations can generally be traced for great distances. On the other hand, physical properties of those formations can change dramatically, within short distances. Since the deposits in question were virtually all deposited under marine conditions, one has only to envision the diversity of depositional environments on a shallow sea floor to appreciate that properties such as porosity and permeability of a stratum can vary greatly in short distances. This is even more true along the edges of depositional basins, such as the case of Pennsylvanian deposits in the Paradox Basin where the proposed repository sites are located. Finally, the DEA's own Figure 3-7 gives a good diagrammatic illustration of this point.

These instances suggest that the DEA's have taken a rather simplified approach to the various lines of documentation.

3.2.3.2.1 Surficial deposits -

through

3.2.3.2.13 Molas Formation - all brief descriptive statements are adequate.

3.2.3.2.14 Leadville limestone - The DEA statement that "The top of the formation is an erosion surface" is true but inadequate. It is well known (Armstrong and Mamet, 1976) that the erosion on the Leadville surface lasted long enough to produce karst topography and a deep red soil. It was even referenced in ONWI 290 (p. 4-4), but not in the DEA's. Karst features on the unconformable top of the Mississippian can be seen over widespread parts of the Rocky Mountains (including at the nearest Mississippian outcrops in southwestern Colorado); they represent a long-lived hiatus. Further, the solution-enlarged joints, sinkholes and caves affect as much as the upper 150 ft. of the Mississippian and locally can contribute to groundwater flow paths. In the candidate area, present access of groundwater to that karst zone could be through the Salt Creek-Bridger Jack-Shay graben system. In the future, periods of higher precipitation could conceivably provide access of fresh water to the sub-salt strata via that graben system the Mississippian karst zone.

3.2.3.2.15 Ouray Limestone -

through

3.2.3.2.19 Ignacio Formation - all adequately covered.

3.2.3.3 Thickness, Lateral Extent and Characteristics of the Host Rock - This section cannot be properly evaluated until the State of Utah receives the geophysical data requested from DOE. Projections of salt thickness are in the proper range, based on my subsurface studies, but there remain questions due to the scarcity of well control which can only be answered by having the same geophysical information that DOE has had.

Further, the presence of commercial deposits of potash cannot be ruled out with the present data base, as the DEA's attempt to do.

3.2.4 Paleontology - adequately covered.

3.2.5 Structure and Tectonics - adequate introductory statement.

3.2.5.1 Faulting - Again, I cannot concur with this section until it is reviewed in the light of the DOE seismic studies. A flag of caution must be raised for the Davis Canyon site in view of subsurface faulting reported by McCleary (1983, Figure A-27, A-30, A-32, A-34 & A-36) and Kitcho, and others (1984 Figure 5-1, & 5-3) in the Paradox and older formations. If there truly are northwest-trending faults beneath the Davis Canyon proposed repository site, then the Davis Canyon site should not be considered for a nuclear waste repository.

3.2.5.2 Seismicity - This part of the Colorado Plateau is cut by the Colorado lineament, which provides an area of seismic activity in the Meanders Anticline area along the Colorado River. The seismic activity extends from the surface to depths of 11 miles (Wong, 1984, pg. 8). Microseismic activity within the candidate area has not been recorded for a long enough period to yield valid judgements.

Although it is not highly relavent to the evaluation of the DEA's, I question why the investigators who prepared this section used the Modified Mercalli (MM) earthquake intensity scale, which is subjective in nature, in preference to the almost universally used Richter scale, (Dobrin, 1960, p. 32, 39) which can be instrumentally measured and more meaningfully quantified. Further, the footnoted reference (DOE, 1984 b, pg. 3-42) offering descriptions of MM intensities, does not appear in the bibliography.

3.2.5.3 Igneous Activity - adequately covered.

3.2.5.4 Uplift, Subsidence and Folding - adequately covered.

3.2.5.5 Salt Flow and Diapir Development - Surface observations would suggest that salt flowage and diapir development are not present at the Lavender and Davis Canyon sites. There are not adequate data to say that these phenomena are not occurring at the depth of salt cycle #6.

3.2.5.6 Dissolution - This aspect has not been adequately considered. The reported (McCleary, 1983; and Kitcho, and others, 1984) northeast-trending sub-salt faults in the Six Shooter Peak area could provide access of water to the lower Paradox salt cycles which could lead to dissolution and eventual collapse of the Davis Canyon site. A second means of providing access of water to the base of the salt section is via the karst zone at the top of the Leadville Formation, and breccia pipe development.

It is well known that breccia pipes are present at many places in the Colorado Plateau. Locally, they are known along the east side of Spanish Valley and at Lockhart Basin. The processes initiating breccia pipe development are not known. The pipes are known to extend to well down into the Paleozoic rocks (as at the Orphan mine along the Grand Canyon) and grow upward by solution stoping. It is felt by some workers that, at least in some cases, the breccia pipes are initiated at the paleo-karst zone at the top of the Mississippian rocks. Until such a pipe breaches the surface it would not be detectable, even though it might be actively stoping through the Paradox salt section. Finally, if a breccia pipe were to be ascending through the Pennsylvanian section it would create a dilatant zone as discussed in my earlier discussion (section II, E). To that zone, nearby groundwater would flow due to the developing low pressure region, thus allowing waters from a breached repository to have access to the lower hydrologic unit. Since the lower hydrologic unit discharges in the Dark Canyon/Mille Crag Bend area to the west (Peter Huntoon, pers. comm.) the radioactive waste would have a ready path to the accessible environmant.

Far more significant to the inadequacy of this section is the absence of any discussion of the effect that jointing has on the increased rate of ground water movement. Further on in the same DEA, DOE (1984 b, pg. 6-88) admits that water flow in fractures can be 1 or more orders of magnitude greater than in the primary porosity of the same rock. The fact that enormous fluid flow can occur in fracture porosity is discussed in my section II, E.

3.2.6 Rock Characteristics -

3.2.6.1 Geomechanical Properties - Rock mechanics is not part of my background, therefore, I will not comment on this section.

3.2.6.2 Thermal Properties - It is stated (DOE, 1984 b, pg. 3-69) "that when a heat source is placed in a salt deposit, water trapped in salt has a tendency to move up the thermal gradient." This phenomenon has been documented at Project Salt Vault. Brine would migrate to the emplacement holes, (accumulation would be 2-11 quarts [Lavender 6-116, 5th draft EA Working Papers] after 20 to 30 years) and contribute to the corrosion of the waste cannisters. This is a matter to be addressed by engineering of the cannisters.

3.2.6.3 Natural Radiation - adequately stated.

3.2.7 Geochemistry - this section has been evaluated by Parry and Morrison (in Chapman et al., 1984).

3.2.8 Mineral Resources - The DEA's gloss-over the oil tested from the Reynolds Mining Company, #1 well only 6 miles northwest of Woodward Clyde, GD-1. Indeed it tested 47 barrels of oil, but the DEA's neglect to say that the oil came from the salt section -- namely from the interbed between salt cycles 13 and 14. Furthermore, it is erroneously stated that the oil was recovered during a drill stem test. According to the well history records at the Utah Oil, Gas and Mining Division, that oil was recovered through perforated production casing.

DOE (1984, b, pg. 3-85) makes the statement that in the evaluation drill hole, GD-1, gas and "a strong petroliferous odor" was reported from interbeds in the Paradox salt section. Unfortunately, there is no follow-up discussion of the implications of those hydrocarbon shows, as indicators of hydrocarbon resources within the Paradox salt section.

Since there are only a small number of oil and gas tests closely surrounding the Candidate Site, I see no good reason for DOE to randomly sample a small number of drill stem tests (7 in the Paradox and 12 in the Leadville Formations) rather than evaluate them all. If there are many more drill stem tests of drill holes in close proximity to the site, then this is an inadequate assessment of potential hydrocarbon reserves.

3.2.8.2 Other resources -

3.2.8.2.1 Uranium/Vanadium - seems adequately covered. Additionaly, during the course of my field evaluations no favorable host lithologies, structure or mineralization were noted in the Moss Back Member of the Chinle Formation (the primary uranium/vanadium host in the area).

3.2.8.2.2 Potash - Paradox cycle 18 as described in the Gibson Dome area, includes sylvite deposits which "are of sufficient thickness and grade to constitute minable deposits" (Hite, 1982), but "it is likely that they do not underlie Davis and Lavender Canyons". Those conclusions were based on rather wide-spaced drill hole data. Until site-specific drillholes are completed, the presence of economic deposits of potash beneath Lavender and/or Davis Canyons cannot be ruled-out.

The economics of, and need for, potash over the life of the repository cannot be predicted. If those deposits are explored or exploited in the future, access of ground water to the repository is likely (Lavender 6-159, Last paragraph., 5th draft, EA Working Paper).

3.2.8.2.3 Miscellaneous Minerals - adequately stated.

3.3.2.1 Hydrology and modeling - Here, again, fractures (joints) are mentioned but their contribution to accelerated ground water movement is not mentioned (see my discussion under section II, E).

C. Review of Guideline Assessment -

The following section will address the degree to which the information presented in Chapter 3 meets the Siting Guidelines.

6.2.1.3 Site Ownership and Control - During the course of my field geologic studies, I observed valid mining claims over the entire Davis Canyon site. Neither in the Statement of Qualifying Condition, nor in the basis of such evaluation (sections 4.1 and 4.1.2.1), do the DEA's discuss their procedures for dealing with existing mining lode claims. Is there a provision for honoring such claims? If such claims are to be honored, how can the DOE reconcile the possibility of future drilling operations on the repository site? Until this is resolved, I cannot agree that the Siting Guidlines have been met.

6.3.1.1 Geohydrology - The basic premise here is that if there is a post-closure release of radionuclides from a repository, it will be transported to the accessible environment by ground water. Thus the evaluation of the site is based on its geologic integrity relative to the transmission of groundwater, as specified in guidelines 10 CFR 960.4-2-1.

6.3.1.1.1 Statement of Qualifying Condition - Within this section the discussion of Relevant Data is, for the most part, logical and complete. In attempting to establish the permeability and effective porosity of the host rock and its surroundings, data is presented which states that the permeability and porosity of buried halite is zero. That is acceptable, but there is no separation made between the salt bed and its bounding interbeds, which clearly have greater permeability, based on the hydrocarbon shows of the interbeds.

If the nuclear waste is to be buried in salt 6, we need to know more of the permeability of the bounding clastic interbeds. It is through those interbeds that ground water could have access to salt 6 especially if the more competent units (such as the interbeds) are jointed.

It is likely that the entire stratigraphic section has undergone tectonic, earth tide or regional tension stresses which have produced the jointing seen on all surface exposures. In my section II-E, I have discussed the implications of jointing, and the magnitude of potential fluid flow in fracture (joint) porosity. Dilatancy in the vicinity of the repository working is also discussed there as it could enhance water flow into the Paradox salt section with resulting dissolution.

DOE (1984 b, pg. 6-87) states, "No salt dissolution has been detected within 10 kilometers (6 miles) of the site ..." In my opinion, that is an unacceptable statement. Is can be said that there are no surface indications of dissolution, but incipient dissolution at depth cannot be precluded. This statement also applies to the "Analysis" section on pg. 6-88 (DOE, 1984 b).

On pg. 6-88 of DOE (1984 b) and pg. 6-81 of DOE (1984 a) the presence of fractures and fracture porosity is admitted, as well as the fact that such secondary porosity will permit ground water flow rates of one or more orders of magnitude greater than in the primary porosity of the same rock. Based on this and the extensive jointing observed during my geologic field studies, I find that the Qualifying Condition (6.3.1.1.1) has not been met.

DOE's concern with the validity of drill stem tests is interesting, in light of the fact that they used only a random sampling of the drill stem tests available.

The concerns I expressed in discussing the DEA Chapters 3 above are all applicable to the question of whether the geohydrologic conditions at Lavender and Davis Canyons meet the siting guidelines. Basically, I am concerned that DOE and its subcontractors have not considered some of the potential means of providing ground water circulation to salt 6.

6.3.1.1.2 Analysis of Favorable Conditions (3) - On pg. 6-90 (DOE, 1984 b) and pg. 6-83 (DOE, 1984 a) it is stated that to adequately characterize the sites, exploratory drilling might have to be conducted within Canyonlands National Park. Clearly, such exploratory drilling would violate the sanctity of the National Park. A favorable condition is, therefore, not present.

6.3.1.2 Geochemistry - This section is being addressed by Parry and Morrison (in Chapman et al, 1984).

6.3.1.3 Rock Characteristics - In DOE (1984 b, pg. 6-101; and 1984 a, pg. 6-93) thermal uplift is mentioned as contributing to a 2.5 - 3 ft. expansion over the proposed repository. The DOE does not take this matter the next step, relating the uplift to dialation of the joints and then relating enlarged fractures and increased ground water movement to the pervasive jointing in the proposed sites.

The ramifications of joint porosity-enhanced groundwater flow, and the dilatant zone characterized by low pressures resulting from thermal uplift have not been discussed by DOE. In view of very large production worldwide of water and hydrocarbons from fracture reservoirs at great depths, I cannot accept the claim (DOE, 1984 b p. 6-101, paragraph 1) that effective fractures will not be present below 951 ft. depth (as caused by tensile stresses resulting from thermal uplift). If the ability of each joint to better transmit water as a result of thermal uplift is accepted, then I cannot accept this portion of the DEA's which claims that the thermomechanical alteration of the rock mechanics will not significantly reduce the isolation characteristics of the host rock.

6.3.1.4 Climatic Changes - I concur with the findings of this section.

6.3.1.5 Erosion - The DEA's statements of this section are acceptable.

6.3.1.6 Dissolution - This section cannot be properly evaluated for accuracy and adequacy until the DOE makes available to the State of Utah the seismic data on which this section is so heavily based.

Another short coming in the Statement of Qualifying Condition begins on pg. 6-111 (DOE, 1984 b) and pg. 6-104 (DOE, 1984 a). In the discussion of the Shay/Bridger Jack/Salt Creek graben system, up to 320 ft. of offset is documented along with the suggestion "that the graben is a through-going feature that may provide a pathway for ground-water circulation, resulting in dissolution". In the same paragraph it is stated that no drill hole data exist to evaluate such dissolution. The well history records at The Utah Oil, Gas and Mining Division document the drilling of the Placid Oil Co., USA #DU-2 and the cavernous porosity it encountered in the upper Mississippian section. The Placid test, located on the edge of the Shay graben, clearly renders invalid, DOE's claim of no drill hole data in the graben. Omissions, such as this one, lead me to question the thoroughness of the entire DEA's.

If it could be accepted that dissolution is not currently present at the proposed sites, it does not neccessarily follow that dissolution will not breach the repository via thermally enlarged joints and the resulting accelerated groundwater flow after closure, or via breccia pipes.

6.3.1.7 Tectonics - This section can likewise, not be evaluated until the

State of Utah is given the seismic data and interpretations (DOE, 1984 b, p. 6-115 and DOE, 1984 a, p. 6-107).

6.3.1.7.2 Analysis of Favorable Condition - I am concerned with the possibility of a fault in the northeast-trending Bogus Pocket, as evidenced by the fault-filling calcitic rocks found during my surface geologic studies (discussed above). In light of this, I cannot concur that a favorable condition is present.

6.3.1.8 Human Interference and Natural Resources - Since the presence of economical potash deposits beneath the Lavender and Davis Canyon sites cannot be precluded with the available data, I cannot concur with the findings of this section. Secondly, the "economic" aspect of such deposits is based on the deposit being mined by traditional methods. Why does DOE fail to consider the economics of solution mining such as is the process at the Texas Gulf operation at Potash, Utah, 30 miles due north of the Davis Canyon site?

The potential for economic hydrocarbon occurrences beneath the sites is based on an incomplete analysis of nearby drill stem tests. Thus the presence of economic hydrocarbon occurrences cannot be precluded.

6.3.3.2 Rock Characteristics - DOE (1984 b, pg. 6-146 and 1984 a, pg. 6-140) again calls on seismic reflection data to justify the presence of an adequate thickness of salt #6 at the sites. As I have stated several times above, this evidence for qualification cannot be accepted until the State of Utah has access to those seismic data and interpretations and provides concurrence. In view of this situation I cannot agree with the DEA's non-disqualifying findings.

IV. CONCLUSIONS and RECCOMENDATIONS:

In closing I would say that the majority of the inadequacies of the DEA's data handling could be resolved by the DOE by:

1. making the seismic and related data available to the State of Utah;
2. performing geologic field mapping to become aware of the extensive jointing;
3. gathering and evaluating all data pertinent to the known karst surface on the top of the Leadville Formation, including the examination of cuttings and cores from oil and gas tests in the Candidate Area (many of which are available for study at the Utah Geological and Mineralogical Survey);
4. considering the possible effects of the joints and thermal uplift

on hydrology as it might impact post-closure ability of the repository to adequately contain radionuclides; and

5. researching and using all of the drill stem test data and not just a random sampling thereof.

I recommend that the State of Utah:

1. make all possible efforts to acquire the seismic data and interpretations used by DOE and its contractors, and have them independently evaluated;

2. have State hydrologists develop scenarios and perform appropriate modeling to evaluate the effects on fracture permeability of thermal uplift, and dilatancy; modeling should also consider the resulting initiation of dissolution, the required conditions to sustain dissolution, and of eventual collapse;

3. perform additional detailed geologic field work measuring joint strikes and dips to establish if there is any anomalaous change of trend which could be related to subsurface dissolution; and

4. review drill cuttings of the lower 200 ft. of Pennsylvanian and upper 300 ft. of Mississippian rocks, for all nearby oil tests, to evaluate the extent and development of the karst surface.

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APPENDIX D

REVIEW OF DOE-SPONSORED STUDIES AND CONCLUSIONS ASSOCIATED WITH THE EFFECT ON VISUAL QUALITY OF SITING A HIGH-LEVEL NUCLEAR WASTE REPOSITORY IN UTAH

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CONTENTS

TABLES

ILLUSTRATIONS

REVIEW OF DOE-SPONSORED STUDIES AND CONCLUSIONS ASSOCIATED WITH THE EFFECT ON VISUAL QUALITY OF SITING A HIGH-LEVEL NUCLEAR WASTE REPOSITORY IN UTAH

INTRODUCTION

The U.S. Department of Energy (DOE) is currently engaged in identifying sites which would be potentially suitable for the long-term storage of high-level radioactive waste. Utah is included in the list of states which may have sites with the appropriate geologic components for such a repository. A unique feature of these sites (the Davis Canyon and Lavender Canyon sites in the Gibson Dome area) is that they are in remarkably close proximity to Canyonlands National Park. In fact, the primary area of consideration is immediately adjacent to the eastern park boundary. This set of circumstances has generated considerable discussion concerning the environmental impacts which locating a high-level radioactive waste repository at the Davis Canyon site could have on Canyonlands. The specific attraction of the park, in terms of its scenic beauty, causes particular attention to be drawn to the possible extent of impacts to the areas' visual quality.

In October of 1983 the State of Utah released a report describing a study which began to clarify the actual magnitude of the issue of visibility associated with repository siting in Davis Canyon (Johnson, State of Utah, 1983). That report accomplished this objective by identifying the potential visibility of both the repository site itself and the alternative proposed railroad access routes.

This report summarizes a follow-up to that original study. It was designed more to complete the information necessary to comprehensively review and assess the results of a similar visibility investigation completed by Bechtel Group, Inc. (BGI) and released by the Office of Nuclear Waste Isolation (O.N.W.I.) entitled 'Visual Aesthetics Study: Gibson Dome Area, Paradox Basin, Utah (ONWI 454), in March 1984. That information was used to support and substantiate conclusions by the DOE in addressing potential visual impact in the Draft Environmental Assessment. Although completed with a somewhat different purpose than the 1983 study, the findings summarized in this report also contribute to a better understanding of the larger question of visibility and potential visual impact of the proposed repository development in Davis Canyon as well as to the overall Environmental Assessment review process in general.

The review nature of this work dictated that the goals and objectives reflect that focus. The methodology was constructed in a manner that would replicate the methodology used in ONWI 454 as much as practical. Computer modeling techniques for determining visibility similar to those used in ONWI 454 (and the same as those used in the State's 1983 study) were implemented in this review. However, the process of reviewing ONWI 454 in addition to the use of the data produced in ONWI 454 in the recently released Draft of the Environmental Assessment (DEA) (DOE, 1984) revealed the need for a modification in the application of the methodology used in ONWI 454.

Two types of structural components of the proposed repository complex were selected for visibility testing. In contrast with ONWI 454, the locations of all three components were identified as visible from Utah Highway 211. In addition, inconsistencies and inaccuracies were found in the DEA in using the results of ONWI 454 to support conclusions relating to visual impact.

GOALS AND OBJECTIVES

The considerations presented by implementing a review process contributed to the development of both an overall purpose and subsequent methodology for this project. The purpose was to provide information which could be used to better review and evaluate the findings presented in ONWI 454 as well as the DEA in the area of potential visual impact. Since the greatest uncertainty identified in a preliminary review of ONWI 454 and the DEA related to the potential visibility of the proposed repository site in Davis Canyon, an application and implementation of the ONWI 454 methodology which would allow for a more comprehensive review was necessary. Within this context, two procedural objectives were formulated which would enhance the comprehensiveness of the review:

1. Review the methodological aspects of ONWI 454 in an effort to reconstruct it where appropriate as well as introduce modifications of its application where clear justification existed. This would allow for actual implementation of the refined methodology to evaluate the results presented in ONWI 454. The intent of this process was to provide more definitive information (and comprehensible maps) relative to the potential visibility of the proposed Davis Canyon site.

2. Use the information collected in the initial portion of the review process to assess the appropriateness of the assumptions and conclusions regarding visibility that the DOE had ascribed to the Davis Canyon site in ONWI 454 and the Draft of the EA.

METHODOLOGY

The purpose and objectives required an approach that combined literature review with modified procedural reconstruction of actual data analysis. The process is best described in the four phases it was implemented.

PHASE I: LITERATURE REVIEW

As outlined in the objectives, a procedure for data analysis had to be based on the procedure used in ONWI 454. An initial review of the methodology sections of that document was necessary.

Discussion of Phase I

The Visual Aesthetics Study: Gibson Dome Study Area, Parodox Basin, Utah (ONWI 454, March 1984) summarizes the information used and the results of a study conducted to determine the visibility of potential repository sites in the area titled. Other than the Draft Environmental Assessment, no other moderately comprehensively documentation of visual studies conducted in association with repository development proposals for this area has been released to the state by DOE (as of this writing).

ONWI 454 discusses the methodology used to obtain the results regarding visibility only in very sketchy terms (in general it is poorly documented from a scientific perspective). Some effort is applied to describing the proposed facility. However, the information used was out of date years prior to the release of the report. The report invested considerable time on describing several alternative sites with seemingly relatively low potential for selection or development while little time was spent documenting the actual elevation data collection process or the rationale by which the view origins at the sites themselves were selected. For purposes of reconstruction, the most useful information in the report consisted of:

1. The source of the elevation values necessary for visibility determination. A 1968 U.S.G.S. topography map with 80 foot contour intervals is described. The reference section of the report lists the 1:62,500 scale Canyonlands and Vicinity map as a source document.
2. The source of the information for the height of the structures tested for visibility. A 1981 BGI report is referenced for general repository characteristics and a 1982 BGI report is referenced for the locations of the proposed railroad routes.
3. The computer model used in the "viewshed analysis". The U.S. Forest Service VIEWIT model was implemented.

Additional information which should have been included in ONWI 454 to allow for more comprehensive review includes:

1. The rationale for and actual locations of the structures tested for visibility within each site. Although adequate in some cases, the maps provided in ONWI 454 were not at all sufficiently legible to identify these locations particularily in the case of Davis Canyon.
2. A clearer description or illustration of the extent of topographic data collected. This would give a better indication of the comprehensiveness of the study especially within Canyonlands.
3. Readable maps displaying the results of all of the visibility tests.

PHASE II: RECONSTRUCTION AND REVISION of the ONWI 454 METHODOLOGY

Completing the review of the methodology used in ONWI 454 provided the background necessary to reconstruct the procedures and parameters used in that study. Some of those parameters and in some cases the application of the procedure itself demanded revision simply because new and additional information was available for this review which was unavailable at the time the study summarized in ONWI 454 was initiated (although it was available prior to its publication).

Discussion of Phase II

The review of ONWI 454 revealed a plethora of questions and concerns. However, an extremely narrow time frame allowed only the highest of priorities to be addressed. From the state's viewpoint, the most important question relative to visibility centered around the Davis Canyon site. A discrepnacy was immediately apparent between the results in ONWI 454 and the results of the state's 1983 study (Johnson, State of Utah, 1983). This contrast required clarification and verification. While many questions were to remain unanswered (e.g., the extent of visibility inside all of Canyonlands; the actual visual impact and contrast as opposed to speculation), the question of the potential visibility of the Davis Canyon site was affordable to address in the relatively short time period.

Reconstruction of the process (as is common in scientific fields when evaluating results) used in ONWI 454 to determine visibility was difficult. Exact and complete reconstruction was impossible due to the lack of thorough documentation (described in the previous section). It was possible to follow the structure of that process in three general areas, although prudence dictated modified courses of action in some cases. The three areas included:

1. The U.S.G.S. Canyonlands National Park and Vicinity map (U.S.G.S., 1968) was used as a source for topographic data in the state's original visibility study (Johnson, State of Utah, 1983). It was possible to reuse that data for this review process. Although the cellular resolution was less than what was used in ONWI 454, the fact that the data source was identical justified the use of the data. ONWI 454 did not describe the process used to automate the elevation data. This review used the process described in the state's 1983 report.
2. ONWI 454 used a 1981 BGI report to identify structural characteristics of the proposed repository. Although portions of that report may still apply in some aspects of conceptual repository design, that report on repository structures was generally outdated. A modification was made in the ONWI 454 methodology specifically in the areas of the proposed repository site plan as well as locations and dimensions of structural characteristics. This review used the most currently available information regarding repository design for the Davis Canyon site from the Draft of the Environmental Assessment (DOE, 1984).
3. The algorithms used in the visibility testing portion of the VIEWIT software are common to a number of "line of sight" visibility determining programs based on cellular representations of topographic data. The model used in this review is comparable to VIEWIT in that regard and includes components that utilize the same data for other types of terrain analysis.

The result of this preliminary review was the development of a methodology that focused on the objectives outlined. Intentional modifications were made to the ONWI 454 methodology (as far as it is possible to compare) in an effort to provide more complete, useful and accurate results based on more current and comprehensive information. The methodology implemented in the Data Analysis Phase is outlined and clarified below.

Methodology Implemented for Obtaining Comparable Results

Activity 1: Project Planning and Management

Tasks: Planning: Communicate with state Nuclear Waste Technical Review Coordinators to define precise needs and focus of project and products.

Clarification: Review progress with Technical Coordinators.

Manage: Schedule and monitor resource availability.

Report: Inform Technical Coordinators and Policy Group of progress and results.

Activity 2: Data Collection

Tasks: Review ONWI 454 methodology.

Reconstruct and revise ONWI 454 methodology.

Conversion of data from previous state study to usable format.

Procedure development and testing: Test alternative methods of file transfer and combination for best graphic display.

Digitize: Add data and features to the project data base which were not already available at appropriate scales.

Activity 3: Data Analysis

Tasks: Structure selection: Select appropriate (representative and unique) repository structures from latest repository site plan for visibility testing with assistance from the Technical Review Coordinators.

Visibility Testing: Implement algorithm to identify visible areas.

Calculations: Use appropriate data to calculate necessary information regarding visibility (e.g., road lengths).

Activity 4: Output

Tasks: Design appropriate display format and content.

Program development: Link commands necessary to produce desired output (i.e., maps and tables).

PHASE III: IMPLEMENT PROCEDURE (Data Analysis)

Implementation of the procedure outlined above allowed for obtaining information regarding the potential visibility of structures of the proposed repository in Davis Canyon.

Discussion of Phase III

As mentioned earlier, elevation data for the project area had been collected for a previous state-funded study. It was possible to reuse that data thus making data collection considerably less time intensive. Although the geographic extent of that data was slightly less than that used in ONWI 454, it was more than sufficient for the specifics of this review (see Johnson, State of Utah, 1983 for a complete list of the actual values and the Review Area map in this report for the areal extent of the data used).

The process of selecting the structural components of the repository which were tested for visibility dictated that they be of two types: structures that were representative of the repository in general and structures which were considered to have a potential to be particularily noticeable. Three structures were tested for visibility from both ground level and at their maximum height. They were (1) the service shaft headframe (maximum height of 220 feet), (2) the group of buildings near the middle of the site plan described as the maintenance building complex (maximum height of 30 feet), and the meteorological tower (maximum height of 198 feet) located at the extreme southern end of the site. Figure 1 illustrates their location in the proposed Davis Canyon site plan.*

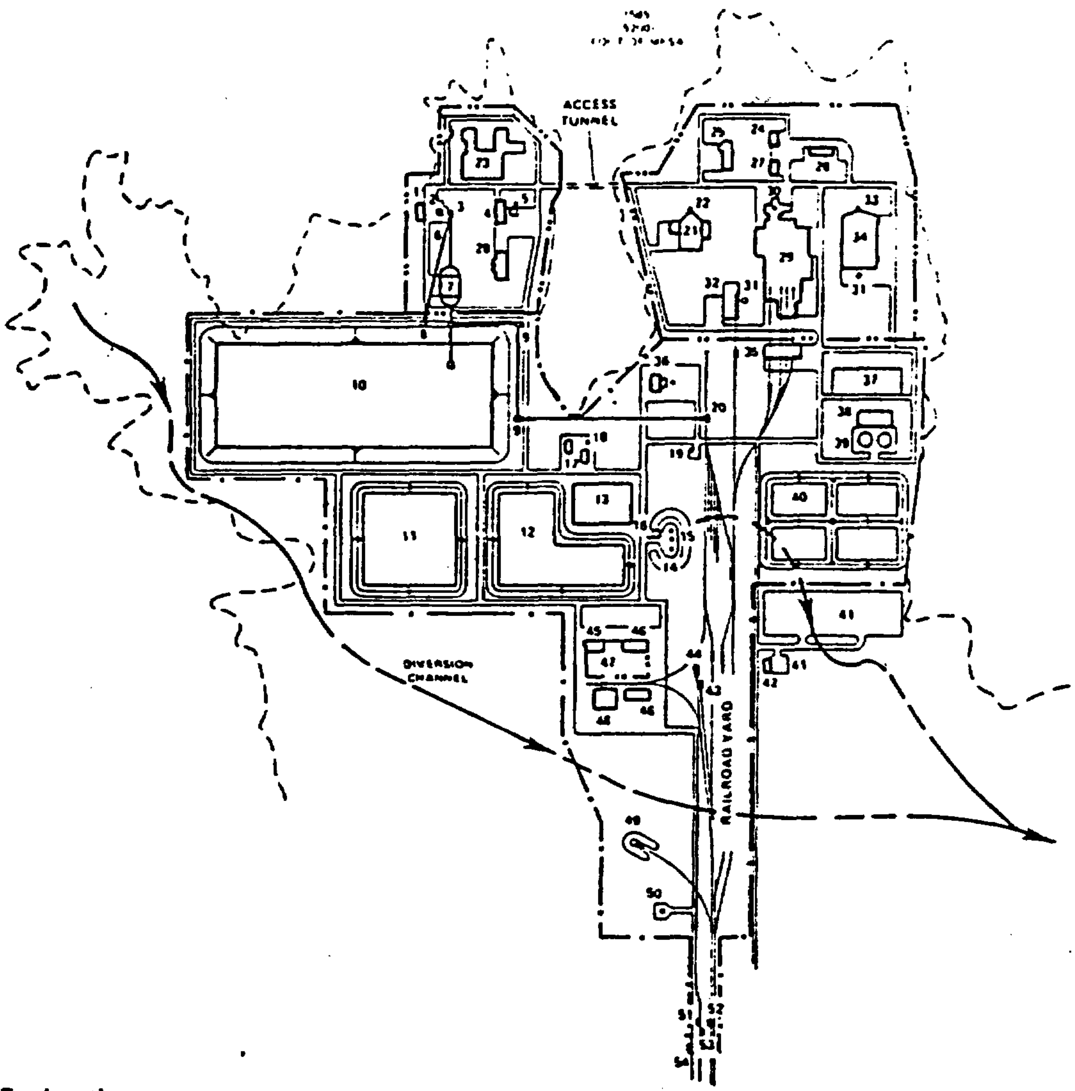
Another point of divergence between the application of the two methodologies is important to mention. ONWI 454 tested the visibility of some of the alternative proposed railroad corridors only to their coincidence. The state's 1983 study extended those routes to the Davis Canyon site based on the data available at that time. The revised maps of the state's 1983 study, included in the Results section for comparative reference, also show the complete routes.

The geographic area of review covers the same area as the state's 1983 study and is highlighted in the Canyonlands National Park and Surrounding Area map within the context of the surrounding region. The relative location of the repository site and the alternative railroad routes proposed for access to Davis Canyon to the topography and other administrative and cultural features is seen in the enlarged Review Area map with computer-generated shaded relief for topographic reference. These maps follow.

* This is a revision of the site plan used in the 1983 study. As a result, time was taken to revise portions of that study concurrently. The opportunity was also taken to reconstruct the maps presented in the 1983 study to comply with the format used in the current review. The revised 1983 maps and the summary statistics of that study are also presented in the results section.

PHASE IV: REVIEW AND EVALUATE DOE ASSUMPTIONS AND CONCLUSIONS

The additional information regarding the potential visibility of the Davis Canyon repository site made it possible to review and evaluate the assumptions that the DOE is expressing in ONWI 454 and the Draft of the EA. A complete discussion of this topic can be found in the Results section of this report.



Explanation

1 Service shaft filter building
2 Service shaft
3 Transfer tower
4 Ventilation supply filter building
5 Ventilation supply shaft
6 Reclaim tunnel
7 Live storage & surge building
8 Reclaim hopper
9 Salt transfer tower
10 Salt stockpile
11 Salt runoff pond
12 Treated wastewater holding pond
13 Wastewater treatment facilities
14 Potable water tank
15 Fire water storage tanks
16 Fire/potable water pumphouse
17 Cooling towers
18 Chemical feed building
19 Railroad control tower
20 Salt loadout structure
21 Unexposed air exhaust filter building
22 Unexposed air exhaust shaft
23 Underground operations building
24 Firehouse, security & medical treatment center
25 Administration & operation control center
26 Electric power building
27 Environmental & instrument laboratory
28 Compressor chiller building
29 Waste handling & packaging facility
30 Waste shaft
31 Confinement exhaust stack
32 Storage yard
33 Confinement air exhaust shaft
34 Confinement air exhaust filter building
35 Noncontaminated railcar/truck washdown area
36 Steam plant
37 Abandoned material & equipment storage yard
38 Raw water treatment
39 Raw water storage tanks
40 Storm water detention ponds
41 Parking lot
42 Visitors center
43 Railroad inspection pit
44 Railroad maintenance building
45 Maintenance building
46 Storage shed
47 Storage yard
48 Warehouse
49 Suspect Railcar/truck storage area
50 Meteorological tower
51 Truck inspection pit
52 Railcar inspection pit
53 Monitoring station
54 Guardhouse

Scale

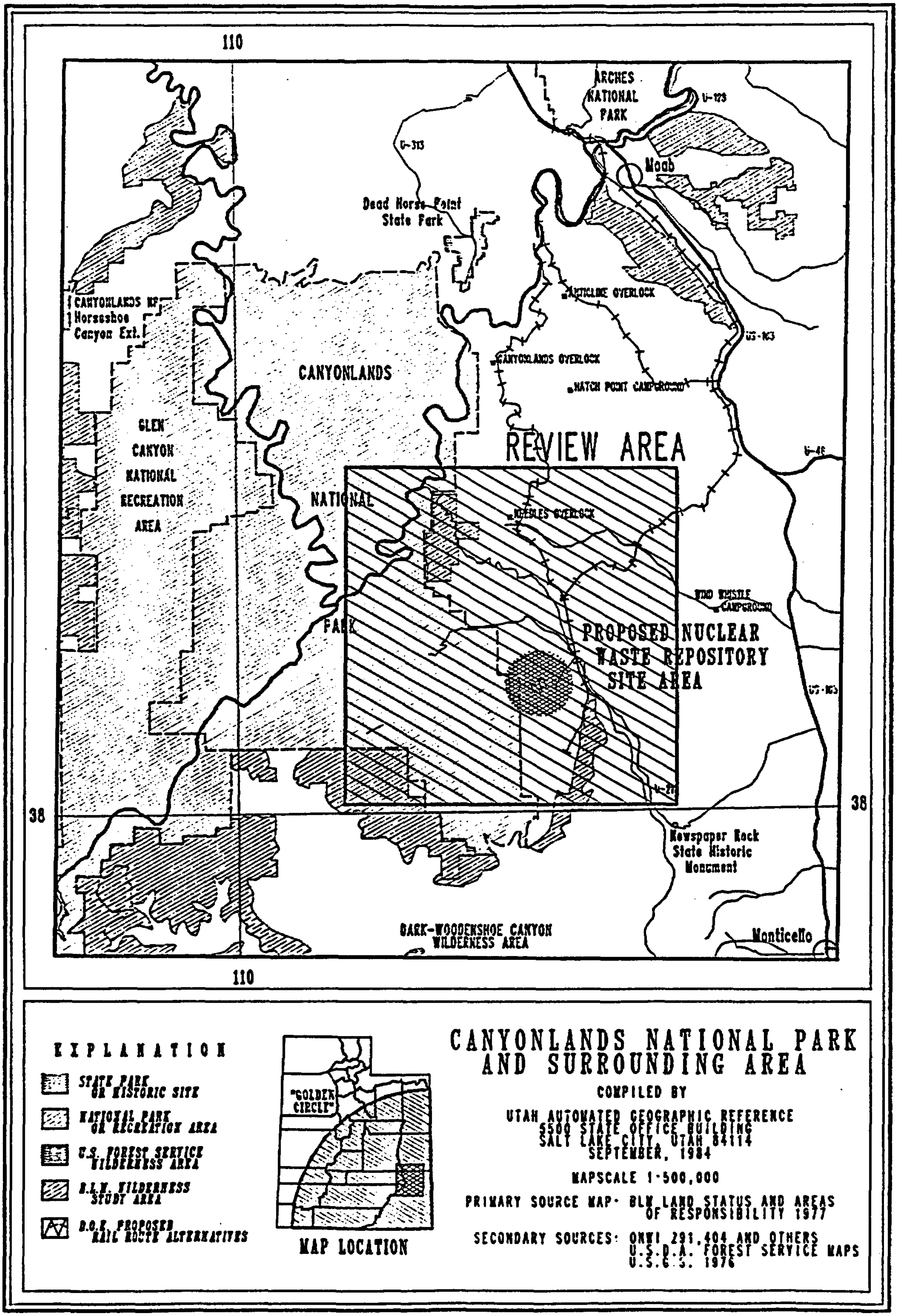
0 500 1000 Feet

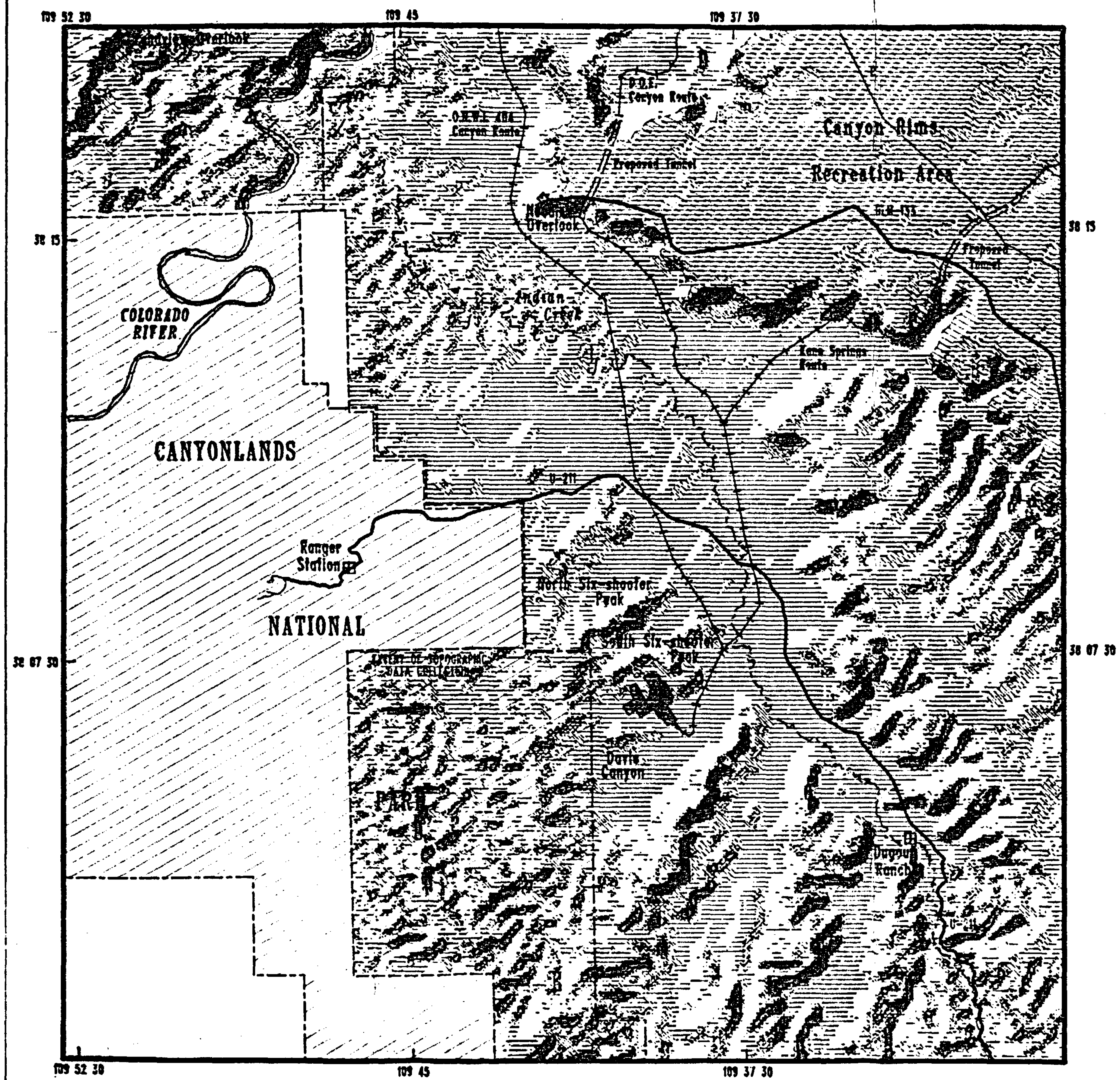
0 150 300 Meters

Repository Site Layout Plan
Davis Canyon

Figure 1

From the final Draft Environmental Assessment
for Davis Canyon, Utah, Chapter 5


110
ARCHES NATIONAL PARK
U-128
U-313
Moab
Dead Horse Point State Park
ANTICLINE OVERLOOK
US-163
CANYONLANDS NP Horseshoe Canyon Ext.
CANYONLANDS
CANYONLANDS OVERLOOK
HATCH POINT CAMPGROUND
REVIEW AREA
U-46
GLEN CANYON NATIONAL RECREATION AREA
NATIONAL
NEEDLES OVERLOOK
WIND WHISTLE CAMPGROUND
PARK
PROPOSED NUCLEAR WASTE REPOSITORY SITE AREA
US-163
38
38
Newspaper Rock State Historic Monument
DARK-WOODENSHOE CANYON WILDERNESS AREA
Monticello
110
EXPLANATION
STATE PARK OR HISTORIC SITE
NATIONAL PARK OR RECREATION AREA
U.S. FOREST SERVICE WILDERNESS AREA
B.L.M. WILDERNESS STUDY AREA
D.O.E. PROPOSED RAIL ROUTE ALTERNATIVES
"GOLDEN CIRCLE"
MAP LOCATION
CANYONLANDS NATIONAL PARK AND SURROUNDING AREA
COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
5500 STATE OFFICE BUILDING
SALT LAKE CITY, UTAH 84114
SEPTEMBER, 1984
MAPSCALE 1:500,000
PRIMARY SOURCE MAP: BLM LAND STATUS AND AREAS OF RESPONSIBILITY 1977
SECONDARY SOURCES: ONWI 291,404 AND OTHERS
U.S.D.A. FOREST SERVICE MAPS
U.S.G.S. 1976



STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

REVIEW AREA

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

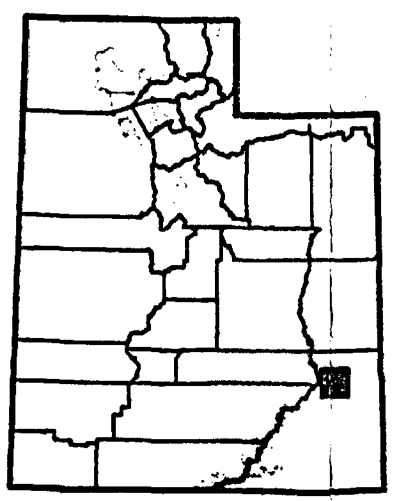
SCALE 1:150,000

EXPLANATION

Proposed Davis Canyon High-level Nuclear Waste Repository Development site.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

PRIMARY SOURCE MAP:
U.S.G.S. Canyonlands National Park and Vicinity. 1968. 1:62,500

ADDITIONAL SOURCES:
O.N.W.I. reports 404, 291, 454, and others

Statutory Environmental Assessment for Davis Canyon. Fifth Draft. August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design. 1982

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RESULTS

A review process of this type generates two types of results. The process of document review itself creates results in the form of comments, criticisms, and recommendations. The process of implementing a previously used methodology to verify results and conclusions of another study generates another kind of results. In a larger context, the results of this review will be discussed in three areas. First, the results of the revised application of the ONWI 454 methodology used in this review will be contrasted with the conclusions presented in ONWI 454 and how those are referenced in the DEA. Second, other concerns relating to procedures and conclusions in ONWI 454 will be highlighted. Third, concerns about the conclusions presented in the DEA relative to the visual issue will be discussed.

RESULTS OF THE IMPLEMENTATION OF THE REVISED ONWI 454 METHODOLOGY

The minor but critical modifications made in the application of the ONWI 454 methodology caused a substantial difference to be realized in the visibility determination. The most notable of these is the visibility of the Davis Canyon repository site from Utah Highway 211. Table 1 summarizes the results of the review of the visibility tests. The maps following Table 1 illustrate the extent of visibility of each of the proposed repository structures tested along with a Composite Visibility map showing the combined visibility of all three structures.

TABLE 1

VISIBILITY OF DAVIS CANYON SITE FROM MAJOR ROADS

		Service Shaft Headframe	Maintenance Building Complex	Meteorological Tower	TOTAL (any structure)
Length of UT Hwy. 211 from where structure is visible	Ground level	Not visible	.80 mi. 4,221 ft.	.94 mi. 4,951 ft.	1.45 mi. 7,674 ft.
	Max. ht.	.31 mi. 1667 ft.	.99 mi. 5,212 ft.	2.09 mi. 11,020 ft.	2.59 mi. 13,412 ft.
Length of Needles Overlook road from where structure is visible	Ground level	Not visible	Not visible	.13 mi. 689 ft.	.13 mi. 689 ft.
	Max. ht.	Not visible	Not visible	.13 mi. 689 ft.	.13 mi. 689 ft.

Comparison and Contrast of Visibility Results

In sharp contrast with the ONWI 454 results, this review shows that the Davis Canyon site is visible from Utah Highway 211. Proposed repository structures would be visible both at ground level and at their maximum height. A companion finding (which may even more interesting) is the indication that some of the proposed structures might also be visible from the road which terminates at Needles Overlook inside the Canyon Rims Recreation Area. In particular the tests on the meteorological tower and the maintenance building complex indicate potential visibility.

An element of inconsistency is found when comparing sections of the Fifth Draft of the EA with ONWI 454. ONWI 454 concludes that "a structure...would

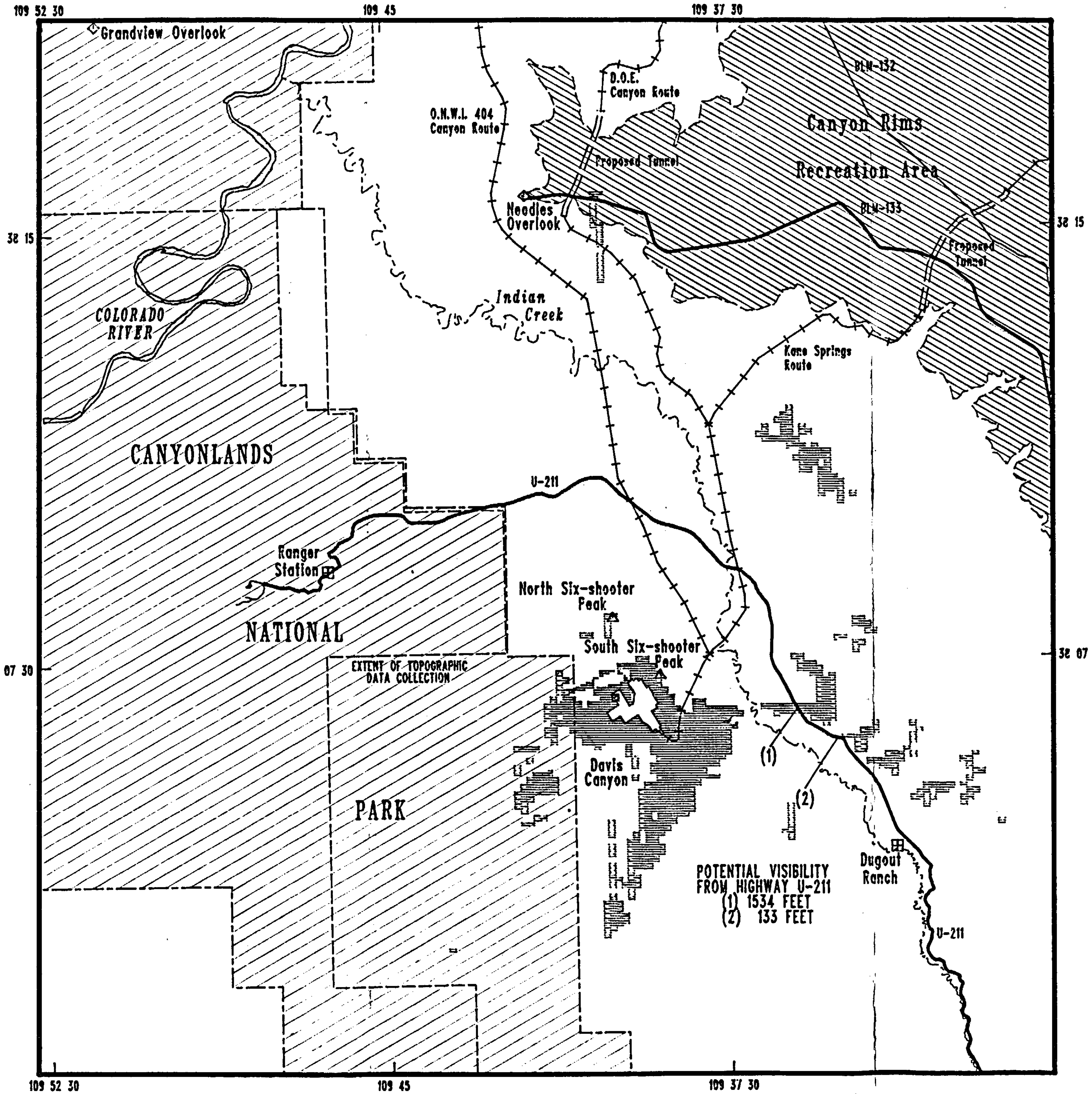
STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED
NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

SERVICE SHAFT HEADFRAME

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

SCALE 1:150,000



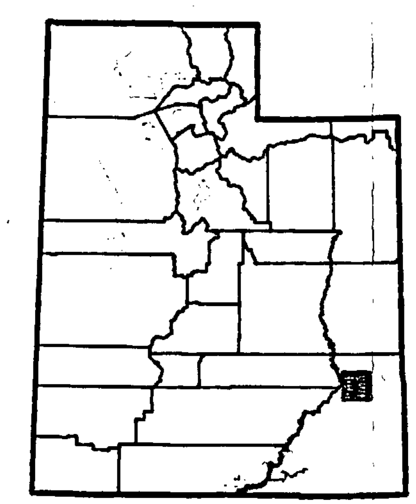
EXPLANATION

Approximate location of the SERVICE SHAFT HEADFRAME within the Proposed Repository site.

Locations within the Study Area from where the Proposed Repository SERVICE SHAFT HEADFRAME could be VISIBLE at a height of 220 feet.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

PRIMARY SOURCE MAP:
U.S.G.S. Canyonlands National Park and Vicinity, 1968, 1:62,500

ADDITIONAL SOURCES:
O.N.W.I. reports 404, 291, 454, and others

Statutory Environmental Assessment for Davis Canyon, Fifth Draft, August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

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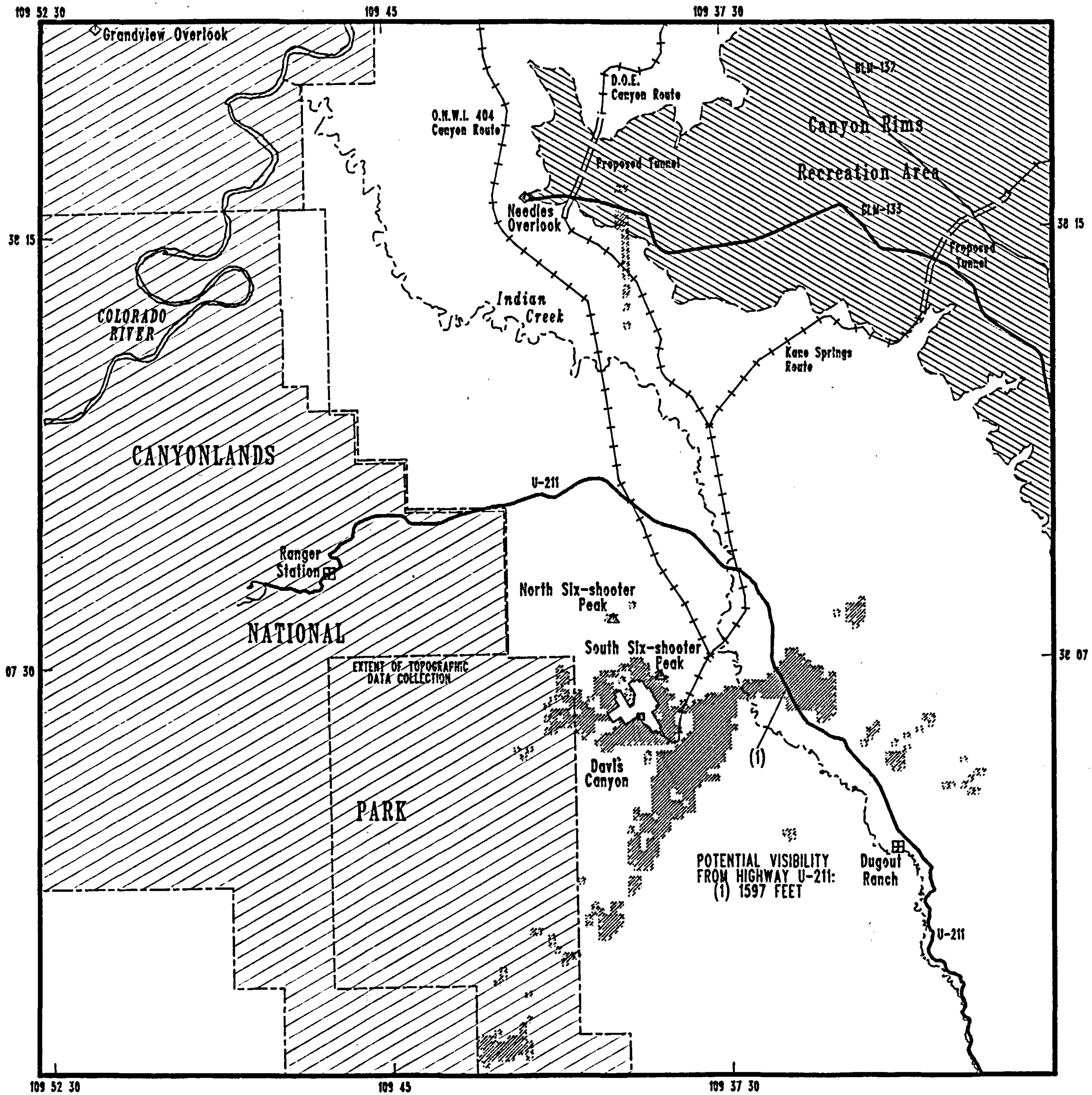


STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

MAINTENANCE BUILDING COMPLEX

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

SCALE 1:150,000

5 0 5 MILES
5 0 5 KILOMETERS

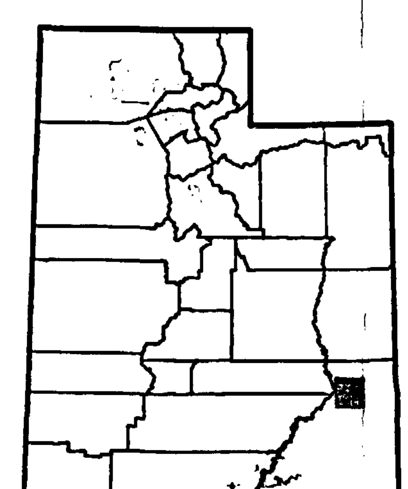
EXPLANATION

Location of the MAINTENANCE BUILDING COMPLEX within the Proposed Repository site.

Locations within the Study Area from where the Proposed Repository MAINTENANCE BUILDING COMPLEX could be VISIBLE at a height of 30 feet.

Also Available On Aperture Card

TI APERTURE CARD



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ADDITIONAL SOURCES:
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U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

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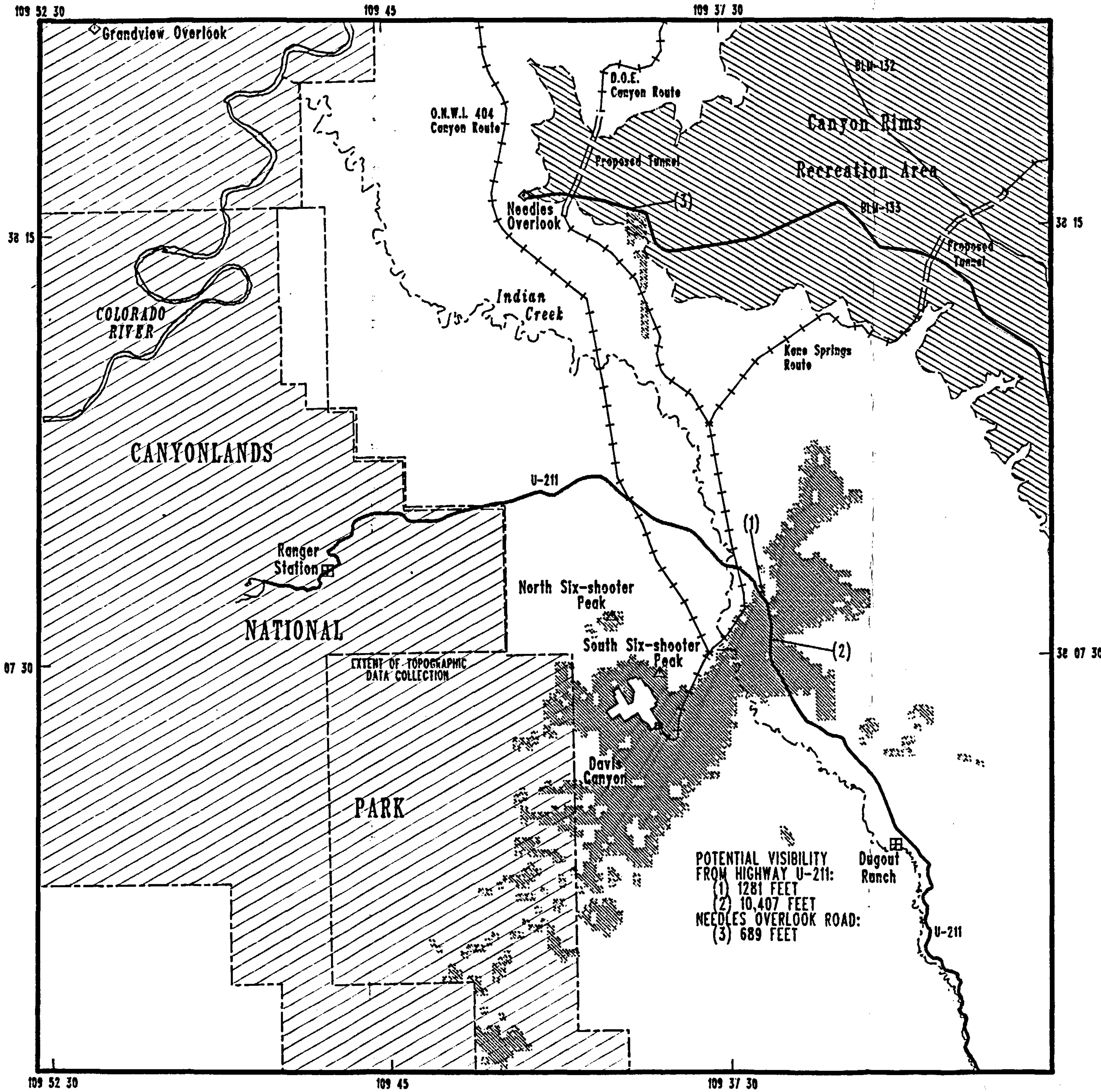


STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

METEOROLOGICAL TOWER

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

SCALE 1:150,000

5 0 5 MILES

5 0 5 KILOMETERS

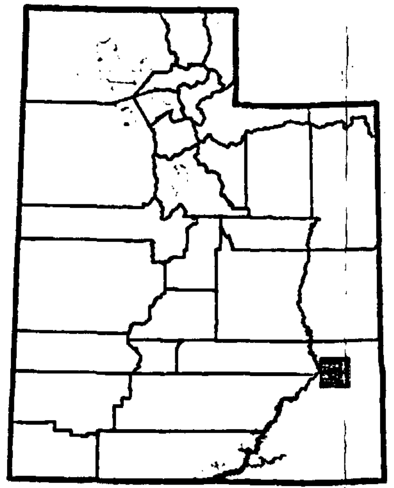
EXPLANATION

Location of the METEOROLOGICAL TOWER within the Proposed Repository site.

Locations within the Study Area from where the Proposed Repository METEOROLOGICAL TOWER could be VISIBLE at a height of 197 feet.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

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Statutory Environmental Assessment for Davis Canyon, Fifth Draft, August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

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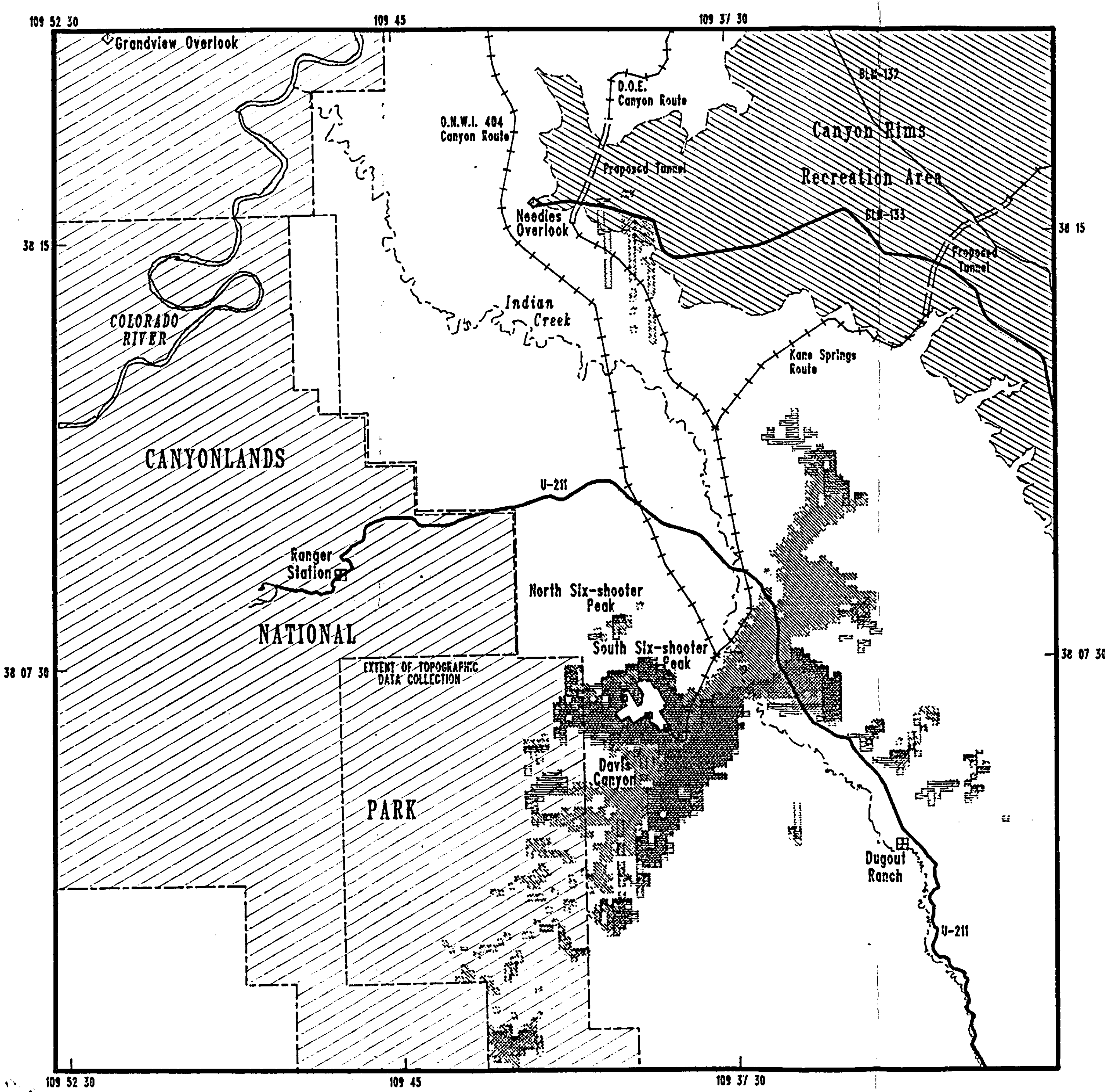


STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

COMPOSITE VISIBILITY

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

Also Available On Aperture Card

TI APERTURE CARD

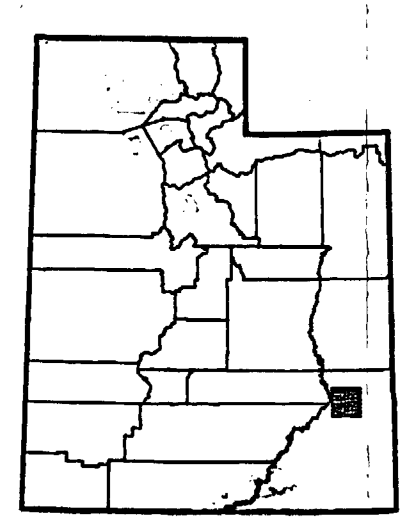
SCALE 1:150,000

5 0 5 MILES

5 0 5 KILOMETERS

EXPLANATION

- Approximate location of the Structural Component of the Proposed Repository which was tested for Visibility.
- Locations within the Study Area from where the Proposed Repository SERVICE SHAFT HEADFRAME could be Visible at a height of 220 feet.
- Locations within the Study Area from where the Proposed Repository MAINTENANCE BUILDING COMPLEX could be Visible at a height of 30 feet.
- Locations within the Study Area from where the Proposed Repository METEOROLOGICAL TOWER could be Visible at a height of 197 feet.



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U.S.-D.O.E. Briefing on Repository Design, 1982

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not be visible from U211." (p.77). The limited scope of the visibility testing of the exploratory shaft facility in ONWI 454 does not adequately support this conclusion. The DEA in Chapter 4 also indicates that the exploratory shaft facilities would not be visible from U211 (pp. 4-107 - 4-109) while in Chapter 5 it is admitted that the facility may be visible from U211 (p.5-66). Adequate justification or, especially, quantification is not provided in the available information to support either of these conclusions.

ONWI 454 and chapters 4 and 5 of the DEA (sections 4.2.1.7 and 5.2.6) speculate about the significance of the visual "impact" of repository development based on comments in ONWI 454 and anticipated results of future applications of the BLM Visual Resource Management process. No ONWI reports have been released which document the actual application of the VRM procedures in Davis Canyon or which support these conclusions.

ONWI 454 summarizes the results of visibility tests from a series of observation locations in the Gibson Dome area. The focus of the state's 1983 study was to make this type of assessment (that study was completed prior to the release of ONWI 454). Both studies use some of the same general view origins while, again, the application of the methodology differs. The Utah 1983 study clearly identified the visibility of the Davis Canyon site (at ground level) from a viewing location on Utah Highway 211 east of the site. ONWI 454 concludes that "...a structure at the Davis Canyon site would not be visible from Utah Highway 211" (p.77).(The DEA does acknowledge visibility of the facility from U211 but fails to quantify the distance as mentioned previously.) The state's 1983 study also clarified the extent of visibility of the alternative proposed railroad routes from major viewing locations in the area. Table 2 summarizes the pertinent results of Utah 1983 including repository visibility. The maps following Table 2 (from Utah, 1983) show the extent of visibility of the proposed facilities.

TABLE 2

VISIBILITY OF PROPOSED RAILROAD ROUTES
AND REPOSITORY SITE
FROM CRITICAL VIEWING LOCATIONS

Critical Viewing Location	Length of O.N.W.I.-404 CANYON ROUTE Visible	Length of D.O.E. CANYON ROUTE Visible	Length of KANE SPRINGS ROUTE Visible	Area of REPOSITORY SITE Visible
Grand View Point Overlook	9.3 mi.	6.8 mi.	4.9 mi.	0.0 acres
Needles Overlook	12.9 mi.	9.4 mi.	6.1 mi.	0.0 acres
Hwy. 211 Northern Location	1.9 mi.	3.9 mi.	4.2 mi.	0.0 acres
Hwy. 211 Southern Location	2.7 mi.	2.3 mi.	1.4 mi.	117.6 acres 34% of site

Chapter 5 (section 5.2.6) of the DEA also speculates as to the expected degree of "impact" and contrast presented by construction of one of the proposed railroad routes. The assumption is that the BLM-VRM contrast rating procedure "...will identify necessary design or mitigative measures..." (p. 5-67). In fact, the BLM-VRM contrast rating process is designed to quantify contrasts and "define acceptable limits of visual impact" (BLM, 1978; section 8431) not "identify" mitigation measures. By identifying elements of high contrast, those elements become candidates for mitigation emphasis. The

STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

CVL ON U-211 EAST OF SITE

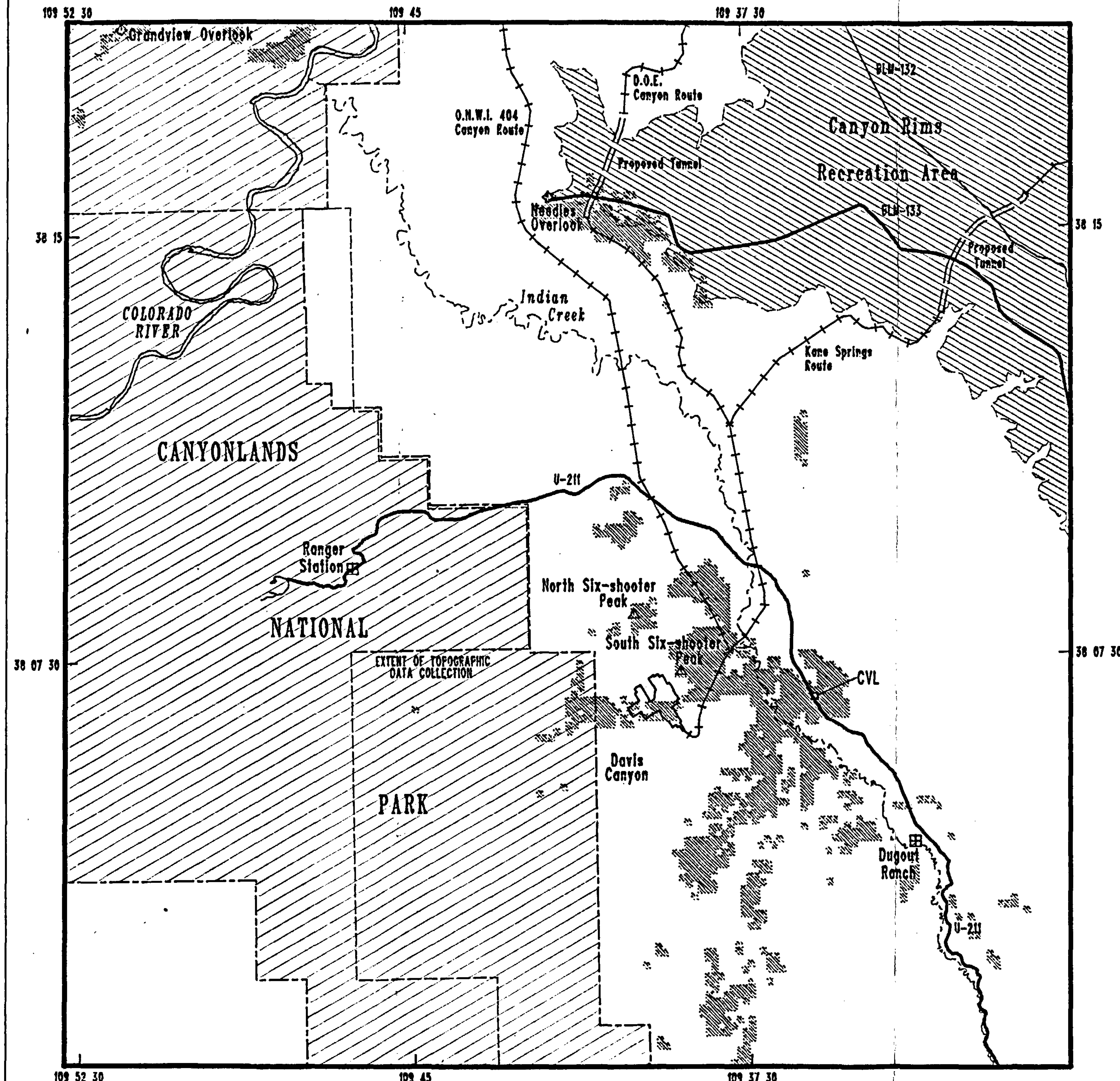
COMPILED BY

UTAH AUTOMATED GEOGRAPHIC REFERENCE

State Office Building

December 1984

SCALE 1:150,000



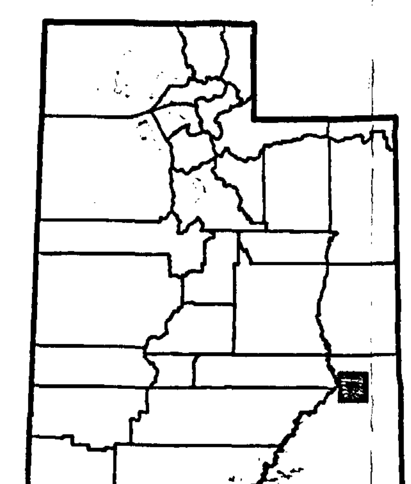
EXPLANATION

Location of designated Critical Viewing Location (CVL) at viewing turnout on highway U-211 east of site.

Areas visible within Review Area from Critical Viewing Location.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

PRIMARY SOURCE MAP:
U.S.G.S. Canyonlands National Park and Vicinity, 1958, 1:62,500

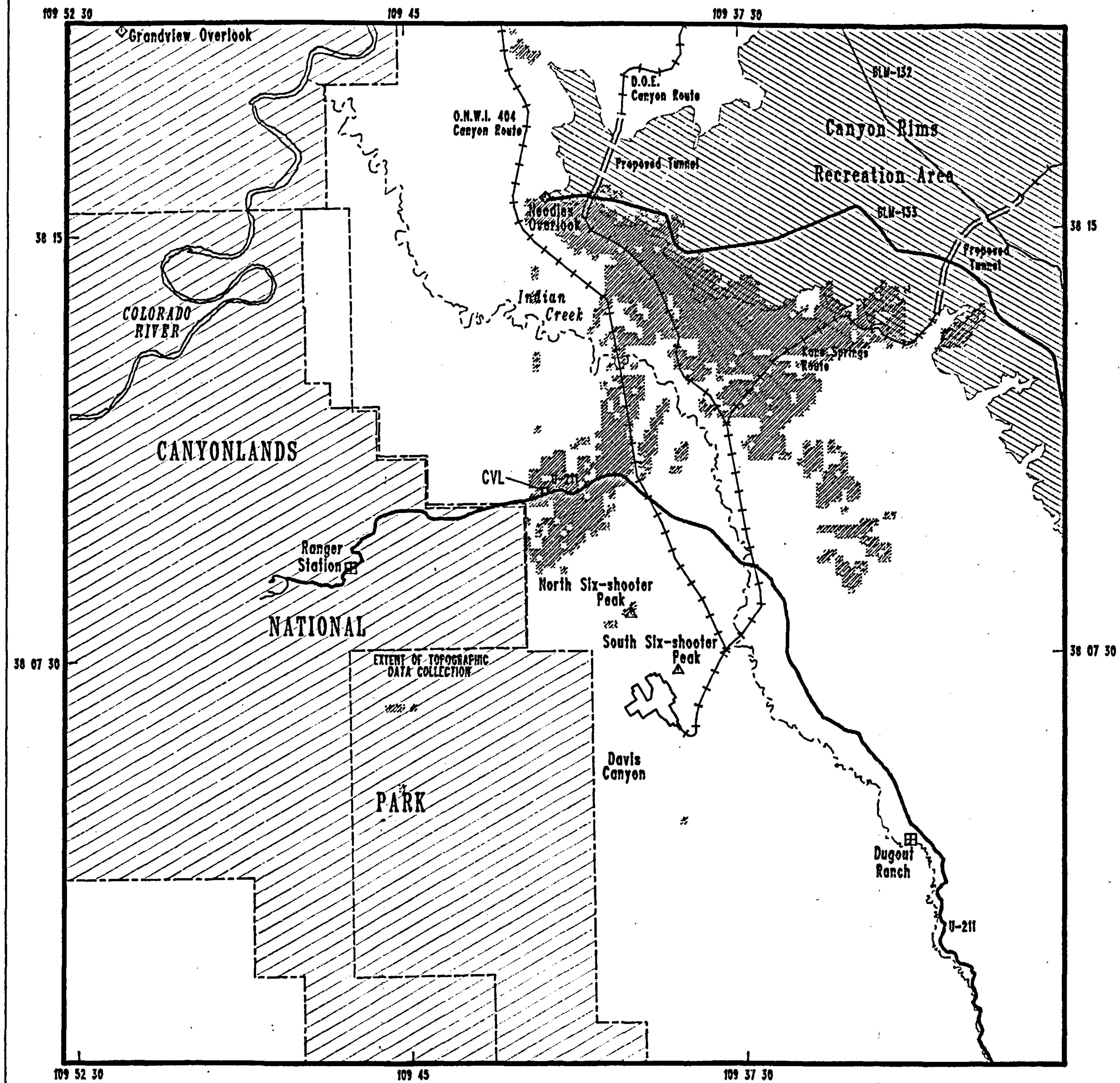
ADDITIONAL SOURCES:
O.N.W.I. reports 404, 291, 454, and others

Statutory Environmental Assessment for Davis Canyon, Fifth Draft, August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

8506100455-06



STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

CVL ON U-211 NORTH OF SITE

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

SCALE 1:150,000

5 0 5 MILES

5 0 5 KILOMETERS

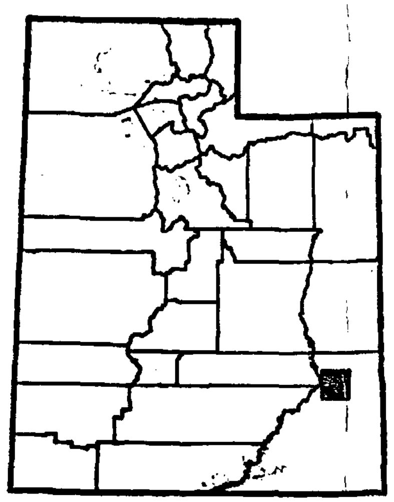
EXPLANATION

Location of designated Critical Viewing Location (CVL) on highway U-211 northwest of site.

Areas visible within Review Area from Critical Viewing Location.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

PRIMARY SOURCE MAP:
U.S.G.S. Canyonlands National Park and Vicinity, 1968, 1:62,500

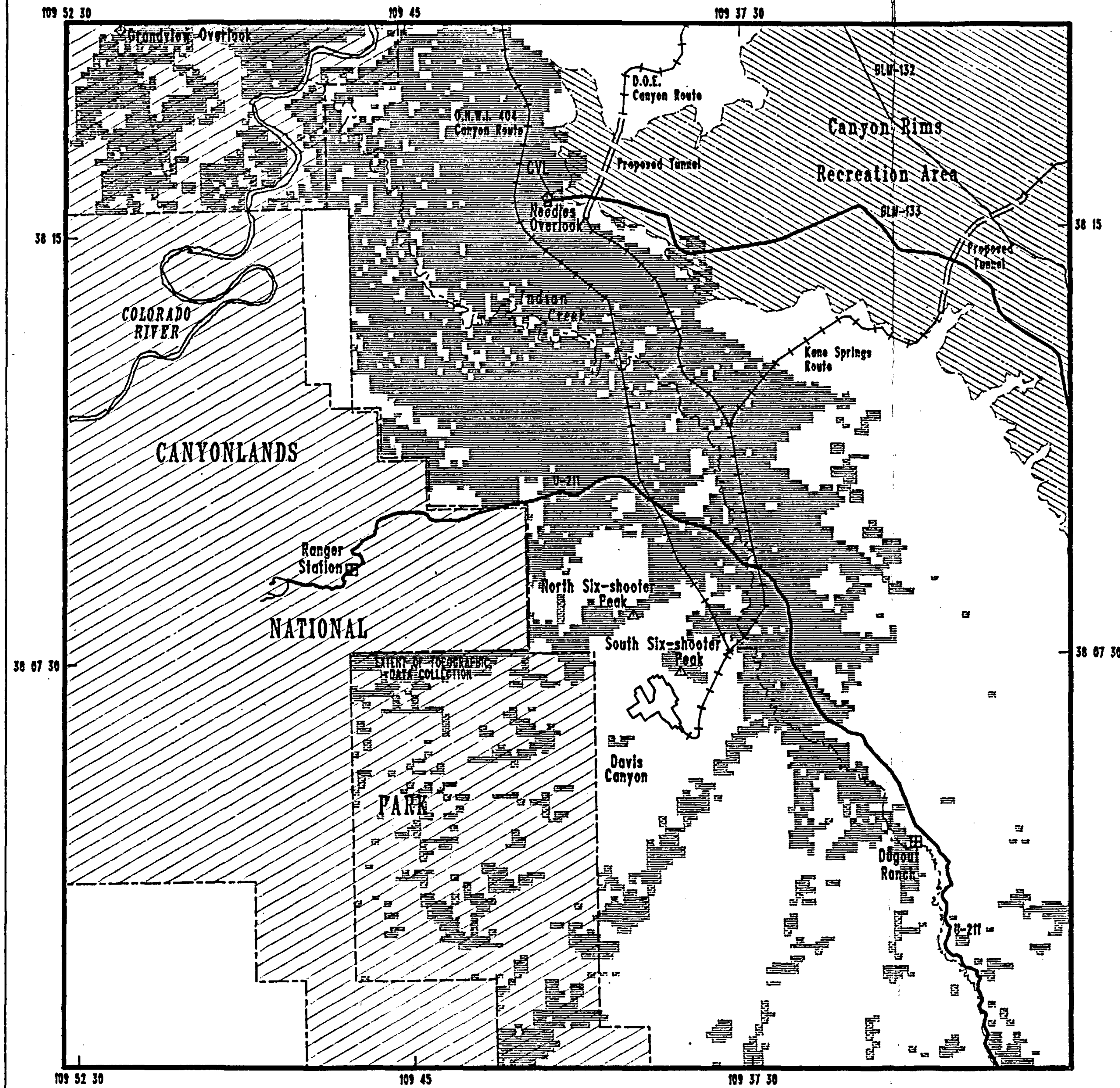
ADDITIONAL SOURCES:
O.N.W.I. reports 404, 291, 454, and others

Statutory Environmental Assessment for Davis Canyon, Fifth Draft, August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

8506100455-07



STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

CVL AT NEEDLES OVERLOOK

COMPILED BY
UTAH AUTOMATED GEOGRAPHIC REFERENCE
State Office Building
December 1984

SCALE 1:150,000

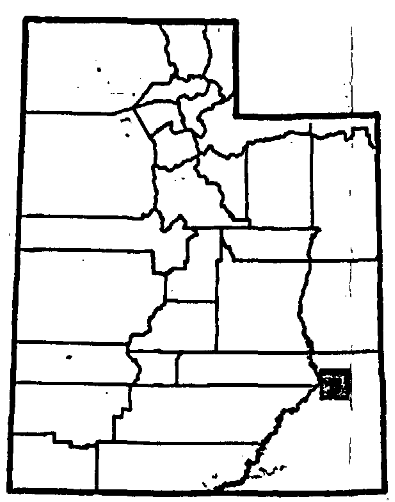
EXPLANATION

▫ Location of designated Critical Viewing Location (CVL) at Needles Overlook.

▒ Areas visible within Review Area from Critical Viewing Location.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

PRIMARY SOURCE MAP:
U.S.G.S. Canyonlands National Park and Vicinity, 1968, 1:62,500

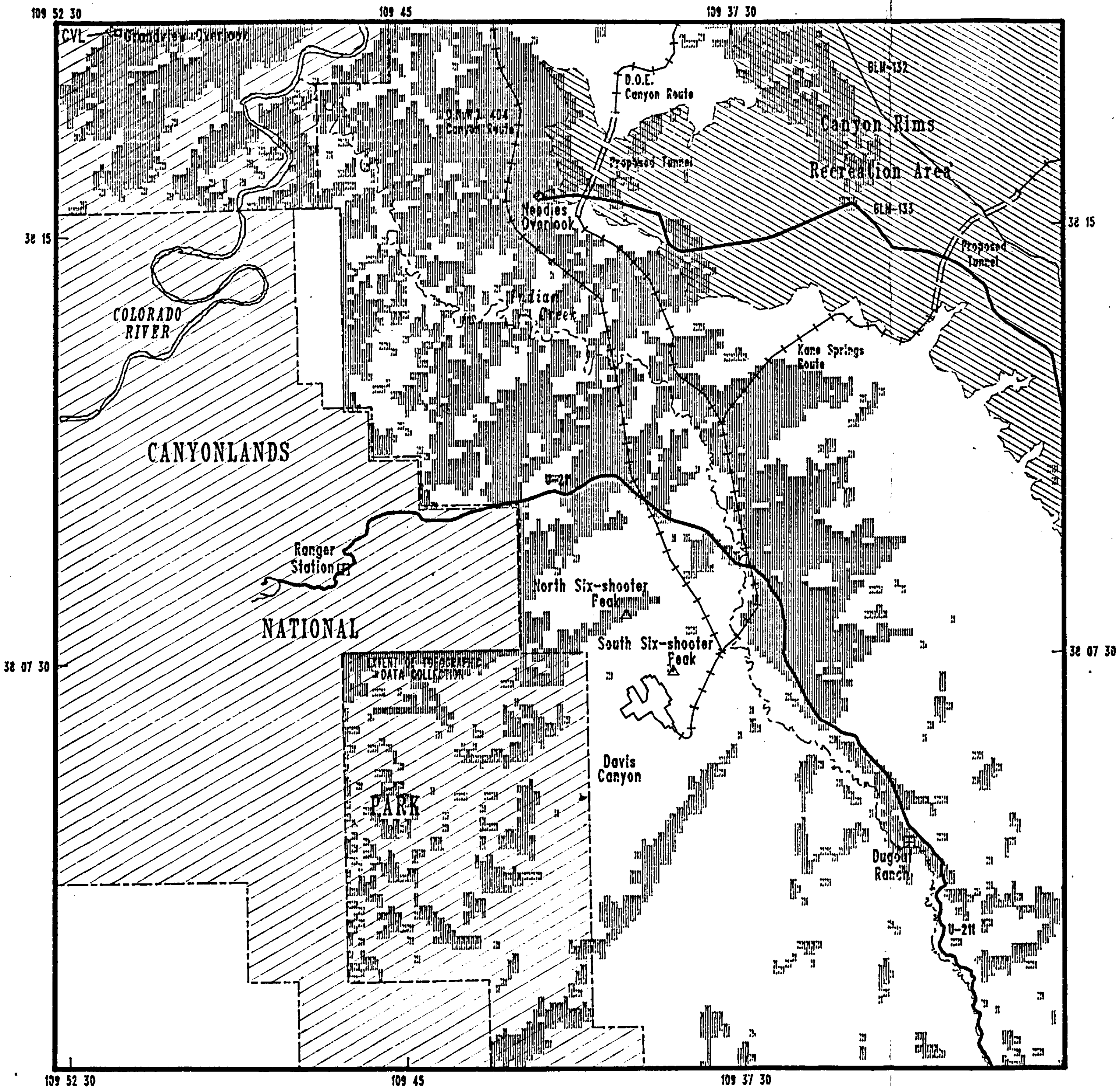
ADDITIONAL SOURCES:
O.N.W.I. reports 404, 291, 454, and others

Statutory Environmental Assessment for Davis Canyon, Fifth Draft, August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

8506100455-08



STATE OF UTAH

VISIBILITY ASSESSMENT OF THE PROPOSED NUCLEAR WASTE REPOSITORY DEVELOPMENT AREA

CVL AT GRANDVIEW OVERLOOK

COMPILED BY

UTAH AUTOMATED GEOGRAPHIC REFERENCE

State Office Building

December 1984

SCALE 1:150,000

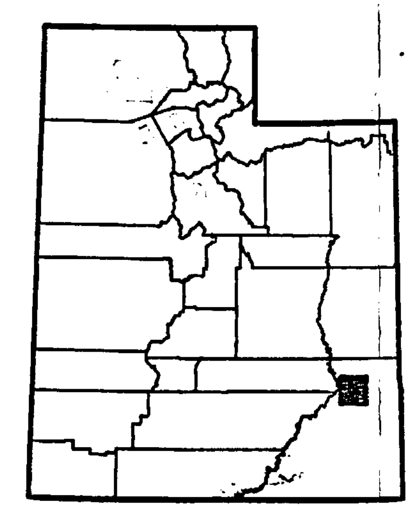
EXPLANATION

Location of designated Critical Viewing Location (CVL) at Grandview Overlook.

Areas visible within Review Area from Critical Viewing Location.

Also Available On Aperture Card

TI APERTURE CARD



INDEX MAP

PRIMARY SOURCE MAP:
U.S.G.S. Canyonlands National Park and Vicinity, 1968, 1:62,500

ADDITIONAL SOURCES:
O.N.W.I. reports 404, 291, 454, and others

Statutory Environmental Assessment for Davis Canyon, Fifth Draft, August 1984

U.S.G.S. 15 minute quadrangle maps 1:62,500

U.S.-D.O.E. Briefing on Repository Design, 1982

8506100455-09

contrast ratings themselves must be interpreted and mitigation recommended by a qualified landscape architect (section 8431.33A). Again, no ONWI reports or other technical information have been released which document the application of the BLM-VRM contrast rating process by the DOE or that support the conclusions presented.

ADDITIONAL COMMENTS ON ONWI 454

Comparison of the procedural aspects with the conclusions of ONWI 454 raises questions about the purpose of the study. Methodologically it contained at least three critical shortcomings from a visibility assessment standpoint only (some of which were also discussed earlier).

1. The site plan used to determine visibility was years out of date. Eventhough the study had been initiated in 1981, the ensuing three years prior to its release provided ample time to revise the procedure to utilize more current site plans. In addition, ONWI 454 submits rationale that the point selected for testing was the probable location of the shaft headframe in the exploratory shaft facility (ESF). The DEA provides a site plan for the ESF which is located in a different area of Davis Canyon than the site plan used for the visibility testing in ONWI 454 (see section 4.2.1.7, page 4-23 of the DEA). <u>No</u> sections of the ESF will be located at the point where ONWI 454 tested the Davis Canyon site for visibility. This additional information completely invalidates <u>any</u> conclusions regarding visibility of the Davis Canyon site which the DOE is presenting. The use of the results of ONWI 454 to base conclusions

regarding visibility is not valid. ONWI 454 is the only available technical documentation on Davis Canyon visibility. It presents unusable results.

2. Similarly, only one structure (point) in that original site plan was tested for visibility. However, subsequent conclusions relative to the visibility of the Davis Canyon site were based on the analytical results presented in ONWI 454. More locations with greater representation of the repository should have been tested.

3. The portion of ONWI 454 that tests and discusses the visibility of the proposed alternative railroad routes is also incomplete. ONWI 404 is sited as the source for the railroad routes but ONWI 454 tests the visibility of routes which terminate several miles north of the Davis Canyon site. The rationale was that no decision had been made on the exact location of the final sections of the railroads. This reasoning was unjustified and inconsistent in that the location of that section was no more uncertain than the other sections. Total mileages without this section are summarized in ONWI 454. The fact remains: there would be extensive visibility of all routes from both inside and outside of Canyonlands National Park (ONWI 454, pp.47-72).

Serious concern is raised regarding the conclusions of potential visual impact. Throughout ONWI 454 there is considerable speculation about the degree of contrast and compatibility between the existing landscape and the proposed repository in Davis Canyon through simulated application of the BLM-VRM process (e.g.,p. 73). No data has been presented upon which to base the anticipated contrast ratings or the conclusions that the contrasts/impacts could be mitigated to an acceptable level based on the VRM class. Additionally, ONWI 454 (and the DEA) erroneously states that "...the degree of contrast for any one element [of an] activity in a Class II area should not exceed moderate [2] and the total contrast rating score for each feature may not exceed 12." (p. 39). The BLM-VRM manual states that "...the contrast rating score [for any feature] may not exceed 10." in a Class II area (section 6320.11B).

A critical oversight in ONWI 454 and the DEA is the failure to explicitly acknowledge Canyonlands National Park as a Class I area. None of the contrast or impact speculation addresses or even seriously considers this important fact. The potential negative influence which facilities associated with repository development could have on the visual quality of the landscape as viewed from inside Canyonlands is a major factor in considering the Gibson Dome sites in general and the Davis and Lavender Canyon sites in particular.

ONWI 454 summarizes visibility tests from five potential sites. Most (if not all) of the immediate attention in the Gibson Dome area has centered on the Davis Canyon site (with the Lavender Canyon site also recognized). The justification for testing the visibility of the other three sites is not provided in ONWI 454 and is difficult to ascertain. Are these actually potential candidate sites and if so, why isn't more assessment in all areas (e.g.,environmental, socio-economic, etc.) being conducted for them as well as Davis and Lavender Canyons? If they are not candidate sites then why were they included in the analysis at all and why were those efforts perhaps not redirected toward more complete analysis of the other sites?

Additional concerns arise from review of the report. Included in those are the admission that "...in 1981...42,098 people entered Canyonlands via U211." (p. 11) and that the Colorado River Canyon "...is a major visual resource in the area." (p. 13). These realizations could (and should) be factored into the conclusions regarding potential visual impact. No reference is made to them in the sections of ONWI 454 that discuss impacts.

ADDITIONAL COMMENTS ON THE DRAFT ENVIRONMENTAL ASSESSMENT

Concerns relative to the approach in addressing visual contrasts have already been raised. Again in the DEA there is considerable speculation about potential contrasts translated to impacts but little or no documentation of actually implemented procedures by DOE are presented to support the conclusions.

A descrepnacy exists within the DEA itself regarding the location and resultant visibility of the service shaft headframe. Although all visibility tests for this structure were conducted from a point on the east side of the site, the site plan (see Figure 1) shows the service shaft headframe on the west side of the site. (This situation caused considerable consternation during the planning phase of this review.) If this is in fact the case, the visibility data for this structure as presented in the DEA, even in the exploratory shaft phase, would be invalid.

Section 5.2.6 of the DEA also describes other features which would have been constructed during site characterization (e.g., the meterological tower). Why were these not also tested for visibility? In contrast with ONWI 454, the DEA also suggests that even the shaft headframe would be visible from U211 (p. 5-66) although it fails to quantify the distance or degree of contrast or identify the analytical source of the information.

Conclusions of insignificant impact on Canyonlands due to small numbers of visitors to remote areas does not take into account the sensitivity of the viewer, the opportunities foreclosed, the degree of contrast, the fact that the viewer origin is within a class I area, or that the feature will probably be located in the foreground/middle-ground distance zone from the location indicated at the head of Davis Canyon.

The conclusions of visual impact (p. 5-68) of the proposed repository make no mention of the visibility from U211. This is another remarkable oversight after previously admitting that the facility would be visible from that primary access road to Canyonlands. In addition the admission that "nighttime skyglow impact from illumination could affect significantly large numbers of visitors." (p. 5-68) brought few suggestions for mitigation measures.

If the DOE actually intends to implement the BLM-VRM process it should do so with comprehensiveness both in terms of the accuracy and the scope of the assessment. It should assess the potential impacts of all facilities throughout the process. The DEA does not even hint at implementing the short-term/long-term contrast evaluation process as dictated in the VRM process documentation for a facility with the construction characteristics similar to those of the proposed repository (section 8440.11C of BLM, 1978).

Apparently the DOE has a key problem with the integration of data from different disciplines. The DEA makes only slight reference to air quality-related impacts to the visual resource. The pristine clarity of the air and resulting expansive vistas in this region are keys to its attractiveness as a tourist destination. The speculative conclusion of the expected impacts of reduced air quality on visual and aesthetic quality (section 5.2.5.6) desperately need more thorough investigation, integration, and quantification to comprehensively assess potential impacts.

The results of the visibility tests are displayed on maps which are almost wholly unreadable. With the simplification of advanced cartographic and reproduction techniques now available, excuses for maps or illustrations of this extremely poor quality, especially in a study as critical as this, are difficult to understand.

RECOMMENDATIONS

This review information regarding the potential visibility of the proposed high-level nuclear waste repository and ancillary facilities has stimulated a number of varied suggestions. These recommendations are made to encourage more comprehensive and better quality assessment of potential impacts that repository development could bring to the visual resources in the Davis Canyon area.

1. The State of Utah should require the DOE to complete more comprehensive visibility studies to determine areas requiring contrast rating. This should be completed for all repository-related facilities at any likely Utah site as well as for any transportation routes required to access the facility along their entire lengths from their origins to the actual site for any iteration of any alternative.

2. The DOE (and the state) should become intimately familiar with the BLM-VRM process if the intention is to implement it in assessing visual impacts. This or a similarly proven methodology should be an integral part of the impact assessment process. The DOE should employ a qualified landscape architect to conclude, compile, and release quantitative contrast ratings for <u>all</u> of the repository-related facilities prior to any construction or characterization. In addition, using the contrast ratings, the DOE should compile specific recommendations for alternative mitigation strategies for any contrast rating that exceeds the allowable for the management area.

3. An integrated study of the cumulative effects of air quality deterioration and visual contrast or influence should be completed for all proposed repository facilities prior to any construction-like activity.

4. The State of Utah should retain or employ a seasoned "expert" in the specific area of visual studies (including air quality considerations) to assist with document review and legal consultation on the visual issue associated with potential repository development. This resource could be invaluable in compiling appropriate documentation for future general and legal reference.

5. The DOE should themselves or require their subcontractors to employ a cartographer to complete final, readable maps for inclusion in all their reports, especially those related to repository siting.

SUMMARY

The U.S. Department of Energy is considering sites in Utah for the long-term containment of high-level radioactive waste. One of those sites, Davis Canyon, is within one mile of Canyonlands National Park. The specific attraction of the Park in terms of its scenic beauty causes particular attention to be drawn to the possible extent of impacts to the area's visual quality.

The DOE has discussed the potential visibility and visual impacts associated with repository and railroad route development in Davis Canyon. Those studies and findings were reviewed and evaluated in the context of additional visibility information. Questions were raised as to the completeness of the analysis and justification for the conclusions.

Implementation of the technical review process included actual visibility verification following the methodology in ONWI 454. That methodology was reconstructed while its application was modified to reflect more current input information to conduct a thorough review of the study's findings.

Discrepancies were identified in findings of visibility of the Davis Canyon site between ONWI 454 and the review. The review identified extensive visibility of repository structures along Utah highway 211 (2.7 miles) as well as potential visibility from the road to Needles Overlook.

Recommendations were made for improved quality and quantity of visibility, visual impact assessment, and documented data to support conclusions presented in the Draft Environmental Assessment.

REFERENCES

Bechtel Group, Inc., 1984. Visual Aesthetics Study: Gibson Dome Area, Paradox Basin, Utah, ONWI-454. Prepared for Office of Nuclear Waste Isolation, Columbus, Ohio.

Johnson, Michael, Utah Office of Planning and Budget, 1983. Visibility Analysis of the Davis Canyon High-Level Nuclear Waste Repository Proposal. Prepared for the State of Utah.

U.S. Department of Energy, 1984. Draft Environmental Assessment, Davis Canyon, Utah.

U.S. Department of the Interior, Bureau of Land Management, 1978. Visual Resource Management Manual.

APPENDIX E

Appendix E

CRITIQUE OF NOISE IMPACT ANALYSIS

IN

DOE DRAFT ENVIRONMENTAL ASSESSMENT

FOR

PROPOSED NUCLEAR WASTE REPOSITORY

IN

DAVIS CANYON, UTAH

by

James D. Foch, Jr.
152 Castleford Circle
Danville, CA 94526

March 14, 1985

CONTENTS

1. SPECIFIC FINDINGS

FINDING 1: Atmospheric absorption coefficients used in the prediction of exploratory shaft construction noise (Ref. 2, p. 53), and in the prediction of blasting noise (Ref. 3, Appendix A, revised calculation N-11), are approximately twice as large as the accepted values (Refs. 4, 5) for the temperature and relative humidity assumed in the environmental assessment.

SIGNIFICANCE: All sound levels predicted for the proposed activity are in error on the low side: Ldn contours and audibility contours enclose less area than they should.

RECOMMENDATION: All sound level predictions should be repeated with correct absorption coefficients or, possibly, corrected to take into account accepted absorption coefficients.

FINDING 2: Anomalous absorption due to ground effect has been overemphasized by underestimating source heights (Ref. 2, p. 52; Ref. 3, Appendix A, calculation N-16) and, possibly, by neglecting local ground conditions (absence of appreciable amounts of grass).

SIGNIFICANCE: Computer predictions are in error on the low side by up to seven decibels.

RECOMMENDATION: Anomalous absorption due to ground effect should be reassessed taking into account local ground conditions and realistic average height of source point and observation point.

FINDING 3: The role of temperature inversions in enhancing long range sound propagation has been seriously underestimated. The computer programming device used to simulate temperature inversions can enhance sound by at most three decibels, even though 15 decibel enhancements would not be unreasonable. Temperature inversions appear to have been ignored in predicting sound levels due to blasting.

SIGNIFICANCE: Temperature inversions due to nocturnal cooling are so common in Utah that they must be taken into account, particulary for the many activities which will produce appreciable amounts of sound 24 hours per day.

RECOMMENDATION: Predicted sound levels due to machines and blasting should be reassessed by using models which are intermediate between spherical divergence and cylindrical divergence, or by using established empirical correlations for temperature inversion effects.

FINDING 4: Blasting calculations are in error due to a double counting of the scaled depth of burial correction (Ref. 3, Appendix A, revised calculation N-11).

SIGNIFICANCE: All predictions of peak blasting sound levels are seven decibels too low.

RECOMMENDATION: Increase all predictions of peak blasting sound levels by seven decibels, adjust blasting sound audibility contours accordingly, and correct contours for cumulative blasting sound exposure.

FINDING 5: Predicted sound levels due to blasting are unrealistic in that the same explosive charge has been assumed for exploratory shaft construction and seismic exploration (Ref. 3, Appendix A, revised calculation N-11). The quantitative basis for predictions of sound levels due to blasting during railroad construction (Ref. 1, p. 5-71) is unclear.

SIGNIFICANCE: Peak blasting sound levels depend on the size and number of charges detonated, as well as other site specific variables. Charges used for exploratory shaft construction and railroad construction are likely to be greater than charges used for seismic exploration.

RECOMMENDATION: More realistic blasting plans should be developed and used in the noise analysis. In the absence of such plans, estimates from surface mining experience may be useful.

FINDING 6: Computer modeling of natural barriers is overly simplistic and seriously misleading. Some locations in Canyonlands National Park, for example, are modeled as if they were shielded by barriers to the extent of 24 decibels (Ref. 1, p. 4-101), even though viewshed analysis (Ref. 1, p. 4-105) indicates the locations have a clear line of sight to ground level structures at the Davis Canyon site. The refraction of sound over barriers by temperature inversions seems to have been neglected.

SIGNIFICANCE: Modeling of natural barriers plays a crucial role in the noise analysis of the draft environmental assessment. The barrier models greatly reduce the noise impact of the proposed activity.

RECOMMENDATION: Modeling of natural barriers should be improved by taking into account the actual terrain between source point and observation point, even if this means the number of observation points must be reduced. Predictions should include explicit indication of the magnitude of effects attributable to the natural barrier. Refraction of sound over natural barriers by temperature inversions should also be taken into account.

FINDING 7: The field measurements are too limited to be representative, and appear to be marred by equipment failure and uncertain calibration. In addition, altitude corrections may have been neglected during calibration.

SIGNIFICANCE: Good field measurements of the existing environment are an essential part of a draft environmental assessment. They are needed to provide a reliable reference point against which to judge the noise impact of the proposed activity. Ambient sound levels are probably much lower (most of the time) than allowed for in the draft environmental assessment.

RECOMMENDATION: Sound level measurements should be made on enough occasions to provide a representative sample. If, for example, seasonal wind patterns exist, such patterns should be taken into account in the field measurement plan (so as to avoid drawing conclusions from a biased sample). Measurements should be made at enough sites to represent fairly the area likely to be affected by the project. At least some of the measurements should be repeated merely to provide quality assurance. A high quality tape recorder should be used to make numerous recordings of indigenous sounds for subsequent octave band analysis with automated equipment, because the octave band results for indigenous sounds determine audibility of project related noise.

FINDING 8: Peak seismic blasting pressures are assumed to diminish more rapidly with distance (Ref. 3, Appendix A, revised calculation N-11) than is appropriate for great distances (Ref. 6).

SIGNIFICANCE: The geographic area within which seismic blasts will be audible has been underestimated.

RECOMMENDATION: Peak seismic blasting pressures, particularly at distances where audibility limits are at issue, should be based on a distance exponent of 1.1 rather than the 1.35 used in the draft environmental assessment.

FINDING 9: The criterion for "percent highly annoyed" has been misapplied. According to the draft environmental assessment, the sleep interference threshold of Ldn = 50 dBA (Ref. 7) should be reduced 15 decibels because "interior noise within a typical home is 15 decibels less than the exterior level" (Ref. 1, p. 4-99). The fallacy here is that the sound level at night in a campground is not likely to be as high as the sound level within a typical home.

SIGNIFICANCE: The criterion for "percent highly annoyed" would be a much lower value of Ldn if the logic of the draft environmental assessment were applied consistently. A greater area of impact would result, and more persons would be affected.

RECOMMENDATION: If a criterion for "percent highly annoyed" is to be applied as envisioned in the draft environmental assessment, it should be based on representative samples of measured sound levels in the existing environment.

FINDING 10: The potential role of seismic blasting has not received adequate attention. Terrain too rough for thumper trucks, or a desire for exceptionally good quality seismic reflection data, could result in much more seismic blasting than is foreseen in the draft environmental assessment (Ref. 1, pp. 4-18, 4-19).

SIGNIFICANCE: Most seismic blasting in the U.S. is above ground. If above ground blasting were used, no mitigation measures would be possible. Each blast would be audible over a hundred square miles or more, and 30 to 50 such blasts per day would not be an unreasonable expectation.

RECOMMENDATION: The draft environmental assessment, consistent with its worst case approach, should include thorough consideration of the impact of seismic blasting.

FINDING 11: The noise survey foreseen as part of the site characterization activities (Ref. 1, p. 4-71) is much too limited in scope.

SIGNIFICANCE: If the proposed site characterization activity occurs, the noise produced will have an impact on the surrounding public and private lands. A carefully planned noise monitoring program, together with relevant meteorological measurements, could provide a trustworthy data base for noise impact analysis in any subsequent draft environmental impact statement for repository construction.

RECOMMENDATION: Numerous automated noise monitors, of the type which can operate unattended for a week or more, should be deployed around the site if site characterization activities are initiated. Coordinated meteorological measurements should be carried out to document the factors influencing long range sound propagation to affected areas. Noises from site characterization activities, such as blasting, or all night operation of equipment, should be exploited as test cases to document the actual role of barriers, canyons, temperature inversions, ground effect, etc.

FINDING 12: The use of annual averages to characterize temperature inversions is inappropriate. Temperature inversions are much more prominent during the summmer than the winter, and more persons use the adjacent public lands during the summer than the winter.

SIGNIFICANCE: Temperature inversions enhance long range sound propagation significantly. The magnitude of the effect depends on the strength of the inversion and its height, increasing with both factors.

RECOMMENDATION: Temperature inversions should be characterized using the detailed information in the source (Ref. 8) cited in the draft environmental assessment, or site specific data should be obtained and used.

FINDING 13: The use of man-made barriers as a mitigating measure (Ref. 1, p. 4-102) will be of limited value because of the refracting influence of temperature inversions on long range sound propagation.

SIGNIFICANCE: If the noise impact analysis is wrong, there may be no "technical fix".

RECOMMENDATION: All putative mitigating measures should be analyzed carefully and thoroughly, as if it were certain they would be needed.

2. ANNOTATED COMMENTS

Note: *Text from the draft environmental assessment is italicized;* comments are not italicized.

page 15...*During repository construction, short duration noise levels from intermittent blasting may be audible over 5 miles from the site center for the initial period of shaft construction (approximately 2 weeks). The blasting for the rail-line tunnel may be audible up to 12 miles away. During operation, machinery noise would be heard in the Park, and the noise made by the trains hauling waste may be audible up to 8 miles from the track. Possible mitigation measures include the proper scheduling of activities and the use of physical sound barriers....*The distances specified here for limits of audibility are too low because of errors in the treatment of blasting and of atmospheric absorption, and because the background or indigenous sound levels have been overestimated.

page 16...*Highway access to the Davis Canyon site would use U.S. Highway 191, which may need to be upgraded at certain points. A new 29-mile highway would be constructed to connect the site to U.S. Highway 191. Rail access would require the construction of 37 miles of rail line over hilly terrain from the Potash Branch of the Denver and Rio Grande Railroad to the Davis Canyon site. The route would require tunnels under the Canyonlands and Needles Overlooks, a bridge over the Colorado River, and a crossing of the Park Service extension of State Highway 211....*Each of these "access" projects would ordinarily merit an environmental assessment or an environmental impact statement. They are barely touched upon in the present draft environmental assessment. It is as if the other, much larger scale, activities envisioned made the "access" projects inconsequential.

page 3-148...*The Needles District, on the western edge of the Davis Canyon site, had 51,100 visits during 1983. April, May, and June had the highest number of visits in that year (Table 3-17). This section of Canyonlands National Park is accessible via Highway U-211 and a National Park Service extension of U-211. Of the total visitors to the Needles District, 65 to 75 percent entered the back country. The number of reported visitors to Davis Canyon in 1983 was 829. These are regarded as conservative figures. Normally, jeep trail registers and back country permits are used to determine the number of visitors to Davis Canyon. During the latter half of 1983, however, several floods washed out the register boxes, and data are not available from that source for July through December. Because of this and informal observations of nonregistrations, the National Park Service estimates that actual visitation was at least 50 percent higher (NPS, 1984). Approximately 50 percent of all the visitors to the District use Horse Canyon or Salt Creek, located near the southeast boundary of the park, This area is also used extensively for outdoor education schools (BLM, 1982b, p. 62; Canyonlands National Park, General Management Plan, 1978)....*To the extent that outdoor amphitheatres exist in the park, special criteria (protecting against speech interference by project related noises) may be applicable.

page 3-166...*Mixing height and wind speed influence regional air quality. Commonly, mixing heights and controlling inversion layers have a large diurnal variation (low in the morning and high in the afternoon). The Davis Canyon site generally has relatively high mixing heights and moderate wind speeds. The most restrictive dispersion season is winter, when both mixing heights and wind speeds are low.*

Poor dispersion conditions (episodes) that persist for long durations can result in buildup of ground-level ambient concentrations produced by emissions. An episode is defined as the occurrence of mixing heights less than 1,500 meters (4,921 feet) on at least two consecutive days, wind speeds of less than four meters per second (8.9 miles per hour), and no significant precipitation. For example, Grand Junction, Colorado (the closest reporting station to the geologic repository operations area) reported 43 episodes totaling 193 days during a 50 year period (Holzworth, 1972, p. 83). Fourteen of these episodes were at least 5 days long, totaling 111 days. Winter episodes were the longest....These episodes are prolonged temperature inversions, during which long range sound propagation would be significantly enhanced without diurnal relief.

page 3-168...*The nearest data source for average annual winds is at Green River, approximately 145 kilometers (90 miles) north-northwest of the Davis Canyon site. There, winds average 2.1 meters per second (4.7 miles per hour), with the prevailing directions from the southwest through west. The highest annual average wind speed, 3.0 meters per second (6.7 miles per hour), was from the south-southwest (NOAA, 1974). However, both wind speed and direction may differ for the site because of variations in local terrain and the channeling effects of valleys*....The occurrence of wind enhances sound propagation downwind and diminishes it upwind. To the extent that prevalent wind speeds and directions can be identified around the site, they should be taken into account in assessing noise impact.

page 3-169...*The noise environment of the Davis Canyon site is characterized as quiet, consistent with its rural character. Noise in this sparsely populated area is primarily caused by wind passing over the vegetation. Additional noise is created by natural sources such as birds and insects, and occasional human-related sources such as aircraft and surface vehicles. Areas in the vicinity of the jeep trails experience high noise levels from recreational vehicle activity. The complex topography in the area can result in both increased attenuation of noise because of barrier effects, and reduced attenuation as a result of noise reflection.*

One measure of noise is the A-weighted sound pressure level, L90, the value equaled or exceeded 90 percent of the time. Hourly L90 values as low as 19 a-weighted decibels (dBA) have been measured during night and early morning hours in and near *the Davis Canyon site. These measurements were made at Peekaboo Springs campground in Canyonlands National Park, Davis Canyon, and Dugout Ranch. Another measure of noise is the sound pressure level of a constant sound that has the same energy as the time-varying sound measured over a given time interval. Twenty-four-hour-energy-equivalent levels (Leq) have ranged from 34 dBA in Canyonlands National Park to 41 dBA at Dugout Ranch, where ranch activities contribute to the ambient noise level. The minimum hourly Leq measured in the area was 20 dBA. The day-night sound pressure level, Ldn, defined as the 24-hour A-weighted equivalent sound pressure with a 10 dBA penalty applied to the nightime levels (2200 to 0700 hours), was found to range from 37 dBA in Canyonlands National Park to 46 dBA at Dugout Ranch (BGI, 1983b, ONWI-460, p. 8).*

*The U.S. EPA has not promulgated any community noise regulations pursuant to the Noise Control Act of 1972 that are applicable to site characterization and repository construction, operation, and closure. The Act requires Federal agencies to comply with state and local noise regulations. Currently, there are no applicable state or local regulations at this site....*The dominant role attributed to wind as a generator of indigenous sound is probably an artifact of the limited field sample. The quantitative empirical values cited for Ldn and Leq cannot be accepted as reliable, for the same reason. EPA has played a vigorous and well publicized role in trying to protect national parks from noise pollution: Bryce Canyon National Park--strip mining noise; Grand Teton National Park--airport noise; Glacier National Park--seismic exploration noise.

page 4-71...*A two-season noise survey will be conducted to evaluate background sound levels. Sound-level data will be used in the analysis of impacts due to repository construction and operation.*

Sound-level data will be collected for the site for summer and winter seasons, including weekdays and weekends, and at all times of the day and night. Survey points and sampling periods will be designed to develop a representative statistical statement of the background sound levels at the Davis Canyon site. Existing noise sources at the site will be identified and octave band analyses will be performed to characterize significant noise sources. The instrument reading method of octave band analyses involves recording the average, maximum, and minimum sound levels for each octave band. These data will be used to determine sound levels at each location. To provide correlations with measurements, additional information on other parameters also will be recorded during the survey. Meteorological observations including wind speed, wind direction, temperature, and relative humidity will be made at each sampling location. Measurements obtained near roadways will be accompanied by a traffic count. Sound source observations will be recorded during each sample and include a notation of the predominant sound sources.

Each seasonal monitoring period will be approximately one week and require a field sampling team of two persons. Personnel access to the site and perimeter will be required; no equipment *installations are necessary. Field sampling teams will be working day and night on a periodic basis; however, no construction or permanent facilities will be necessary at sampling locations....*This is a "bare bones" noise survey. It doesn't even address the issue of validating the projections contained in the draft environmental assessment.

page 4-99...*There are no local or state regulations on permissible environmental noise levels. Two indicators of broadband environmental noise impact are used here. First, the U.S. Environmental Protection Agency (EPA) has identified an Ldn of 55 A-weighted decibels (dBA) as the level sufficient to protect the public from the effects of environmental noise in normally quiet outdoor areas where many people spend time (EPA, 1947). The Ldn is the average day/night energy equivalent level for the entire day with a 10 decibel penalty added to nightime levels (10:00 p.m. to 7:00 a.m.) to account for people being more sensitive to noise during these hours. The EPA has recommended adoption of an Ldn less than 55 dBA as a goal in project planning of future programs. Although no health and welfare effects are expected to occur where levels are under 55 dBA, a significant increase in noise over the existing conditions may lower the quality of the environment. The existing Ldn levels are expected to average between 35 dBA and 45 dBA with 35 dBA being typical of remote areas and 45 dBA being typical of areas near highways and communities.*

The human effects for outdoor Ldn levels of 55 dBA include these:

- *Slight speech communication interference beyond 1 meter*
- *Less than 5 percent of the population may be highly annoyed, depending on attitude and other non-acoustical factors.*

The second indicator of noise impact used here predicts the cumulative effect of activity interference due to noise measured in terms of annoyance. Although other factors, such as an individual's attitude toward a noise source, may influence reaction to activity interferences, the percentage of people highly annoyed in a given environmental situation provides a useful indication of the severity of the impacts. Results of all surveys involving transportation noise show a remarkable consistency between measured Ldn levels and the subjective reaction of high annoyance (Schultz, 1978). The types of sounds from transportation are similar to those expected from construction activities. Although speech-interference is one of the primary reasons for adverse community reactions to noise, sleep-interference is also a primary consideration. The associated interior noise within a typical home is 15 decibels less than the exterior level (EPA, 1974). Thus, the overnight camper in Canyonlands National Park would be 15 decibels more sensitive to intruding noise. The results of Schultz have been modified by this 15 decibel reduction in an attempt to account for the overnight camper. Therefore, this modified correlation between the average subjective reaction of being highly annoyed and Ldn levels is offered to provide a perspective of the *expected human response to noise from the project. It should be noted that "percent highly annoyed" is applicable to a large community but may be statistically less meaningful when applied to estimating the reaction to noise from the few individuals near the Davis Canyon site whose attitudes, along with other non-acoustical factors, may modify this effect. It should also be noted that noise will be audible beyond the distance at which an individual may be annoyed. The nearest designated primitive campground is located 8 kilometers (5 miles) from the site. The Canyonlands National Park is within 1.3 kilometers (0.8 mile) of the exploratory shaft. The nearest point of interest is the Tower Ruin, located within 4.8 kilometers (3 miles) of the exploratory shaft. The nearest residence is Dugout Ranch, located 9.5 kilometers (6 miles) away.*

The impact of tonal noise from the equipment is more difficult to quantify, based on existing information. Tonal noise may be produced by equipment, depending on the type and condition (wear) of the equipment. Although typical octave band information exists for the equipment to be used, the specific tonal components and their magnitudes depend on the manufacturer of the equipment.

Two factors aid in minimizing tonal noise impacts:

1. *The broadband noise caused by equipment such as engine (mobile equipment) tends to mask the tones, reducing the likelihood that the tones would be audible in noise sensitive areas.*
2. *Many of these tones (for noise sources such as welding rigs and air compressors) are at high frequencies (greater tha 1000 Hertz) and are, therefore, reduced by atmospheric attenuation.*

The Occupational Safety and Health Administration (OSHA) regulates noise in the work place. Noise control measures will be applied as necessary to meet OSHA regulations.

*The minimum Ldn in the area has been determined by field measurement to be approximately 37 A-weighted decibels (BGI, 1983d; ONWI-460, p. 8). Therefore, the project-related 35 A-weighted decibels contour is intended as an approximation of the boundary of potential annoyance for worst-case activities....*The use of Ldn as a descriptor for the acoustic environment in quiet, pristine places is inappropriate. This is vividly illustrated by the requirement of a 10 decibel penalty (according to Ldn methodology) during nights, which are often remarkably quiet on western public lands. Even if Ldn were used, it would make no sense to refer to the 55 dBA level identified by EPA as necessary to protect the public health and welfare with an adequate margin of safety. Here the issue is protecting the environment. EPA has not used the 55 dBA level in its efforts to protect the national parks referred to earlier...The Schultz work on "percent highly annoyed" (Ref. 8) is not germane to the present draft environmental assessment. Schultz's work concerned community reaction to noise of aircraft, street traffic, expressway traffic, and railroads. In other words, urban noise pollution...The efficacy of broadband noise in masking tonal noise is likely to be very modest, since only acoustic energy in a critical band (approximately a one third octave band) around the tonal component can contribute to masking...The minimum Ldn cited above from field measurements cannot be regarded as reliable, since it is derived from such a limited and questionable data base. Use of the Ldn = 35 dBA isopleth as an indication of the boundary of potential annoyance from worst case activities is unjustified, as discussed earlier.

page 4-100...*The noise predominantly associated with site characterization activities will occur during a three-month period when the construction activities of site preparation, surface facility construction, shaft drilling and casing, and shaft sinking overlap. Potential noise impacts arising from exploratory shaft development activities have been modeled (BGI, 1983, ONWI-460). The types of equipment to be used during exploratory shaft development have been tentatively identified in Section 4.1.2. Average meteorological conditions were assumed for the site, based on an average of 40 years (1936 to 1975) of Grand Junction, Colorado meteorological data. The average temperature was 53 F and the average relative humidity was 45 percent. An early morning inversion layer corresponding to the annual mean morning mixing height was assumed to persist. Attenuation from atmospheric distance and air absorption were treated by the model. Canyon walls, which act as noise barriers, were factored into the computer analysis.*

The modeling results are graphically presented in Figure 4-18. This figure presents the Ldn noise isopleths caused by exploratory shaft construction with a legend relating Ldn levels to percent highly annoyed. The following is a summary of modeling results:

1. *Equipment noise will result in noise levels exceeding an Ldn of 35 A-weighted decibels within approximately 2.9 kilometers (1.8 miles) of the site center (BGI, 1983, ONWI-460).*
2. *The Ldn 45 A-weighted decibels contour extends approximately 2.3 kilometers (1.4 miles) from the site center.*
3. *The Ldn 55 A-weighted decibels contour extends about 1.3 kilometers (0.8 mile) from the site center.*
4. *Noise levels using commercial power or industrial turbines are approximately equivalent.*

Areas outside the project-related 35 A-weighted decibels contour on Figure 4-18 are not expected to be affected by noise from exploratory shaft construction activities. Major points of interest in Canyonlands National Park such as Peekaboo Springs, Tower Ruin, and Gothic Arch are all located outside the project-related 35 A-weighted decibels contour. An absolute distance at which noise will be audible cannot be determined because of the many variables which affect audibility. These factors include

* *Background noise level*
* *Atmospheric conditions*
* *Frequency of the intruding noise and the background noise*
* *Presence of intervening structures*
* *Activity of the individual*
* *The amount of hearing loss of the individual, etc.*

However, using a broadband noise of 15 A-weighted decibels (5 A-weighted decibels below the minimum hourly Leq level) as a criterion for audibility, and assuming optimum listening conditions and average meteorological conditions, noise from site characterization activities (excluding blasting) may be audible 6.7 kilometers (4.2 miles) from the site (Figure 4-19). Noise from construction activities may be audible near the east edge of the park boundary in Davis Canyon and along Highway 211 east of the exploratory shaft. Noise levels at the nearest residence, Dugout Ranch, are not expected to increase perceptibly as a result of drilling activities.

Shaft sinking for the larger of the two shafts will occur over an eleven-month period using conventional shaft mining techniques. (This period does not coincide with the period modeled.) As part of this activity, blasting will occur once per day to break up rock in the shaft. The initial impact zone (corresponding to the C-weighted Ldn of 55 dBA (sic)) from blasting may be audible (barely) up to 12 kilometers (7.2 miles) from the shaft. As the shaft is sunk, the daily blasts will become less audible. After a period of four days to two weeks, blasting noise should not be audible for more than 1.6 to 3.2 kilometers (1 to 2 miles).

*Other phases of onsite development during site characterization activities are not expected to be as noisy as the period modeled....*As pointed out above, barrier modeling is inconsistent with viewshed analysis, temperature inversion effects have been underestimated, and atmospheric absorption has been overestimated. As a result, all distances cited in connection with Ldn and audibility isopleths are in error. In addition, the quantitative connection posited between Ldn and "percent highly annoyed" rests on faulty logic. Thus, *major* points of interest in Canyonlands National Park will not be spared from noise impact. All project related noises will be audible at greater distances than stipulated in the draft environmental assessment, and blasting noise associated with the larger exploratory shaft will be audible for a longer period of time.

page 4-102...*Field studies requiring borehole drilling will result in noise levels typical of small-bore drilling. Many of the boreholes will be located near or immediately outside of the site boundary. Therefore, borehole drilling may impact areas within the Canyonlands National Park, Ldn levels within 1.4 kilometers (0.9 mile) of a drill rig may exceed 55 dBA. Drilling will take place 24 hours per day during borehole drilling periods.*

*Noise from other proposed activities would result from vehicular traffic, backhoes, and trucks used for seismic work. Standard four-wheel-drive vehicles, backhoes, and seismic trucks would produce considerably less noise than the drilling operations. The duration of these activities would be short and/or intermittent. Generators at the proposed atmospheric monitoring stations would operate for one year, but would be audible for only a short distance, as they would be enclosed within an insulated instrument shed....*Borehole drilling will impact the park, and the impact will be especially great at night when indigenous sound levels are low and temperature inversions enhance all project related noises.

page 4-102...*Possible mitigation measures include these:*

- *Implementation of additional equipment noise controls to the equipment*
- *Selection of equipment manufacturer to minimize or eliminate any annoying audible tonal components*
- *Erection of barriers between major noise sources and noise sensitive areas to reduce noise impacts to acceptable levels for off-site areas*

*If the Davis Canyon site is chosen for site characterization, then consultation with appropriate agencies will determine the need for any of the above mitigative measures....*It is likely the equipment source sound levels used in the draft environmental assessment presupposed common noise control measures. Thus, it is impossible to assess what additional measures, if any, might reasonably be implemented. Man-made barriers are probably not a viable mitigative measure because of the strong sound refracting influence of temperature inversions at the site.

page 4-118...*Based on environmental analysis, project noise is considered as potentially affecting the most visitors. Noise may interefere with these in-park activities: camping, hiking, back-packing, searching for solitude, and sight-seeing. Therefore, noise will be used to analyze environmental impacts to park visitors.*

The relationship between noise and annoyance (Section 4.2.1.6) suggested that below 35 Ldn no one would be highly annoyed and only a small percentage of persons with the 35 Ldn range would be highly annoyed. However, for a worst-case analysis on visitation impacts, it was assumed that (1) everyone within the 35 Ldn range for machine noise and 35 C-weighted day/night levels (CDNL) for blasting will be highly annoyed, (2) the area they were visiting was their primary reason for visiting the park, (3) they would not be able to find another place in the park to substitute for that experience, and (4) they would not return to Canyonlands in the future.

Noise of both a broadband character (from site activities) and impulsive character (from blasting) needs to be considered in properly evaluating noise impacts on tourists at the Canyonlands National Park. Two isopleths are provided for both broadband and blasting impacts which assist in estimating possible human reaction to noise. The first represents the region of "high annoyance;" the second represents the region of "audibility." For site activities, the region of "high annoyance" is defined as the area within the Ldn = 37 dBA was not added (sic). A conservative assumption was made that all tourists who enter this isopleth would be highly annoyed although, based on social impact studies, only 2.3 percent of them may be characterized as highly annoyed at that sound level. (To compute this 2.3 percent, the addition of a 15 dBA correction factor was applied to a "% highly annoyed" versus Ldn curve *derived from social impacts studies. This correction is meant to account for the fact that all tourists are likely to be outside rather than inside sound attenuating structures.) "Audibility" is taken as the 15 dBA contour and is obtained from noise propagation calculations from site sources (ambient and contributions from blasting not included). It should be noted that the minimum ambient at the site vicinity was measured as Ldn = 37 dBA (approximately 30 dBA residual ambient in terms of 24-hour Leq). Occasionally, however, minimum 1-hour Leq values were found to drop down as low as 20 dBA in the Canyonlands vicinity motivating the 15 dBA contour from site noise as the limit of audibility. This choice of 15 dBA for the audibility isopleth, therefore, has some built-in conservatisms since it assumes simultaneous occurrence of the very low ambient (on 1 hour Leq basis) and the noisiest portion of site work.*

For blasting, the C-weighted Ldn value (CDNL) of 35 dBA (sic) is taken as the region of high annoyance. Social impact studies in community settings have indicated less than 3% of the population would be highly annoyed at that CDNL level of 35 DBA (See above note on 15 dBA correction added). Assumed in this section is that all visitors within that contour will be highly annoyed.

Because the major site characterization activities are confined to the exploratory shaft site, environmental changes to the park would occur in the Needles District. Under absolute worst case assumptions, 14 percent of the total annual park visitors to Davis Canyon would potentially be within audible range of machine noise (Figure 4-22). Audible noise would be heard at the range depicted on Figure 4-22 (15 dBA) only under extreme conditions. So the actual percentage of annual visitors who would be expected to hear machine noise would be far less. This will occur during the 18-month period during which work on the lower hydrostratigraphic unit wells and the exploratory shaft construction takes place. Figure 4-22 shows annual park visitation within the audible range and the area of high annoyance for machine noise. The percentage of annual park visitors entering a canyon or canyons at the trailhead is the basis for determining the percentage of park visitors affected.

Assuming that audible blasting will occur within a two-week period, an additional 1.9 percent of annual visitors to the park could hear the noise. Blasting annoyance decreases as the shaft is sunk. According to Section 5.2, 1 percent of daily park visitors would be in an area where they could be highly annoyed by the initial surface blasts for the 6.7-meter (22-foot) diameter shaft (Figure 4-23). The duration of annoying levels of noise in the park will be one week.

When the percentage of park visitors in the area of high annoyance is adjusted to reflect the annual visitation, the percentage is smaller because blasting would be annoying for only one week. The percentage of annual visitation highly annoyed by blasting would be only .02 percent.

Based on Section 4.2.1.6 and 3.6.2.4, only about two percent of the total annual Park visitors would be highly annoyed by noise emitted from site characterization activities associated with the Davis Canyon site. Visitors within the audible range *would also be in areas designated by the National Park Service as vehicle corridors for off-road vehicles already having significant noise levels. In 1984, Upper Salt Creek and Horse Canyons were classified by the National Park Service as having high levels of noise, while Davis Canyon was identified as having moderate levels of noise....*According to the preceding comments and specific findings, all quantitative conclusions about impact must be revised upward.

page 4-137...*Geologic Field Studies...Noise impacts restricted to approximately 1 km (.6 mile) from locations....*This finding allegedly includes borehole drilling, about which (earlier in the draft environmental assessment) it was said that the Ldn may exceed 55 dBA within a distance of 1.4 kilometers!

page 4-139...*Exploratory Shafts...Increase in sound levels is limited to 2.9 kilometers (1.8 miles) from the site center, and perceptibility may extend to 8 kilometers (5 miles). Shaft blasting, especially during the first several weeks of shaft sinking, could be perceptible at distances of up to 12 kilometers (7 miles)...*As pointed out earlier, blasting will be audible at greater distances than foreseen here because of (1) an error in the blasting noise calculation, (2) overestimation of atmospheric absorption, and (3) overestimation of indigenous or background sounds.

page 5-68...*As discussed in Section 4.2.1.6, two community noise indicators are employed in this environmental assessment. The first indicator is from the U.S. Environmental Protection Agency, which has identified an average day/night sound level (Ldn) of 55 A-weighted decibels (dBA) as the level sufficient to protect the public from the effects of environmental noise in normally quiet outdoor areas where many people spend time (EPA, 1974, p. 3). A methodology for determining "percent highly annoyed" is employed as an indicator of community reaction (Schultz, 1978). This method relates either the Ldn or CDNL level to the average community reaction in terms of "percent highly annoyed". More details concerning the application of these criteria and their interpretation is found in Section 4.2.1.6.*

As previously explained in Section 4.2.1.6, the minimum Ldn in the area has been determined by field measurement to be approximately 37 dBA (BGI, 1983; ONWI-460, p. 8) and may be considered as a background noise level. Therefore, the project-related 35 dB contour is intended as an approximation of the boundary of potential annoyance for worst-case activities.

Potential noise impacts from repository construction and repository operation were modeled as separate cases for the Davis Canyon site (BGI, 1984, Davis Canyon Noise Modeling). For the modeling of repository construction and operation, each piece of equipment was assigned a stationary location based on a typical repository plot plan. Although the location of most equipment will change during the construction period, the movement of equipment was not modeled. The effects of a temperature inversion at elevation 2,070 meters (6,800 feet) was also included in the modeling. The predicted levels represent the *incremental contribution to the existing ambient sound level. Section 4.2.1.6 details other modeling assumptions.*

A worst-case condition for the daily Ldn was modeled by using the peak activity period. For construction, this corresponds to a three-month period in which both site preparation activities and surface and shaft construction activities proceed concurrently. Equipment duty cycles and loading conditions during each work shift were considered in the modeling...Previous remarks about criteria, indigenous or background levels, and accuracy of modeling are applicable here also.

page 5-68...*As in Section 4.2.1.6, the existing Ldn level is estimated to be between 35 dBA and 45 dBA, with 45 dBA being more typical near roadways where the existing level would be higher (Section 3.4.4). The noise modeling results are graphically presented in Figure 5-22 which presents the Ldn isopleths due to repository construction. A legend relating Ldn to "percent highly annoyed" is also provided in Figure 5-22.*

The modeling indicates that the Ldn 55 dBA noise level will extend approximately 4 kilometers (2.5 miles) from the center of the site (Figure 5022). Traffic along the site access route will extend the Ldn 55 dBA level to 0.2 kilometer (0.1 mile) on either side of the road. Intervening canyon walls will decrease these distances.

The Ldn noise levels along the park boundary may be as high as 50 dBA. Noise levels intruding into Horse Canyon in Canyonlands National Park near major points of interest such as Peekaboo Springs, Tower Ruin, and Gothic Arch will be less than 35 dBA. The areas impacted by repository construction will be from the Park boundary in Davis Canyon and west to the higher elevations east of Horse CAnyon.

As described in Section 4.2.1.6 the implementation of additional noise controls, the selection of equipment to minimize audible tonal noise, and the proper maintenance of both equipment and noise control devices will reduce the noise impacts to Canyonlands National Park. Enclosure of the large air compressor packages is an example of a mitigating measure that could be implemented. However, the noise from large mobile construction equipment will be audible along the eastern edge of Canyonlands National Park adjacent to Davis Canyon.

Rail construction noise has not been modeled. Two construction crews will be slowly moving along the selected rail route corridor for a year. Some estimates can be made based on the construction equipment identified by Stearns-Roger Services, Inc. (1983a, p. 8-7). Areas within 0.5 kilometer (0.3 mile) of construction activity will probably exceed Ldn 55 dBA, and tunnel blasting may be audible up to 19 kilometers (12 miles) from the construction site for a period of approximately 50 days.

Periodic blasting (six blasts per day for one year, four blasts per day for a second year) will take place during repository shaft construction (Section 5.1). The CDNL of 35 decibels will extend as far as 5.0 kilometer (3.1 miles) from the blast site, or approximately 2.9 kilometers (1.8 miles) into Canyonlands National Park. Blasting noise may be initially *audible for a 19 kilometer (12-mile) radius, but as the shafts are sunk, the noise will diminish. After four days to two weeks, the limit of audibility will be 1.6 to 3.2 kilometers (1 to 2 miles)...*Previous remarks about indigenous or background sound levels, accuracy of modeling, and projected impacts are applicable here also. Note that the draft environmental assessment Ldn value of 50 dBA on the park boundary certainly must be revised upward to account for errors and inconsistencies already discussed. The basis for predictions of noise from railroad construction activities has not been reviewed in this critique.

page 5-71...*Noise predictions for Davis Canyon repository operations use the same ambient conditions and assumptions used for construction. Rail traffic and automobiles and trucks along the highway will intermittently affect receptors along their routes. Much of the mechanical equipment will be located in concrete buildings having wall thicknesses between 30.5 and 61 centimeters (12 and 24 inches). The noise reduction provided by such massive enclosures will vary from 35 decibels for the low octave bands to over 70 decibels for the high octave bands (Watters, 1959). Thus, noise from equipment located within these buildings will be sufficiently reduced so that it will not be a significant contribution to community noise. Therefore, these sources, and those below ground in the repository, were not considered in the modeling.*

Noise modeling results are graphically presented in Figure 5-23. The figure presents the Ldn isopleths due to repository operation. The figure also presents a legend relating Ldn to "percent highly annoyed". Noise model predictions indicate that site operation noise levels in the vicinity of the repository facility will be less than 35 dBA beyond 1.8 kilometers (1.1 miles) of the site, except along highway and rail corridors. Offsite traffic will extend this area.

Areas outside the Ldn 45 dBA are not expected to be significantly affected by noise from site activities, since the existing Ldn level is expected to be between 35 dBA and 45 dBA, except for areas near roadways where existing levels would be higher (Section 3.4.4). The Ldn 45 dBA contour will exist approximately 1.1 kilometer (0.7 mile) from the site center.

The Ldn 55 dBA contour anticipated for operations extends approximately 0.8 kilometer (0.5 mile) from the site center. Operation of the rail will result in a Ldn 55 dBA contour which will extend approximately 0.02 kilometer (0.013 mile) on either side of the rail as a result of one round trip per day. A normal rail right-of-way is 0.012 kilometer (.007 mile) on either side of the center line. The Ldn 55 dBA contour will extend approximately 0.32 kilometer (0.2 mile) from the rail. The noise impact zone will be wider as the rail line approaches the site and the noise from site operation combines with that from rail operation. Rail noise may be occasionally audible approximately 12.8 kilometers (8 miles) from the rail line.

Facility operation will increase local highway traffic, thereby increasing existing noise levels by approximately 3 decibels for each doubling of traffic volume. The Ldn 55 dBA *would occur approximately 0.015 kilometer (0.01 mile) from the road leading to the site. No residences are known to be located within 0.15 kilometer (0.09 mile) of the proposed access road. No impact is anticipated as a result of increased traffic noise.*

Local long-term (life of plant operation) impacts will include areas within 0.8 kilometer (0.5 mile) of the site center where levels are expected to exceed the EPA recommended criterion of Ldn 55 dBA. No residences nor parkland lie within the zone of impact. Onsite activities may occasionally be heard over an 8.5 kilometer (5.3 mile) radius (Section 4.1.2.6).

As described in Section 4.2.1.6, all noise calculations have been made using conservative assumptions. For example, a low ambient noise level was assumed; standard equipment noise levels were used (without additional noise control), all noise sources were presumed to be operational at the same time; etc. As a result, actual noise impacts are expected to be less than those predicted above.

Except for occasional railroad activities, no impulse noise sources would be present during plant operation. The discussion of tonal noise presented in Section 4.2.1.6 is applicable here.

*Section 4.2.1.6 also describes several mitigative measures that may be taken to reduce noise impacts. These include the use of noise control devices on selected equipment to reduce noise emission, erection of barriers around major noise sources to reduce noise transmission in the direction of noise sensitive areas, and purchase or lease of a buffer zone where noise impacts are significant. The implementation of these mitigating measures may reduce the noise impacts; however, noise from rail traffic, large mobile equipment and stationary mechanical equipment will remain audible along the east edge of Canyonlands National Park. If the Davis Canyon site is selected, mitigative measures will be developed, based on discussions with appropriate agencies...*Previous remarks apply. Note in addition that Ldn values stipulated here are inconsistent with values stipulated elsewhere in the draft environmental assessment. Note also that the boundary of significant noise impact has somehow crept up to Ldn = 45 dBA!

page 5-73...*Noise caused by decommissioning of the site has not been modeled. However, the quantity and horsepower of equipment are not expected to exceed those used during repository construction. Short-term impacts from noise should be less than those identified for the repository construction (Section 5.2.7.1)*...No comment.

page 5-73...*The preceding noise analysis assumes that no mitigation measures are incorporated in machinery or activities. Mitigation of noise is technically possible and economically feasible. For the repository construction both machinery noises and explosive noises may be mitigated. Machinery noises may be mitigated by adding sound-dampening equipment to cooling fans and intake superchargers, and by adding more muffling to exhausts. Such practices are common in Europe, and the control technology is readily available. The effect of the dampening is to reduce sound power levels by 3 to 6 dB, with concomitant reductions in* *predicted sound pressure levels.*

*Explosive noises, especially for at or near surface explosions can be mitigated by covering the blast area with sound-absorbing foam blankets. Again, such a mitigation technique can substantially reduce the range at which explosions may be heard...*The mitigation of machinery noise entails extra cost and requires faithful maintenance to remain effective. The quantitative benefit of foam blankets for blasting cannot be assessed from the information contained in the draft environmental assessment.

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APPENDIX F

CRITIQUE OF THE NOISE IMPACT ANALYSIS
IN THE DRAFT ENVIRONMENTAL ASSESSMENT FOR THE
DAVIS CANYON SITE, UTAH

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(Edited by J. Wittman and T. Ristau)

NOISE - GENERAL COMMENTS

INAPPROPRIATE ABSORPTION COEFFICIENTS HAVE BEEN UTILIZED IN THE NOISE MODELING:

Atmospheric absorption coefficients used in the prediction of exploratory shaft construction noise (Paradox Basin Noise Study, ONWI-460, 1983; page 53), and in the prediction of blasting noise ("Letter Report, Paradox Noise Impacts," LIBNO-2185, November 1984; Appendix A, revised calculation N-11), are approximately twice as large as the accepted values (see Handbook of Noise Control (2d Ed.), 1979; and ANSI Standard S1.26-1978) for the temperature and relative humidity assumed in the Environmental Assessment (EA). All sound levels predicted for the proposed activity are in error on the low side; thus, L_{dn} contours and audibility contours shown on the maps in the EA enclose less area than they should. Sound level predictions should be repeated with correct absorption coefficients or, possibly, corrected to take into account accepted absorption coefficients.

GROUND ABSORPTION HAS BEEN OVEREMPHASIZED:

Anomalous absorption due to ground effect has been overemphasized by underestimating source heights (Paradox Basin Noise Study, ONWI-460, 1983, page 52; and "Letter Report, Paradox Noise Impacts," November 1984, Appendix A, calculation N-16) and, possibly, by neglecting local ground conditions (such as the absence of appreciable amounts of grass). Computer predictions are thus in error on the low side by up to seven decibels. Anomalous absorption due to ground effect should be reassessed, taking into account local ground conditions and considering a realistic average height of source point and observation point.

TEMPERATURE INVERSION EFFECTS HAVE BEEN UNDERESTIMATED:

The role of temperature inversions in enhancing long range sound propagation has been seriously underestimated. The computer programming device used by the DOE contractor to simulate temperature inversions can enhance sound by at most three decibels, even though 15 decibel enhancements would not be unreasonable. Temperature inversions appear to have been ignored in predicting sound levels due to blasting. Temperature inversions due to nocturnal cooling are so common in Utah that they must be taken into account, particularly for the many activities which will produce appreciable amounts of sound 24 hours per day. Predicted sound levels due to machines and blasting should be reassessed by using models which are intermediate between spherical divergence and cylindrical divergence, or by using establishing empirical correlations for temperature inversion effects.

The use of annual averages to characterize temperature inversions is inappropriate. Temperature inversions enhance long range sound propagation significantly. The magnitude of the effect depends on the strength of the inversion and its height, increasing with both factors. Temperature inversions should be characterized using the detailed information in the source cited in the draft EA (Holzworth and Fisher, 1979) or else site-specific data should be obtained and used.

The use of man-made barriers as a mitigating measure (Draft EA, Davis Canyon Site, page 4-102) will be of limited value because of the refracting influence of temperature inversions on long range sound propagation. If the noise impact analysis is wrong, there may be no "technical fix." All potential mitigating measures should be analyzed carefully and thoroughly, so that their potential effectiveness in actually reducing noise impact can be assessed.

BLASTING SOUND HAS BEEN UNDERESTIMATED:

Blasting calculations are in error due to a double counting of the scaled depth of burial correction ("Letter Report, Paradox Noise Impacts," November 1984; Appendix A, revised calculation N-11). All predictions of peak blasting sound levels should be increased by seven decibels, blasting sound audibility contours should be adjusted accordingly, and contours for cumulative blasting sound exposure should be corrected.

Also, predicted sound levels due to blasting are unrealistic in that the same explosive charge has been assumed for exploratory shaft construction and seismic exploration ("Letter Report, Paradox Noise Impacts," November 1984; Appendix A, revised calculation N-11). The quantitative basis for predictions of sound levels due to blasting during railroad construction (see the draft EA, Davis Canyon Site, page 5-71) is unclear. Peak blasting sound levels depend on the size and number of charges detonated, as well as other site-specific variables. Charges used for exploratory shaft construction and railroad construction are likely to be greater than charges used for seismic exploration. More realistic blasting plans should be developed and used in the noise analysis. In the absence of such plans, estimates from surface mining experience may be useful.

MODELING OF NATURAL BARRIERS IS MISLEADING:

Computer modeling of natural barriers is overly simplistic and seriously misleading. Some locations in Canyonlands National Park, for example, are modeled as if they were shielded by barriers to the extent of 24 decibels (see the Draft EA, Davis Canyon Site, page 4-101), even though viewshed analysis (EA, page 4-105) indicates the locations have a clear line of sight to ground level structures at the Davis Canyon site.

The refraction of sound over barriers by temperature inversions seems to have been neglected. Modeling of natural barriers plays a crucial role in the noise analysis of the draft environmental assessment. The barrier models greatly reduce the apparent noise impact of the proposed activity. Modeling of natural barriers should be improved by taking into account the actual terrain between source point and observation point, even if this means the number of observation points must be reduced. Predictions should include explicit indication of the magnitude of effects attributable to the natural barrier. Refraction of sound over natural barriers by temperature inversions should also be taken into account.

NOT ENOUGH SITE SPECIFIC DATA WAS GATHERED:

The field measurements are too limited to be representative, and appear to be marred by equipment failure and uncertain calibration. In addition, altitude corrections may have been neglected during calibration. Good field measurements of the existing environment are an essential part of a draft environmental assessment. They are needed to provide a reliable reference point against which to judge the noise impact of the proposed activity. Average ambient sound levels are likely much lower than stated in the EA, and thus determinations of impact made using the interpretation of modeling results should be altered to more accurately reflect actual conditions.

Sound level measurements should be made on enough occasions and at enough locations to provide a representative sample. If, for example, seasonal wind patterns exist, such patterns should be taken into account in the field measurement plan (so as to avoid drawing conclusions from a biased sample). Measurements should be made at enough sites to fairly represent the area likely to be affected by the project. At least some of the measurements should be repeated merely to provide quality assurance. A high quality tape recorder should be used to make numerous recordings of indigenous sounds for subsequent octave band analysis with automated equipment, because the octave band results for indigenous sounds determine the audibility of project related noise.

NOISE DISSIPATION IS OVERESTIMATED:

Peak seismic blasting pressures are assumed to diminish more rapidly with distance ("Letter Report, Paradox Noise Impacts," November 1984; Appendix A, revised calculation N-11) than is appropriate for great distances (ANSI Standard S2.20-1983). Because of this assumption, the geographic area within which seismic blasts will be audible has been underestimated by the DOE. Peak seismic blasting pressures, particularly at distances where audibility limits are at issue, should be based on a distance exponent of 1.1 rather than the 1.35 used in the EA.

THE "ANNOYANCE" CRITERION IS MISAPPLIED:

The criterion for "percent highly annoyed" as an indicator of impact has been misapplied. According to the EA, the sleep interference threshold of L_{dn} = 50 dBA (Schultz, 1978) should be reduced 15 decibels because "interior noise within a typical home is 15 decibels less than the exterior level" (Draft EA, Davis Canyon Site, page 4-99). The fallacy in that logic is that the sound level at night in a campground is not likely to be as high as the sound level within a typical home.

Because of this error, the criterion for "percent highly annoyed" would be a much lower value of the L_{dn} if the logic of the draft environmental assessment were applied consistently. Thus, a greater geographic area would be affected, and more persons would also be affected. If a criterion for "percent highly annoyed" is to be applied as envisioned in the EA, it should be based on representative samples of measured sound levels in the existing environment, rather than upon a samples gathered in a community environment.

THE AMOUNT OF SEISMIC BLASTING IS UNDERESTIMATED:

The potential role of seismic blasting in creating noise impact has not received adequate attention. Terrain too rough for thumper trucks, or a desire for exceptionally good quality seismic reflection data (a reasonable data need for a project where geologic characteristics must be defined to the best extent possible), could result in much more seismic blasting than is foreseen in the EA (see the Draft EA, Davis Canyon Site, pages 4-18 and 4-19).

Most seismic blasting in the U.S. is above ground. If above-ground blasting were used, no mitigation measures would be possible. Each blast would be audible over a hundred square miles or more, and 30 to 50 such blasts per day would not be an unreasonable number for that type of exploration. The draft EA, consistent with its stated conservative approach, should have included thorough consideration of the impact of large scale seismic blasting upon the surrounding environment.

THE NOISE SURVEY PROPOSED DURING THE SITE CHARACTERIZATION PHASE IS TOO LIMITED:

The noise survey foreseen as part of the site characterization activities (see the Draft EA, Davis Canyon Site, page 4-71) is much too limited in scope. If the proposed site characterization activity occurs, the noise produced will have an impact on the surrounding pubic and private lands. A carefully planned noise monitoring program, together with relevant meteorological measurements, would be required to provide a trustworthy data base for noise impact analysis.

Numerous automated noise monitors, of the type which can operate unattended for a week or more, should be deployed around the site before site characterization activities are initiated. Coordinated meteorological measurements should be carried out to document the factors influencing long range sound propagation to affected areas. Noises from site characterization activities, such as blasting, or all night operation of equipment, should be exploited as test cases to document the actual role of barriers, temperature inversions, and ground effect in enhancing or reducing noise impact.

NOISE -- LINE-BY-LINE COMMENTS

Comments on the Executive Summary

Environmental Assessment, page 15: ..."During repository construction, short duration noise levels from intermittent blasting may be audible over 5 miles from the site center for the initial period of shaft construction (approximately 2 weeks). The blasting for the rail-line tunnel may be audible up to 12 miles away. During operation, machinery noise would be heard in the Park, and the noise made by the trains hauling waste may be audible up to 8 miles from the track. Possible mitigation measures induce the proper scheduling of activities and the use of physical sound barriers" ...

> Comment: The distances specified here for limits of audibility are too low because of errors in the treatment of blasting and of atmospheric absorption, and because the background or indigenous sound levels have been overestimated. Thus, the geographic reach of noise effects has been underestimated in the EA.

Environmental Assessment, page 16: ..."Highway access to the Davis Canyon site would use U.S. Highway 191, which may need to upgraded at certain points. A new 29-mile highway would be constructed to connect the site to U.S. HIghway 191. Rail access would require the construction of 37 miles of rail line over hilly terrain from the Potash Branch of the Denver and Rio Grande Railroad to the Davis Canyon site. The route would require tunnels under the Canyonlands and Needles Overlooks, a bridge over the Colorado River, and a crossing of the Park Service extension of State Highway 211." ...

> Comment: Each of these "access" projects would ordinarily merit an environmental assessment or an environmental impact statement of its own. These activities are barely touched upon in the EAs, and are not assessed adequately for any environmental impact. Noise impact would be but one facet of a full investigation and analysis of these related projects, and should be included in the discussion of cumulative impacts of the entire repository activities, including preliminary and final access construction, operation, and decommissioning.

Comments on Chapter 3

Environmental Assessment, page 3-148: ... "The Needles District, on the western edge of the Davis Canyon site, had 51,100 visits during 1983. April, May, and June had the highest number of visits in that year (Table 3-17). This section of Canyon lands National Park is accessible via Highway U-211 and a National Park Service extension of U-211. Of the total visitors to the Needles District, 65 to 75 percent entered the back country. The number of reported visitors to Davis Canyon in 1893 was 829. These are regarded as conservative figures. Normally, jeep trail registers and back country permits are used to determine the number of visitors to Davis Canyon. During the latter half of 1983, however, several floods washed out the register boxes, and data are not available from that source for July through December. Because of this a informal observations of nonregistrations, the National Park Service estimates that actual visitation was at least 50 percent higher (NPS, 1984). Approximately 50 percent of all the visitors to the District use Horse Canyon or Salt Creek, located near the southeast boundary of the park. This area is also used extensively for outdoor education schools (BLM, 1982b, p. 62; Canyonlands National Park, General Management Plan, 1978)." ...

> Comment: To the extent that outdoor amphitheatres exist in the park, special criteria (protecting against speech interference by project related noises) may be applicable. These aspects are not discussed in the EA, nor are any special criteria proposed for minimizing adverse effects on these existing uses and activities.

Environmental Assessment, page 3-166: ... "Mixing height and wind speed influence regional air quality. Commonly, mixing heights and controlling inversion layers have a large diurnal variation (low in the morning and high in the afternoon). The Davis Canyon site generally has relatively high mixing heights and moderate wind speeds. The most restrictive dispersion season is winter, when both mixing heights and wind speeds are low. "

"Poor dispersion conditions (episodes) that persist for long durations can result in buildup of ground-level ambient concentrations produced by emissions. An episode is defined as the occurrence of mixing heights less than 1,500 meters (4,921 feet) on at least two consecutive days, wind speeds of less than four meters per second (8.9 miles per hour), and no significant precipitation. For example, Grand Junction, Colorado (the closest reporting station to the geologic repository operations area) reported 43 episodes totaling 193 days during a 50 year period (Holzworth, 1972, p. 83). Fourteen of these episodes were at least 5 days long, totaling 111 days. Winter episodes were the longest." ...

> Comment: These episodes are prolonged temperature inversions, during which long range sound propagation would be significantly enhanced without diurnal relief. Noise effects from project activities would thus also be enhanced during these periods. The EA does not recognize the significance of these meteorological conditions for noise impacts.

Environmental Assessment, page 3-168: ... "The nearest data source for average annual winds is at Green River, approximately 145 kilometers (90 miles) north-northwest of the Davis Canyon site. There, winds average 2.1 meters per second (4.7 miles per hour), with the prevailing directions from the southwest through west. The highest annual average wind speed, 3.0 meters per second (6.7 miles per hour), was from the south-southwest (NOAA, 1974). However, both wind speed and direction may differ for the site because of variations in local terrain and the channeling effects of valleys." ...

> Comment: The occurrence of wind enhances sound propagation downwind and diminishes it upwind. To the extend that prevalent wind speeds and directions can be identified around the site, they should be taken into account in assessing noise impact.

Environmental Assessment, page 3-169: ... "The noise environment of the Davis Canyon site is characterized as quiet, consistent with its rural character. Noise in this sparsely populated area is primarily caused by wind passing over the vegetation. Additional noise is created by natural sources such as birds and insects, and occasional human-related sources such as aircraft and surface vehicles. Areas in the vicinity of the jeep trails experience high noise levels from recreational vehicle activity. The complex topography in the area can result in both increased attenuation of noise because of barrier effects, and reduced attenuation as a result of noise reflection."

"One measure of noise is the A-weighted sound pressure level, L_{90}, the value equaled or exceeded 90 percent of the time. Hourly L_{90} values as low as 19 A-weighted decibels (dBA) have been measured during night and early morning hours in and near the Davis Canyon site. These measurements were made at Peekaboo Springs campground in Canyonlands National Park, Davis Canyon, and Dugout Ranch. Another measure of noise is the sound pressure level of a constant sound that has the same energy as the time-varying sound measured over a given time interval. Twenty-four-hour-energy-equivalent levels (L_{eq}) have ranged from 34 dBA in Canyonlands National Park to 41 dBA penalty applied to the nighttime levels (2200 to 0700 hours), was found to range from 37 dBA in Canyonlands National Park to 46 dBA at Dugout Ranch (BGI, 1983b, ONWI-460, p. 8)."

"The U.S. EPA has not promulgated any community noise regulations pursuant to the Noise Control Act of 1972 that are applicable to site characterization and repository construction, operation, and closure. The Act requires Federal agencies to comply with state and local noise regulations. Currently, there are no applicable state of local regulations at this site." ...

> Comment: The dominant role attributed to wind as a generator of indigenous sound is probably an artifact of the limited field sample. The quantitative empirical values cited for L_{dn} and L_{eq} cannot be accepted as reliable for the same reason. EPA has played a vigorous and well publicized role in trying to protect national parks from noise pollution: Bryce Canyon National Park--strip mining noise; Grand Teton National Park--airport noise; Glacier National Park--seismic exploration noise. This information should have been utilized in determining criteria for the environmental impacts of project-related noise (rather than utilizing the inappropriate "community annoyance" standard).

Comments on Chapter 4

Environmental Assessment, page 4-71: ... "A two-season noise survey will be conducted to evaluate background sound levels. Sound-level data will be used in the analysis of impacts due to repository construction and operation."

"Sound-level data will be collected for the site for summer and winter seasons, including weekdays and weekends, and at all times of the day and night. Survey points and sampling periods will be designed to develop a representative statistical statement of the background sound levels at the Davis Canyon site. Existing noise sources at the site will be identified and octave band analyses will be performed to characterize significant noise sources. The instrument reading method of octave band analyses involves recording the average, maximum, and minimum sound levels for each octave band. These data will be used to determine sound levels at each location. To provide correlations with measurements, additional information on other parameters also will be recorded during the survey."

"Meteorological observations including wind speed, wind direction, temperature, and relative humidity will be made at each sampling location. Measurements obtained near roadways will be accompanied by a traffic count. Sound source observations will be recorded during each sample and include a notation of the predominant sound sources."

"Each seasonal monitoring period will be approximately one week and require a field sampling team of two persons. Personnel access to the site and perimeter will be required; no equipment installations are necessary. Field sampling teams will be working day and night on a periodic basis; however, no construction or permanent facilities will be necessary at sampling locations." ...

> Comment: This is a "bare bones" noise survey. It does not even address the issue of validating the projections contained in the draft environmental assessment. The ongoing problem of identifying appropriate criteria for determining the magnitude of environmental impact due to noise is not addressed by this proposed study.

Environmental Assessment, page 4-99: ..."There are no local or state regulations on permissible environmental noise levels. Two indicators of broadband environmental noise impact are used here. First, the U.S. Environmental Protection Agency (EPA) has identified an L_{dn} of 55 A-weighted decibels (dBA) as the level sufficient to protect the public from the effects of environmental noise in normally quiet outdoor areas where many people spend time (EPA, 1947). The L_{dn} is the average day/night energy equivalent level for the entire day with a 10 decibel penalty added to nighttime levels (10:00 p.m. to 7:00 a.m.) to account for people being more sensitive to noise during these hours. The EPA has recommended adoption of an L_{dn} less than 55 dBA as a goal in project planning of future programs. Although no health and welfare effects are expected to occur where levels are under 55 dBA, significant increase in noise over the existing conditions may lower the quality of the environment. The existing L_{dn} levels are expected to average between 35 dBA being typical of areas near highways and communities."

"The human effects for outdoor L_{dn} levels of 55 dBA include these:

* Slight speech communication interference beyond 1 meter
* Less than 5 percent of the population may be highly annoyed, depending on attitude and other nonacoustical factors."

"The second indicator of noise impact used here predicts the cumulative effect of activity interference due to noise measured in terms of annoyance. Although other factors, such as an individual's attitude toward a noise measured in terms of annoyance. Although other factors, such as an individual's attitude toward a noise source, may influence reaction to activity interferences, the percentage of people highly annoyed in a given environmental situation provides a useful indication of the severity of the impacts. Results of all surveys involving transportation noise show a remarkable consistency between measured L_{dn} levels and the subjective reaction of high annoyance (Schultz, 1978). The types of sounds from transportation are similar to those expected from construction activities. Although speech-interference is one of the primary reasons for adverse community reactions to noise, sleep-interference is also a primary consideration. The associated interior noise within a typical home is 15 decibels less than the exterior level (EPA, 1974). Thus, the overnight camper in Canyonlands National Park would be 15 decibels more sensitive to intruding noise. The results of Schultz have been modified by this 15 decibel reduction in an attempt to account for the overnight camper. Therefore, this modified correlation between the average subjective reaction of being highly annoyed and L_{dn} levels is offered to provide a perspective of the expected human response to noise from the project. It should be noted that "percent highly annoyed" is applicable to a large community but may be statistically less meaningful when applied to estimating the reaction to noise from the few individuals near the Davis Canyon site whose attitudes, along with other nonacoustical factors, ma; modify this effect. It should also be noted that noise will be audible beyond the distance at which an individual may be annoyed. The nearest designated primitive campground is located 8 kilometers (5 miles) from the site. The Canyonlands National Park is within 1.3 kilometers (0.8 mile) of the exploratory shaft. The nearest residence is Dugout Ranch, located 9.5 kilometers (6 miles) away."

"The impact of tonal noise from the equipment is more difficult to quantify, based on existing information. Tonal noise may be produced by equipment, depending on the type and condition (wear) of the equipment. Although typical octave band information exists for the equipment to be used, the specific tonal components and their magnitudes depend on the manufacturer of the equipment."

"Two factors aid in minimizing tonal noise impacts:

1. The broadband noise caused by equipment such as engine (mobile equipment) tends to mask the tones, reducing the likelihood that the tones would be audible in noise sensitive areas.

2. Many of these tones (for noise sources such as welding rigs and air compressors) are at high frequencies (greater than 1000 Hertz) and are, therefore, reduced by atmospheric attenuation."

"The Occupational Safety and Health Administration (OSHA) regulates noise in the work place. Noise control measures will be applied as necessary to meet OSHA regulations."

"The minimum L_{dn} in the area has been determined by field measurement to be approximately 37 A-weighted decibels (BGI, 1983d; ONWI-460, p. 8). Therefore, the project-related 35 A-weighted decibels contour is intended as an approximation of the boundary of potential annoyance for worst-case activities." ...

Comment: The use of L_{dn} as a descriptor for the acoustic environment in quiet, pristine places is inappropriate. This is vividly illustrated by the requirement of a ten decibel penalty (according to L_{dn} methodology) during nights, which are often remarkably quiet on western public lands.

Even if L_{dn} were used, it would make no sense to refer to the 55 dBA level identified by EPA as necessary to protect the public health and welfare with an adequate margin of safety. Here the issue is protecting the environment. EPA has not used the 55 dBA level in its efforts to protect the national parks referred to earlier. Schultz's work concerned community reaction to noise of aircraft, street traffic, expressway traffic, and railroads (in other words, urban noise pollution).

The efficacy of broadband noise in masking tonal noise is likely to be very modest, since only acoustic energy in a critical band (approximately a one third octave band) around the tonal component can contribute to masking.

The minimum L_{dn} cited above from field measurements cannot be regarded as reliable, since it is derived from such a limited and questionable data base. Use of the L_{dn} = 35 dBA isopleth as an indication of the boundary of potential annoyance from worst case activities is unjustified, as discussed earlier.

Environmental Assessment, page 4-110: ..."The noise predominantly associated with site characterization activities will occur during a three-month period when the construction activities of site preparation, surface facility construction, shaft drilling and casing, and shaft sinking overlap. Potential noise impacts arising from exploratory shaft development activity have been modeled (BGI, 1983, ONWI-460). The types of equipment to be used during exploratory shaft development have been tentatively identified in Section 4.1.2. Average meteorological conditions were assumed for the site, based on an average of 40 years (1936 to 1975) of Grand Junction, Colorado meteorological data. The average temperature was 53 F and the average relative humidity was 45 percent. An early morning inversion layer corresponding to the annual mean morning mixing height was assumed to persist. Attenuation from atmospheric distance and air absorption were treated by the model. Canyon walls, which act as noise barriers, were factored into the computer analysis."

"The modeling results are graphically presented in Figure 4-18. This figure presents the L_{dn} noise isopleths caused by exploratory shaft construction with a legend relating L_{dn} levels to percent highly annoyed. The following is a summary of modeling results:"

"1. Equipment noise will result in noise levels exceeding an L_{dn} of 35 A-weighted decibels within approximately 2.9 kilometers (1.8 miles) of the site center (BGI, 1983, ONWI-460).

2. The L_{dn} 45 A-weighted decibels contour extends approximately 2.3 kilometers (1.4 miles) from the site center.

3. The L_{dn} 55 A-weighted decibels contour extends about 1.3 kilometers (0.8 mile) from the site center.

4. Noise levels using commercial power or industrial turbines are approximately equivalent."

"Areas outside the projec -related 35 A-weighted decibels contour on Figure 4-18 are not expected to :e affected by noise from exploratory shaft construction activities. Major points of interest in Canyonlands National Park such as Peekaboo Springs, Town Ruin, and Gothic Arch are all located outside the project-related 35 A-weighted decibels contour. An absolute distance at which noise will be audible cannot be determined because of the many variables which affect audibility. These factors include:"

"* Background noise level
* Atmospheric conditions
* Frequency of the intruding noise and the background noise
* Presence of intervening structures
* Activity of the individual
* The amount of hearing loss of the individual, etc."

"However, using a broadband noise of 15 A-weighted decibels (5 A-weighted decibels below the minimum hourly L_{eq} level) as a criterion for audibility, and assuming optimum listening conditions and average meteorological conditions, noise from site characterization activities (excluding blasting) may be audible 6.7 kilometers (4.2 miles) from the site (Figure 4-19). Noise from construction activities may be audible near the east edge of the park boundary in Davis Canyon and along Highway 211 east of the exploratory shaft. Noise levels at the nearest residence, Dugout Ranch, are not expected to increase perceptibly as a result of drilling activities."

"Shaft sinking for the larger of the two shafts will occur over an eleven-month period using conventional shaft mining techniques. (This period does not coincide with the period modeled.) As part of this activity, blasting will occur once per day to break up rock in the shaft. The initial impact zone (corresponding to the C-weighted L_{dn} of 55 dBA (sic)) from blasting may be audible (barely) up to 12 kilometers (7.2 miles) from the shaft. As the shaft is sunk, the daily blasts will become less audible. After a period of four days to two weeks, blasting noise should not be audible for more than 1.6 to 3.2 kilometers (1 to 2 miles)."

"Other phases of onsite development during site characterization activities are not expected to be as noisy as the period modeled." ...

Comment: As pointed out above, the barrier modeling utilized by the DOE in modeling noise is inconsistent with viewshed analysis, temperature inversion effects have been underestimated, and atmospheric absorption has been overestimated. As a result, all distances cited in connection with L_{dn} and audibility isopleths are in error.

In addition, the quantitative connection posited between L_{dn} and "percent highly annoyed" rests on faulty logic. Thus, major points in interest in Canyonlands National Park will not be spared from noise impact. All project related noises will be audible at greater distances than stipulated in the draft environmental assessment, and blasting noise associated with the larger exploratory shaft will be audible for a longer period of time.

Environmental Assessment, page 4-102: ... "Field studies requiring borehole drilling will result in noise levels typical of small-bore drilling. Many of the boreholes will be located near or immediately outside of the site boundary. Therefore, borehole drilling may impact areas within the Canyonlands National Park, L_{dn} levels within 1.4 kilometers (0.9 mile) of a drill rig may exceed 55 dBA. Drilling will take place 24 hours per day during borehole drilling periods."

"Noise from other proposed activities would result from vehicular traffic, backhoes, and trucks used for seismic work. Standard four-wheel-drive vehicles, backhoes, and seismic trucks would produce considerably less noise than the drilling operations. The duration of these activities would be short and/or intermittent. Generators at the proposed atmospheric monitoring stations would operate for one year, but would be audible for only a short distance, as they would be enclosed within an insulated instrument shed." ...

Comment: Borehole drilling will impact the park, and the impact will be especially great at night when indigenous sound levels are low and temperature inversions will enhance all project related noises.

Environmental Assessment, page 4-102: ... "Possible mitigation measures include these:

"* Implementation of additional equipment noise controls to the equipment
* Selection of equipment manufacturer to minimize or eliminate any annoying audible tonal components
* Erection of barriers between major noise sources and noise sensitive areas to reduce noise impacts to acceptable levels for offsite areas."

"If the Davis Canyon site is chosen for site characterization, then consultation with appropriate agencies will determine the need for any of the above mitigative measures." ...

Comment: It is likely the equipment source sound levels used in the draft environmental assessment presupposed common noise control measures. Thus, it is impossible to assess what additional measures, if any, might reasonably be implemented. Manmade barriers are probably not a viable mitigative measure because of the strong sound refracting influence of temperature inversions at the site.

Environmental Assessment, page 4-118: ... "Based on environmental analysis, project noise is considered as potentially affecting the most visitors. Noise may interfere with these in-park activities: camping, hiking, backpacking, searching for solitude, and sightseeing. Therefore, noise will be used to analyze environmental impacts to park visitors."

"The relationship between noise and annoyance (Section 4.1.6) suggested that below 35 L_{dn} range no one would be highly annoyed. However, for a worst-case analysis on visitation impacts, it was assumed the (1) everyone within the 35 L_{dn} range for machine noise and 35 C-weighted day/night levels (CDNL) for blasting will be highly annoyed, (2) the area they were visiting was their primary reason for visiting the park, (3) they would not be able to find another place in the park to substitute for that experience, and (4) they would not return to Canyonlands in the future."

"Noise of both a broadband character (from site activities) and impulsive character (from blasting) needs to be considered in properly evaluation noise impacts on tourists at the Canyonlands National Park. Two isopleths are provided for both broadband and blasting impacts which assist in estimating possible human reaction to noise. The first represents the region of "high annoyance;" the second represents the region of "audibility." For site activities, the region of "high annoyance" is defined as the area within the L_{dn} = 37 dBA was not added (sic). A conservative assumption was made that all tourists who enter this isopleth would be highly annoyed although, based on social impact studies, only 2.3 percent of them may be characterized as highly annoyed at that sound level. (To compute this 2.3 percent, the addition of a 15 dBA correction factor was applied to a "% highly annoyed" versus L_{dn} curve derived from social impacts studies. This correction is meant to account for the fact that all tourists are likely to be outside rather than inside sound attenuating structures.) "Audibility" is taken as the 15 dBA contour and is obtained from noise propagation calculations from site sources (ambient and contributions from blasting not included). It should be noted that the minimum ambient at the site vicinity was measured as L_{dn} = 37 dBA (approximately 30 dBA residual ambient in terms of 24-hour L_{eq}). Occasionally, however, minimum 1-hour L_{eq} values were found to drop down as low as 20 dBA in the Canyonlands vicinity motivating the 15 dBA contour from site noise as the limit of audibility. This choice of 15 dBA for the audibility isopleth, therefore, has some built-in conservatisms since it assumes simultaneous occurrence of the very low ambient (on a 1 hour L_{eq} basis) and the noisiest portion of site work."

"For blasting, the C-weighted L_{dn} value (CDNL) of 35 dBA (sic) is taken as the region of high annoyance. Social impact studies in community settings have indicated less than 3% of the population would be highly annoyed at that CDNL level of 35 dBA (See above note on 15 dBA correction added). Assumed in this section is that all visitors within that contour will be highly annoyed."

"Because the major site characterization activities are confined to the exploratory shaft site, environmental changes to the park would occur in the Needles District. Under absolute worst case assumptions, 14 percent of the total annual park visitors to Davis Canyon would potentially be within audible range of machine noise (Figure 4-22). Audible noise would be heard at the range depicted on Figure 4-22 (15 dBA) only under extreme conditions. So the actual percentage of annual visitors who would be expected to hear machine noise would be far less. This will occur during the 18-month period during which work on the lower hydrostratigraphic unit wells and the exploratory shaft construction takes place. Figure 4-22 shows annual park visitation within the audible range and the area of high annoyance for machine noise. The percentage of annual park visitors entering a canyon or canyons at the trailhead is the basis for determining the percentage of park visitors affected."

"Assuming that audible blasting will occur within a two-week period, and additional 1.9 percent of annual visitors to the park is sunk. According to Section 5.2, 1 percent of daily park visitors would be in an area where they could be highly annoyed by the initial surface blasts for the 6.7-meter (22-foot) diameter shaft (Figure 4-23). The duration of annoying levels of noise in the park will be one week."

"When the percentage of park visitors in the area of high annoyance is adjusted to reflect the annual visitation, the percentage is smaller because blasting would be annoying for only one week. The percentage of annual visitation highly annoyed by blasting would be only .02 percent."

"Based on Section 4.2.1.6 and 3.6.2.4, only about two percent of the total annual Park visitors would be highly annoyed by noise emitted from site characterization activities associated with the Davis Canyon site. Visitors within the audible range would also be in areas designated by the National Park Service as vehicle corridors for off-road vehicles already having significant noise levels. In 1984, Upper Salt Creek and Horse Canyons were classified by the National Park Service as having high levels of noise, while Davis Canyon was identified as having moderate levels of noise." ...

> Comment: According to the preceding comments and specific findings, all quantitative conclusions about impact must be revised upward.

Environmental Assessment, page 4-137: ... "Geologic Field Studies. ...Noise impacts restricted to approximately 1 km (.6 mile) from locations ..."

> Comment: This finding allegedly includes borehole drilling, about which (earlier in the draft environmental assessment) it was said that the L_{dn} may exceed 55 dBA within a distance of 1.4 kilometers! Apparently, not all available information about noise impact has been utilized in making this determination.

Environmental Assessment, page 4-130: ... "Exploratory Shafts. ...Increase in sound levels is limited to 2.9 kilometers (1.8 miles) from the site center, and perceptibility may extend to 8 kilometers (5 miles). Shaft blasting, especially during the first several weeks of shaft sinking, could be perceptible at distances of up to 12 kilometers (7 miles)." ...

> Comment: As pointed out earlier, blasting will be audible at greater distances than foreseen here because of (1) an error in the blasting noise calculation, (2) overestimation of atmospheric absorption, and (3) overestimation of indigenous or background sounds.

Comments on Chapter 5

Environmental Assessment, page 5-68: ... "As discussed in Section 4.2.1.6, two community noise indicators are employed in this environmental assessment. The first indicator is from the U.S. Environmental Protection Agency, which has identified an average day/night sound level (L_{dn}) of 55 A-weighted decibels (dBA) as the level sufficient to protect the public from the effects of environmental noise in normally quiet outdoor areas where many people spend time (EPA, 1974, p. 3). A methodology for determining "percent highly annoyed" is employed as an indicator of community reaction (Schultz, 1978). This method relates either the L_{dn} or CDNL level to the average community reaction in terms of "percent highly annoyed". More details concerning the application of these criteria and their interpretation is found in Section 4.2.1.6."

"As previously explained in Section 4.2.1.6, the minimum L_{dn} in the area has been determined by field measurement to be approximately 37 dBA (BGI, 1983; ONWI-460, p. 8) and may be considered as a background noise level. Therefore, the project-related 35 dBA contour is intended as an approximation of the boundary of potential annoyance for worst-case activities."

"Potential noise impacts from repository construction and repository operation were modeled as separate cases for the Davis Canyon site (BGI, 1984, Davis Canyon Noise Modeling). For the modeling of repository construction and operation, each piece of equipment was assigned a stationary location based on a typical repository plot plan. Although the location of most equipment will change during the construction period, the movement of equipment was not modeled. The effects of a temperature inversion at elevation 3,070 meters (6,800 feet) was also included in the modeling. The predicted levels represent the incremental contribution to the existing ambient sound level. Section 4.2.1.6 details other modeling assumptions."

"A worst-case condition for the daily L_{dn} was modeled by using the peak activity period. For construction, this corresponds to a three-month period in which both site preparation activities and surface and shaft construction activities proceed concurrently. Equipment duty cycles and loading conditions during each work shift were considered in the modeling." ...

> Comment: Previous remarks about criteria, indigenous or background levels, and accuracy of modeling are applicable here also.

Environmental Assessment, page 5-68: ... "As in Section 4.2.1.6, the existing L_{dn} level is estimated to be between 35 dBA and 45 dBA, with 45 dBA being more typical near roadways where the existing level would be higher (Section 3.4.4). The noise modeling results are graphically presented in Figure 5-22 which presents the L_{dn} isopleths due to repository construction. A legend relating L_{dn} to "percent highly annoyed" is also provided in Figure 5-22."

"The modeling indicates that the L_{dn} 55 dBA noise level will extend approximately 4 kilometers (2.5 miles) from the center of the site (Figure 5-22). Traffic along the site access route will extend the L_{dn} 55 dBA level to 0.2 kilometer (0.1 mile) on either side of the road. Intervening canyon walls will decrease these distances."

"The L_{dn} noise levels along the park boundary may be as high as 50 dBA. Noise levels intruding into Horse Canyon in Canyonlands National Park near major points of interest such a Peekaboo Springs, Tower Ruin, and Gothic Arch will be less than 35 dBA. The areas impacted by repository construction will be from the Park boundary in Davis Canyon and west to the higher elevations east of Horse Canyon."

"As described in Section 4.2.1.6 the implementation of additional noise controls, the selection of equipment to minimize audible tonal noise, and the proper maintenance of both equipment and noise control devices will reduce the noise impacts to Canyonlands National Park. Enclosure of the large air compressor packages is an example of a mitigating measure that could be implemented. However, the noise from large mobile construction equipment will be audible along the eastern edge of Canyonlands National Park adjacent to Davis Canyon."

"Rail construction noise has not been modeled. Two construction crews will be slowly moving along the selected rail route corridor for a year. Some estimates can be made based on the construction equipment identified by Stearns-Rogers Services, Inc. (1983a, p. 8-7). Areas within 0.5 kilometer (0.3 mile) of construction activity will probably exceed L_{dn} 55 dBA, and tunnel blasting may be audible up to 19 kilometers (12 miles) from the construction site for a period of approximately 50 days."

"Periodic blasting (six blasts per day for one year, four blasts per day for a second year) will take place during repository shaft construction (Section 5.1). The CDNL of 35 decibels will extend as far as 5.0 kilometer (3.1 miles) from the blast site, or approximately 2.9 kilometers (1.8 miles) into Canyonlands National Park. Blasting noise may be initially audible for a 19 kilometer (12-mile) radius, but as the shafts are sunk, the noise will diminish. After four days to two weeks, the limit of audibility will be 1.6 to 3.2 kilometers (1 to 2 miles)." ...

> Comment: Previous remarks about indigenous or background sound levels, accuracy of modeling, and projected impacts are applicable here also. Note that the draft environmental assessment L_{dn} value to 50 dBA on the park boundary certainly must be revised upward to account for errors and inconsistencies already discussed. The basis for predictions of noise from railroad construction activities has not been reviewed in this critique.

Environmental Assessment, page 5-71: ... "Noise predictions for Davis Canyon repository operations use the same ambient conditions and assumptions used for construction. Rail traffic and automobiles an trucks along the highway will intermittently affect receptors along their routes. Much of the mechanical equipment will be located in concrete buildings having wall thicknesses between 30.5 and 51 centimeters (12 and 24 inches). The noise reduction provided by such massive enclosures will vary from 35 decibels for the low octave bands to over 70 decibels for the high octave bands (Watters, 1959). Thus, noise from equipment located within these buildings will be sufficiently reduced so that it will not be a significant contribution to community noise.

Therefore, these sources, and those below ground in the repository, were not considered in the modeling."

"Noise modeling results are graphically presented in Figure 5-23. The figure presents the L_{dn} isopleths due to repository operation. The figure presents the L_{dn} isopleths due to repository operation. The figure also present a legend relating L_{dn} to "percent highly annoyed". Noise model predictions indicate that site operation noise levels in the vicinity of the repository facility will be less than 35 dBA beyond 1.8 kilometers (1.1 miles) of the site, except along highway and rail corridors. Offsite traffic will extend this area."

"Areas outside the L_{dn} 45 dBA are not expected to be significantly affected by noise from site activities, since the existing L_{dn} level is expected to be between 35 dBA and 45 dBA, except for areas near roadways where existing levels would be higher (Section 3.4.4). The L_{dn} 45 dBA contour will exist approximately 1.1 kilometer (0.7 mile) from the site center."

"The L_{dn} 55 dBA contour anticipated for operations extends approximately 0.8 kilometer (0.5 mile) from the site center. Operation of the rail will result in a L_{dn} 55 dBA contour which will extend approximately 0.32 kilometer (0.2 mile) from the rail. The noise impact zone will be wider as the rail line approaches the site and the noise from site operation combines with that from rail operation. Rail noise may be occasionally audible approximately 12.8 kilometers (8 miles) from the rail line."

"Facility operation will increase local highway traffic, thereby increasing existing noise levels by approximately 3 decibels for each doubling of traffic volume. The L_{dn} 55 dBA would occur approximately 0.015 kilometer (0.01 mile) from the road leading to the site. No residences are known to be located within 0.15 kilometer (0.09 mile) of the proposed access road. No impact is anticipated as a result of increased traffic noise."

"Local long-term (life of plant operations) impacts will include areas within 0.8 kilometer (0.5 mile) of the site center where levels are expected to exceed the EPA recommended criterion of L_{dn} 55 dBA. No residences nor parkland lie within the zone of impact. Onsite activities may occasionally be heard over an 8.5 kilometer (5.3 mile) radius (Section 4.1.2.6)."

"As described in Section 4.2.1.6, all noise calculations have been made using conservative assumptions. For example, a low ambient noise level was assumed; standard equipment noise levels were used (without additional noise control), all noise sources were presumed to be operational at the same time; etc. As a result, actual noise impacts are expected to be less than those predicted above."

"Except for occasional railroad activities, no impulse noise sources would be present during plant operation. The discussion of tonal noise presented in Section 4.2.1.6 is applicable here."

"Section 4.2.1.6 also describes several mitigative measures that may be taken to reduce noise impacts. These include the use of noise control devices on selected equipment to reduce noise emission, erection of barriers around major noise sources to reduce noise transmission in the direction of noise sensitive areas, and purchase or lease of a buffer zone where noise impacts are significant. The implementation of these mitigating measures may reduce the noise impacts; however, noise from rail traffic, large mobile equipment and stationary mechanical equipment will remain audible along the east edge of Canyonlands National Park. If the Davis Canyon site is selected, mitigative measures will be developed, based on discussions with appropriate agencies." ...

> Comment: Previous remarks apply. Note in addition that L_{dn} values stipulated here are inconsistent with values stipulated elsewhere in the draft environmental assessment. Note also that the boundary of significant noise impact has somehow crept up to L_{dn} = 45 dBA (the significance criterion previously used in the EA was L_{dn} = 35 dBA).

Environmental Assessment, page 5-73: ... "The preceding noise analysis assumes that no mitigation measures are incorporated in machinery or activities. Mitigation of noise is technically possible and economically feasible. For the repository construction both machinery noises and explosive noises may be mitigated. Machinery noises may be mitigated by adding sound-dampening equipment to cooling fans and intake superchargers, and by adding more muffling to exhausts. Such practices are common in Europe, and the control technology is readily available. The effect of the dampening is to reduce sound power levels by 3 to 6 dBA, with concomitant reductions in predicted sound pressure levels."

"Explosive noises, especially for at or near surface explosions can be mitigated by covering the blast area with sound-absorbing foam blankets. Again, such a mitigation technique can substantially reduce the range at which explosions may be heard." ...

> Comment: The mitigation of machinery noise entails extra cost and requires faithful maintenance to remain effective. The quantitative benefit of foam blankets for blasting cannot be assessed from the information contained in the draft environmental assessment.

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APPENDIX G

RECLAMATION TECHNICAL REPORT

Proposed High Level Nuclear Waste Repository
Utah Sites

Prepared by the Division of Oil, Gas and Mining
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March 4, 1985

RECLAMATION TECHNICAL REPORT

Soils

Introduction:

The basic information available to the Department of Energy (DOE) for making decisions is not detailed enough at the Davis Canyon site for such decisions to be well-founded. Even at the planning stage, sufficient data are required to assure that decisions are not made by default. For example, when oil shale mining operations or coal mining operations are proposed in similar fragile environments, exhaustive baseline soils and vegetative data are obtained. These baseline data are coupled with (often) a decade of revegetation test plot data to ensure that the quality and character of the existing environment can be understood and to demonstrate that no long term adverse effect will be felt in the local environment. Such information collection should have already been commenced for this proposed project.

The only information available to the DOE is contained in studies such as "The Environmental Characterization Report for the Paradox Basin Study Region--Utah Study Areas" (Bechtel Group, 1982), which relies on information obtained from local experts, the academic community and State and Federal agencies, rather than upon site-specific data collection and analysis. Information contained in Chapter 3 of the Draft Environmental Assessment (EA) is of the same caliber.

The DOE advances the hypothesis that the environment will suffer insignificant impacts which can be largely mitigated and which will have no long-term adverse effects on the ability of the site to support the existing vegetative community and to perpetuate the historic land use of grazing. However, to assure that this assertion is correct, the soils of the area must be salvaged, protected from loss and contamination, and replaced in a way that revegetation efforts can proceed in an unimpaired fashion. Because the data base necessary to support such a conclusion is not available, either the projected impacts must be assumed to be unmitigated until better information is available, or any judgment on the significance of impact must be deferred. For the EAs, the DOE conclusions are based upon speculation, rather than valid data. Hypotheses regarding the effectiveness of mitigation and the degree of residual impact are reached in a nonobjective manner.

Specific concerns regarding the analysis of soils impacts include the following:

The mixing of soil horizons is listed as a possible adverse impact in the EA, but the nature of the adverse impacts is not adequately described. Two major problems that could result from this mixing include: (1) Soil structure and integrity are not insured when reconstruction does not occur. Ripping and disking may alleviate compaction, but will not adequately reestablish the permeability, infiltration capacity and hydraulic conductivity of a mixed material to predisturbance conditions; and (2) the tendency of soils to increase in alkalinity with depth is common in the area (BLM 1978).

Local information on soils indicates pH values and alkali properties increase with depth. Thus, improper handling (mixing) could cause contamination of suitable upper profile soil material with sodic underlying material. If this occurs, revegetation may not be very successful. For example, Chapter 3 of the EA (page 3-111) states that soil pH increases with depth in the Ignacio series, and that the soil becomes strongly alkaline in the deepest sections. The BLM (1978) also states that this is a common tendency in the salt desert region. Thus, the proper handling of alkaline and sodic materials is required to assure the feasibility of reclamation. If soils from different depths are mixed, it is probable that less desirable (possibly near-toxic) salt levels will be brought to the surface, causing soil structure, infiltration capacity, increased sedimentation and erosion problems, as well as problems in revegetation.

Windblown salt is discussed as a potential problem (for soil contamination), and sources of windblown salt are mentioned. No plan addressing local control for each of the sources is included. Indeed, the only mitigation cited is a "default," in which the salt storage pile will presumably crust over naturally and thus "minimize" salt deposition. While covering the salt pile with a membrane is discussed in ONWI-453 for the repository operations stage, for the characterization phase, "crusting" is the only mitigation measure mentioned. As there is no evidence presented that crusting would effectively reduce impacts in the Davis Canyon environment, impacts due to windblown salt during the site characterization phase must be regarded as unmitigated.

Direct destruction of soil aggregates can occur as a function of a steep salinity gradient. When soil micropores were exposed to a dilute salt solution, the attendant movement of water into the micropores resulted in destruction of soil aggregates (Emerson and Bakker 1973). The exact reason for this is not known, but the soil texture and minerology are implicated since soils with lower silt content were found to be more susceptible to salt-induced clay dispersion than like soils with higher silt content (Felhendler et al., 1974).

Salinity, per se, may also have a direct negative effects on soil structure. A reduction of soil hydraulic conductivity (HC) was quantified by Evangelou and Phillips (1984). These researchers demonstrated an eight percent reduction in hydraulic conductivity corresponding to each unit increase in EC in pyritic spoil leachate. The effect of salinity on soil HC is governed by texture. A fine textured soil may more readily experience a decrease in HC than a sandy soil (Shainberg, et al., 1980). This is a matter of degree, since sandy soils have also been shown to be adversely affected (Pupisky 1979).

If the sodicity is high but the salinity is not, the effect of the sodium ion (toxicity to plants) could be devastating to non-tolerant native plants and to soil structure.

Problems for plants owing to soil salinity are in large part related to water availability as a result of low osmotic potentials, nutrient deficiencies and imbalances, direct toxicity, negative effects on soil structure, or a combination of all these factors.

Plants grown in saline soils may be smaller in size but show no other obvious morphological symptoms (Black 1968). This effect may result from the lack of adequate available moisture and from specific ion toxicities. When foliar symptoms do become manifest, it is often in highly saline soils. The presence of excess Cl is often cited as the cause of such toxicities. Such effects are often more pronounced in dry and warm conditions than in cool and moist conditions (Black 1968).

The physiological basis of such damage appears to be linked to disruption of plant membranes through leakiness. Such leakiness results from salt-induced lesions due to the interaction of salt ions with the biological macromolecules which comprise the membranes. The resulting leakage of solutes from cells is caused by such lesions of the plasmalemma. It follows that negative effects on photosynthesis and respiration during salt stress may result from damage to the membranes of chloroplasts and disruption of the mitochondria, respectively (Leopold and Willing 1984).

Since passive nutrient uptake in plants is tied to water uptake, any decrease in available water may result in a nutrient deficiency. As soil moisture decreases, ion uptake by diffusion and mass movement is also decreased (Tisdale and Nelson 1975).

Likewise, the imbalance of nutrients in saline soil solutions may affect the availability of nutrients through antagonism in uptake, and other less understood factors may also be at work. For example plant uptake of nitrates has been shown to be antagonized by chlorides (Geraldson 1977). Similarly, K uptake has been shown to be inhibited by excess in the sodium component of salinity when adequate Ca is absent.

The presence of Ca is critical, because in saline materials, the Na-to-K ratios may be quite high. The ability of the plant to uptake adequate K is critical to its survival. As the ions are similar, the presence of Na and the absence of adequate Ca results in diminished K uptake. This phenomenon appears to be related to the ability of Ca to maintain the geometry of the uptake sites. Absent adequate Ca, Na may be taken up in lieu of K (Epstein 1972). In addition, calcium availability decreases with increasing salinity even when calcium is present in the same relative proportion to other cations (Geraldson 1977). While much of the specific ion toxicity can be attributed to Na and Cl, other ions such as sulfate, bicarbonate, borate and lithium may have adverse effects on plant growth (Epstein 1972).

These effects have an important relationship to other phenomena such as erosion and sedimentation, which are in large part governed by infiltration capacity. Most salinity removed from surface soils is removed in the first two minutes (Jurinak et al, 1979), so infiltration capabilities will remain impaired even in the presence of additional moisture.

Soil density (presumably bulk density) was assumed to be 1.5 (about right for a sandy, loose soil) but was never actually determined. According to the DOE, soils in the vicinity of the site are generally a sandy loam (see Section 3.2.9).

Also, a serious oversight is the lack of any quantification of wind erosion effects in the EA. Wind erosion is not even discussed in the EA, though it would doubtless be a major erosive force in the arid environment of Davis Canyon.

Areas of Concern: Data and Plan Deficiencies

1. Even the limited data available has not been interpreted to assess potential environmental problems. For example, the limited soils data that are available (see Chapter 3 of the EA) raise serious questions about the likelihood of successful reclamation and thus about the likelihood of long-term adverse effects. As an example, since the soil pH is high (greater than 8.5) at depth, it raises a suspicion of a naturally occurring sodium problem which may necessitate special handling practices. Also, one soil unit at the site is described as being alkali, reinforcing concerns regarding sodium.

2. Interestingly, a very sophisticated framework for soils related reclamation procedures is briefly described in Section 4.1.2.4.7. It is stated that soils would be redistributed to a depth corresponding to the depth removed in a given area. Under the best of conditions, this is a difficult commitment to fulfill. At a minimum, an extensive data base would be required. This data base would serve as a guide for soil removal and the best of supervision would be needed to successfully implement plans to remove variable depths of soil and store them by type in multiple stockpiles.

3. Numerous impacts to soils are projected in the EAs. For example, the quality of the soils will be affected by approximately 9 tons of salt per year (see Section 5.2.1.1) from the air shaft. This figure does not include salt deposition incident to storage, transfer, and disposal. Soil losses resulting from water erosion are estimated for Davis Canyon in the working papers for the EA in table 4-10 (which shows a projected increase from 3 to 10 times over the natural loss rate). Soil impacts due to compaction are discussed in Chapter 4 (EA). In all these cases mitigation measures to lessen the magnitude of impact are either not discussed or are mentioned in a cursory fashion, rather than analyzed realistically against the baseline environmental conditions.

4. The assumption that crusting of the salt stockpile will tend to reduce the problem of wind blown salt is made with alarming frequency. It is not supported by data from any appropriate models. The only information given actually tends to admit that salt from the air shaft (see Section 5.2.1.1) will exceed the NRC guidelines. Crust formation on the salt piles may not occur in Lavender and Davis Canyons due to the occurrence of low frequency, high intensity precipitation events and low average humidity, which are not conducive to crust formation. In the November 15, 1984 presentation on salt disposal problems, the DOE stated that crusting was observed where humidity exceeded 70 percent, a relatively rare phenomenon in southeastern Utah.

5. That the location (proximity to salt storage piles) of topsoil and subsoil stockpiles is not presented is symptomatic of the overall lack of planning to assure that salt deposition and contamination problems will in fact not occur.

6. Salt deposition from transport of salt by rail is mentioned in the EA. A detailed analysis of these impacts must be included. Mitigation measures have recently been advanced (by the SRPO, in the November 15, 1984 presentation). These include covering of rail-car offloading and transport areas, and transport of salt in covered cars. (However, this mitigation was discussed in conjunction with repository operations, not with site characterization activities, where salt impacts will presumably remain unmitigated). Substantially more detail must be furnished on impacts and mitigation so that reviewers can determine whether the DOE's conclusions regarding impact are accurate. In the November 15, 1984 presentation regarding repository salt handling and disposal, it was stated that 65 percent of the salt generated during repository activities can be backfilled, which conflicts with the 60 percent figure given in the report prepared by Bechtel Group (BGI 1983d). These types of inconsistencies should be clarified.

Summary:

Appropriate fieldwork, modeling, and testing should be performed to gather data on the effectiveness of the crusting in reducing windblown salt deposition. As impacts cannot be adequately predicted without data, the plan for determining impacts during characterization, rather than assessing the impacts before disturbances commence, means that impacts will be incurred before effective mitigation can be designed. Problems such as how stockpiled soils can be protected from contamination from deposition due to evaporation ponds, salt handling during transfer to storage pile locations and transfer to the ultimate disposal location must be assessed and resolved before damage occurs. This is especially critical because contamination of topsoil could severely affect the potential for future reclamation. And, as reclamation is relied upon heavily for DOE's assertion that all impacts will be insignificant and short-term, such problems should be resolved to assure that the level of residual impact identified in the EAs is correct.

The information currently available is not sufficient for permitting by the State of Utah under the requirements of the Utah Mined Land Reclamation Act of 1975. Specifically, the lack of an organized soil description with maps of adequate scale and with supporting soils chemical and physical data does not provide an adequate basis on which a narrative describing the soils handling plan can be written. As the collection of the necessary information requires months or years of lead-time, and as such data collection has not been commenced by the DOE, the DOE's capabilities of meeting all statutory and regulatory requirements for the characterization activities within programmatic time constraints is in serious doubt. This should be reflected in the Chapter 6 discussions about whether guideline conditions can be met.

Revegetation

General vegetation studies prepared for the proposed project area are described in the EA for the Davis Canyon site. In addition to being inadequate for a general assessment of environmental impacts, the information provided is not specific enough to allow for approval of a mining permit (which would be required for site characterization activities). To meet the requirements of the Utah Mined Land Reclamation Act (Title 40-8, Utah Code Annotated 1953), the DOE must submit a specific description of the vegetation of the proposed disturbed area(s), including, for each vegetation community type proposed to be disturbed, measurements of total vegetative ground cover, cover by individual species, and the amount of acreage of each community type to be disturbed. These studies could only be adequately done at a certain time of year (i.e., June or July). The DOE would also be required to submit a complete and adequate reclamation plan for all disturbed areas.

The DOE proposes to do such studies in the EA (Section 4.1.3.1). These studies must be completed and evaluated for adequacy by the State before a mining permit can be issued and before any ground disturbance can occur.

To date, the DOE has not submitted any kind of specific reclamation plan, or any site-specific data sufficient to show the feasibility of reclamation. Revegetation is discussed in the BLM's 1982 EA on Baseline Studies in the Paradox Basin. It is stated in that document that grasses and forbs can generally be reestablished to predisturbance density and vigor in 2 to 4 years (although not necessarily to the same mix of species that were originally present). Shrubs may take decades to reestablish, and, as the primary communities at the proposed site are dominated by shrubs, areas of disturbance may be noticeable for many years. Site-specific vegetation community studies indicate that invasion of natural vegetation could require 15 to 100 years (Bechtel Group, 1983b). Impacts of this magnitude that will endure for these lengths of time must be considered to be long-term adverse effects upon the environment. These must be identified in the EA, and the level and duration of the impact must be taken into account in determinations whether guideline requirements can be met.

Areas of Concern: Data and Plan Deficiencies:

1. Lack of a site-specific reclamation plan: The DOE states that reclamation will be carried out "... in accordance with BLM seeding specifications" (see page 4-65 of the EA), and it is stated that the federal agencies will "consult" state agencies. This appears to be an attempt by the DOE to circumvent the requirements of the Utah Mined Land Reclamation Act of 1975, as administered by the State of Utah Division of Oil, Gas and Mining. To meet the requirements of Utah law, the DOE must prepare an adequate reclamation plan as per the requirements for a mining permit. A complete reclamation plan takes into account site-specific vegetation information, soil characteristics and postproject land uses, and proposes specific methods and amounts for regrading,

retopsoiling, adding soil amendments, reseeding, and preventing wind or water erosion on newly seeded areas.

Revegetation test or demonstration plots to insure the viability of reclamation techniques have not been prepared, nor are they proposed by the DOE. This is in marked contrast to what is required of mining projects of comparable size and in similar fragile environments, which may have a decade worth of site-specific data.

2. Reclamation of salt-contaminated soil: A major reclamation concern involves the disposition of salt-contaminated soils and reclamation of a large permanent onsite salt storage pile. The DOE discusses reclamation of a potential onsite salt storage pile 100 feet high and over 60 acres in extent (see Bechtel Group, 1983d). The proposed final disposition method is to seal the pile with a membrane, cover it with topsoil, and revegetate it. Apparently, no studies have been done to show that such reclamation is feasible, and several major questions are left unanswered, including those regarding the impermeability of the membrane over time (and the life expectancy of the membrane). Also, no information is provided on how much (what depth) topsoil would be required to reestablish vegetation, particularly deep-rooted shrubs; nor is the source of topsoil identified. The consequences of a salt pile of this size on the local environment if it proves to be unreclaimable are not assessed.

   The existing data with regard to soil salinity and sodicity is very limited, but essentially consists of the 1978 BLM report and the Agriculture Experiment Station--Bulletin 492, which both indicate low salinity in the area of the proposed repository. If the local and nearby soils are of low salt content, impacts due to windblown salt may be proportionately worse. If the species that thrive in these soils have a low salt tolerance, they will be adversely affected by a rapid rise in the salt and/or sodium content of the soil.

   If the sodicity is high but the salinity is not, the effect of the sodium ion (toxicity to plants) could be devastating to non-tolerant native plants and to soil structure.

   If either or both of the problems of increased salinity or sodicity are manifested, with deleterious effects on the local flora, then soil erosion, changes in the community structure, instability and drastic effects on land use (i.e., grazing and wildlife uses), and stream siltation with attendant impacts to fishery will result.

   The effect of excess sodium on soils has been well documented (see BLM Technical Report). In short, by adversely affecting soil structure and drainage properties, the volume of surface water runoff is increased. This causes greater erosion, with attendant siltation and salinization problems in the receiving Colorado River waters. It thus becomes a problem in terms of managing the upper Colorado Basin, rather than simply a localized adverse phenomenon.

The effect of salinity on vegetation and soils is a complex area of investigation and is highly variable in terms of the environment, soils and tolerance of the vegetation in question. While no specific data on vegetation of the Gibson Dome area are available, a bibliography has been provided by ONWI that reflects the uncertainties of the issues, as well as the economic importance of avoiding salinization problems (NUS Corporation, 1984).

3. Disposal of Undesirable Substances: Onsite disposal of salts is discussed by the DOE as a viable disposal option (Bechtel Group, 1983d). A 12 million ton salt pile occupying in excess of 60 acres would be left at the site permanently. Although this method of disposal is opposed by the Colorado River Salinity Control Forum, this is considered an economically and technically feasible option by the DOE. Disposal of salt at a nearby potash mine (Section 4.2.1.2.2) appears to be advanced by the DOE as an an easy solution to the problem (out-of-site, out-of-mind). Assurances made that runoff would be controlled in a responsible fashion at the chosen site are currently not supported. Such a disposal choice could also become a detrimental legacy for future generations. It seems the only mine available for disposal is above the Colorado River and already presents a significant potential salt pollution problem for the river. The necessary control measures will not be maintained and operated forever, so the possibility of future contamination of the Colorado River system will remain if this disposal option is chosen.

   Alternately, a recent document handed out at the Eighth Bimonthly Meeting of the Salt States proposes disposing of salt generated by the exploratory shaft in a sanitary landfill and states that the capacity required is available. This information must be verified before the mitigation is assumed to be available and effective. Also, transport of the salt to an offsite landfill will generate its own set of impacts, which must be assessed.

   The disposal of salt evaporites from holding ponds and residues from mud pits are addressed in a very cursory fashion. For example, "salt contaminated soil" is not defined. Depending on how this is defined, enormous amounts of soil could be slated for disposal.

   Removal of the liner array (associated with protection from leaching under the salt storage pile) is discussed but not acknowledged as critical to reclamation success; nor is the disposal of the liner addressed.

   With regard to storage and mud pit reclamation, the disposal of muds, oils, lubricants, grease, and sediments which accumulate in retention dams is mentioned as a mitigation measure, but no disposal options for these substances are discussed. Highly concentrated occurrences of deleterious substances are acknowledged in the EA, but options for addressing the problem are included. Thus, adverse impacts related to these deleterious substances must be regarded as being, for the present, unmitigated.

In the absence of detailed mitigation plans addressing the above concerns, it appears that the historic land use (grazing) would be compromised greatly for a lengthy period during site characterization, operation and decommissioning of the repository.

4. DOE has not committed to post-closure environmental monitoring: Another issue of concern to the State that is not discussed in the EA is post-closure monitoring of reclamation success. The Utah Mined Land Reclamation Act requires a statutory three year waiting period from the time of reseeding before a bond can be released. Even though three years have elapsed, the bond cannot be released until a minimum standard of cover equaling 70 percent of the natural predisturbance vegetation cover is achieved. The DOE must discuss how it will monitor revegetation success and what will be done if the vegetation standards cannot be met.

Wildlife

The potential effects of a full-scale repository on wildlife are numerous and complex, yet little attempt has been made by DOE to identify these impacts. Without accurate quantification of impacts it is impossible to determine if they can be mitigated, or which is the best siting alternative for the repository, or whether associated facilities such as railroads and utilities can meet guideline requirements.

Areas of Concern: Data and Plan Deficiencies:

1. Impacts at the Actual Exploratory Shaft or Repository Site: Potential impacts at the repository or shaft site include extirpation of the small local deer herd and the trout fishery in Indian Creek, increases in turbidity and sediment in the surface water system, and the effects of windblown salt on flora and fauna. The presence of humans in the area, with associated noise, dust and off-road vehicles, could adversely impact local wildlife populations. Small game animals may be killed outright. Large game may be displaced into surrounding areas where other animals already exist, and the surrounding range may not be able to support the additional displaced animals.

2. Impacts from Transportation Corridors: Impacts from transportation and utility corridors have as much or more potential for serious effects on wildlife as do onsite activities. Proposed railroad corridors could adversely affect bighorn sheep, golden eagles, peregrine falcons, wintering bald eagles, deer, endangered Colorado River fish, pronghorn antelope, sage grouse, Yellowstone cutthroat trout, mountain lions, and prairie dogs, depending upon the exact route chosen. According to the DOE's own studies, the proposed Colorado River route is considered the least attractive biologically (Bechtel Group, 1983c). This route would cross numerous tributary drainages to the Colorado River. These are considered to be "... the most sensitive biological resource in the area ...," due to their value as riparian zones and their contribution to the Colorado River system (see page 3-158 in the EA). Railroad tracks running parallel to the river could also cut off access to the river for bighorn sheep and mule deer, and could affect sensitive cliff-nesting raptors, such as the golden eagle and the Federally-listed endangered peregrine falcon. This route could also contribute sediment and cause other disturbances to the Colorado River and its endangered fish species (the Colorado squawfish, humpback chub and bonytail chub), as well as the candidate razorback sucker. A proposed new road to be constructed in Harts Draw (see the description in the EA) could also affect wildlife by impacting cliff habitat valuable to raptorial birds.

3. Impacts to Federally-Listed Threatened or Endangered Species or Species Considered Sensitive or of High Value to the State: Several Federally-listed threatened and endangered wildlife species and state-valued sensitive species inhabit the repository area. These species would likely be affected by repository activities. They include the Peregrine falcon, Bald Eagle, Golden Eagle, various big game species, and endangered Colorado River fishes, as discussed above.

Raptorial birds will mostly be affected by the destruction or disturbance of cliff habitat. Bald eagles could also be harmed by the destruction of winter roost trees along the Colorado River. A golden eagle nest site is shown on Lavender Mesa (Figure 3-48) between Davis and Lavender Canyons. No discussion of repository impacts or mitigation plans to this nest site are given. Big game such as bighorn sheep, pronghorn antelope, and mule deer may be impacted by loss of habitat, roadkills, and increased hunting and poaching pressure. Repository operations, and particularly the location of transportation corridors, may impact Colorado River endangered fish species through siltation or other water pollution. The endangered Colorado squawfish has been found near the mouth of Indian Creek, which discharges to the Colorado River downstream from proposed repository sites (Ecosystem Studies, Endangered Species Survey). The U.S. Fish and Wildlife Service has indicated its concern for sensitive Colorado River species and their habitats. Formal consultation with the U.S. Fish and Wildlife Service must be initiated <u>before</u> site selection occurs, so that potential impacts on these species may be avoided.

In order to obtain a Mining Permit for a repository site, the DOE would be required to identify and quantify impacts of repository siting, including transportation and utility corridors on all wildlife populations and particularly on threatened or endangered or sensitive species. Development of mitigation techniques to reduce or negate impacts to the maximum extent possible would also be required. This work may take months or years, and, as the DOE has not yet initiated this work, the DOE's ability to meet all regulatory requirements in a timely fashion must be regarded as questionable.

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APPENDIX H

DRAFT

REVIEW OF RADTRAN II MODEL

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March 1985

Introduction

This report reviews the use and assumptions of the RADTRAN II computer model as used in the background reports and Draft Environmental Assessments (D.E.A.s) for the siting of a High Level Nuclear Waste (HLNW) repository at the Davis of Lavender Canyon sites in the State of Utah. the RADTRAN II model calculates the incident-free and accident impacts of transporting radioactive materials.

The report begins by reviewing the relationship between the RADTRAN II model and the Draft E.A.'s for the Davis and Lavender Canyon sites and present the results of the RADTRAN II simulations used in the E.A.s The general characteristics of the model are discussed and are followed by a detailed review of selected assumptions for both the incident-free and accident radiological risk assessments.

A. RADTRAN II AND THE DRAFT ENVIRONMENTAL ASSESSMENTS

RADTRAN II is used to estimate the radiological risks of radioactive waste transportation to the five candidate sites for the HLNW repository. It is used to make a comparison between the sites for the national risk associated with each site and to assess the local risk for a 200km radius around each site. Radiological risks are estimated for both incident-free transportation and for accidents. The basis for the national transportation risk assessment is common to all sites and is reported in Appendix A of the E. A.s. It is derived, in large part, from the Sandia Report on the "Preliminary Cost and Risk Analysis for Transporting Spent Fuel and High-Level Wastes to Candidate Repository Sites: (SAND84-1795, October 1795, under contract to D.O.E.).

Role in the Draft Environmental Assessmets

The radiological risk assessment is an important part of the transportation review component of the E. A. (section 5.3 of both E. A.s) and is one of the main conditions for judging the site against the DOE Siting Guideline 10 CFR 960.5-2-7. In Chapter 7 of the E. A.s, "Comparative Evaluation of Sites Proposed for Nomination", the radiological and nonradiological waste transportation risks are compared for each site and are then combined with four other significant factors (p7-94 Lavender Canyon (L.C.) D.E.A.) to provide a ranking of sites for transportation. This ranking is then combined with the rankings for preclosure environment and socioeconomics using three different aggregation methods (Table 7.25 L.C.D.E.A.). Finally this is combined with ranking for radiological safety at the site, and with the ranking for the ease and cost of siting, construction, operation and closure, to provide a final ranking of sites for the preclosure set of guidelines (Table 7.25 L.C.D.E.A.). This is then combined with the rankings for postclosure to provide an overall ranking of sites (Table 7-26, L.C.D.E.A.). In Tables 7.24, 7.25, and 7.26 the categories are approximately equally weighted but it is not clear how the initial transportation factors are weighted. The weighting issue is discussed further in our Report #3, "General Comments on the Draft Environmental Assessments."

However, it should be clear from the above description that the risks estimated by RADTRAN II do enter into the ranking process for comparative site evaluation. Unfortunately, it is not possible to examine the sensitivity of the final ranking to the RADTRAN II results because the basis for weighting the sites on the transportation guidelines and conditions is not clear.

RADTRAN II Results As Reported in the Draft E. A.s

National Risk Assessment

The national radiological risk estimates for the Davis and Lavender Canyon sites are identical. Table 1 reproduces the estimates for normal transport and accidents, for truck and rail transport modes.

Table 1 (based on Table 5-13 in Draft E. A.s)

Total Risk of Nuclear Waste Transport to Site During Operational Period (26-28 years)

	Latent Cancer Fatalities	
	100% Rail	100% Truck
Normal transport	13.7	2.7
Accidents	0.012	0.001

In the site comparison normal and accident risks are combined to provide the totals reproduced in Table 2.

Table 2 (based on p 7-92 in L.C.D.E.A.)

Total Risk of Nuclear Waste Transport to Site During Operational Period (26-28 years)

	Latent Cancer Fatalities	
	100% Rail	100% Truck
Hanford	18	3.6
Yucca Mtn.	17	3.1
Davis Cn	14	2.7
Dear Smith	11	2.1
Richton	8	1.4

The main reason for the differences in risk is the distance of each site from the major sources of spent fuel.

Regional Risk Assessmnet

The Regional Risk Calculation was performed for a 200km radius around each site for truck and rail and for 2 alternative routings for each mode. The results are shown in Table 3.

Table 3 (based on Table 5-15 and 5-16 in L.C.D.E.A. and D.C.D.E.A.)

	Latent Cancer Fatalities			
	Lavender		Davis	
	Normal	Accident	Normal	Accident
Truck Route 1	0.2	0.00009	0.3	0.00009
Truck Route 2	0.2	0.00006	0.2	0.00006
Rail Route 1	1.4	0.0001	1.4	0.0001
Rail Route 2	1.0	0.00004	1.0	0.00005

B. GENERAL ASSUMPTIONS IN USING RADTRAN II IN THE E.A.s

1. Transportation Modes

The RADTRAN II model permits calculations for routine and accidental radiological risk for a variety of transport modes including truck, air, rail, ship, barge and cargo van, and for a number of possible combinations. In the Draft EAs and the SANDIA 84-1795 report estimates are only reported for 100% truck and 100% rail shipments. Since the risks are proportional to the number of shipments, these exclusive estimates bound the range of risks which would occur under a combination of these two modes. As the bulk of the shipments shift from rail to truck at the national level, the radiological risks from both incident-free transport and accidents decrease. The nonradiological risks increase as shipments shift from rail to truck at the national level. As discussed later in this report (section C.5) this difference seems to be a function of the assumption that rail shipments tend to be stationary for relatively longer or more frequent periods than trucks. It should be noted, however, that truck shipments tend to incur higher occupational risks than those by rail (see Table 20 in Sandia 84-1795 report). It seems quite reasonable to use these two exclusive modes as a basis for the risk assessment for each site.

In the comparison of sites the ranking does not change with the transport mode. However, in reality, different sites may involve different combinations of truck and rail shipments. The risk difference between using 100% truck and 100% rail is much greater than any difference between the sites for each mode. Hence, if the Utah sites involve significantly less rail transportation than other sites, their ranking on radiological risk would change. Since it is very difficult to estimate the balance of truck and rail shipments, and since the uncertainty is not discussed fully in the E.A., the risk comparison may have little value.

2. <u>Accident Clean Up Costs</u>

RADTRAN II permits the calculation of the economic costs of accidents in radioactive waste transportation. Although the Draft EA's do discuss the lifecycle costs of transporting waste to the repository, these costs are only defined as the sum of capital costs, maintenance costs, and shipping charges. Accidents are included in the risk estimates but not in the cost estimates. Accidents could, however, contribute significantly to the cost of transporting waste. The costs of emergency response, clean up, evacuation and possible land purchase can be considerable. Particularly in the case of radioactive materials the costs of litigation, clean up, surveillance, and evacuation, can be very high (e.g., costs of Three Mile Island accident were estimated at $12 million, for the Mississauga chlorine transport accident at $5 million).[1]

Estimates of accident costs should be included in the E.A. but it is not clear that the RADTRAN II model is the most appropriate calculation tool. Some problems are discussed on Page 7 of M. Resnikoff's report on RADTRAN, and it is also clear from the default data given in the RADTRAN II: Revised Computer Code (SAND80-1943; Appendix B) that the costs are grossly underestimated.

3. Health Impacts

RADTRAN II Estimates radiological risk for a range of health impacts including early fatalities, early morbities, latent cancer fatalities and genetic effects. The EAs only report latent cancer fatalities because as noted on page 5-92 (L.C.D.E.A.) the Sandia report 83-0867 (1983) found no acute radiation fatalities projected as a result of releases from any postulated accidents. This may depend on the severity of the "postulated" accidents (see section D.2). No rationale is given for not considering genetic effects in the E.A.

4. Ecological Impacts

The radiological impacts of transportation on the non-human environment are not discussed in the D.E.A.s, although the ecological and environmental impacts of the actual site are discussed. The non-human impacts of waste transport accidents and routing shipments may be important not only because of judgments about the intrinsic value of the non-human environment but because the environment can provide important human ingestion pathways for radionucleides (see later discussion of ingestion pathways in section D.3).

5. Population Estimates

RADTRAN II requires input regarding the percent of travel in each of three population zones defined by population density. The D.E.A.s use 1980 census data for the national risk assessment and from 1983 City County Data Books for the regional assessment. This data is then used to assess the fraction of travel in urban, suburban, and rural zones. This estimate is then used for the full 26 year lifetime transportation risk assessment for the repository. The unit-risk (person-rem per kilometer) factors vary considerably for each zone. Truck transport, for example, has an incident-free non-occupational unit risk estimate of 1.5×10^{-5} for rural areas, $2.r \times 10^{-5}$ for suburban, and 3.3×10^{-5} for urban areas. Hence any shift from one density category to another will be significant.

In other parts of the DEAs population projections are an important factor. Yet the possibility of population growth, and trends in population density associated with urbanization, are not considered for the 26 year lifetime of transport to the repository. At the national level, population growth, and rapid urbanization, are certainly projected to occur over the next 25 years. These changes would probably increase the percentage of travel in urban and suburban areas for HLNW transport. These changes would probably affect the RADTRAN risk estimates.

At the regional level the D.E.A. projects population growth of 37% in San Juan County, and some urbanization associated with the site. This could affect the regional risk estimates. The attached report by Resnikoff also comments on population density on Page 7.

C. REVIEW OF SPECIFIC ASSUMPTIONS

1. Waste Origins and Transport Distance Estimates

The SANDIA report (SAND84-1795) discusses the assumptions and calculations for the estimation of mileage distances used in the national risk estimates for transportation. They point out that detailed truck and rail routes are not generated for individual waste origin sites. Instead 21 geographic centroids were defined and the waste assumed to be shipped from these points. Although this seems like a valid assumption, it would be appropriate to present some estimate of the error associated with this type of assumption in the D.E.A.

We do not wish to comment on the use and validity of the mileages and routes estimated by the HIGHWAY and INTERLINE models. However the RADTRAN II results are obviously sensitive to the routing choices specified for these models, particularly to the assumption that trucks will travel, whenever possible, on freeways, many of which traverse zones of high population density and vulnerability. If the routes were chosen so as to avoid urban areas, the risks might be very different.

2. Population Density Assumptions

The D.E.A.s assume urban population densities of 3861 people per square kilometer (10,000 per square mile). As Resnikoff points out on page 7 of the attached report, this underestimates daytime hour densities in cities. The population density estimates were based on 1980 census data which were contoured and used to estimate % of routes in each population zone. It is not clear what happens when a route is tangent to an urban area, as occurs with many freeways, and there may be many errors associated with the contouring method. As noted in section B.5 the D.E.A.s do not examine the impact of possible national and regional population density changes on radiological risk.

The choice of three categories for population density in RADTRAN II simulations clearly influences results in significantly different risk estimates for both routine transport and accidents, and clearly obscures a gradual continum of exposure to transport risks. The population density assumptions in RADTRAN II could, in fact, be changed to reflect local conditions or specific scenarios.

3. Population Vulnerability

As we pointed out in our first report (p5), risk estimates, in combining both probability and consequences, are very sensitive to the different vulnerabilities of groups in the population. RADTRAN II, as described above, groups people only by population density, and considers only two categories of significantly different vulnerability: occupational and non-occupational groups.

As we mentioned in our first report, certain groups in the population are more vulnerable to routing radiological risks than others (e.g. pregnant women, smokers, children). In the case of the regional risk estimate in the D.E.A.s, those who have already been exposed to radiation as uranium miners are probably more vulnerable to transportation risks. In the case of accidents the D.E.A.s assume adequate emergency response and evacuation. However, the ability of people to escape accidental exposure can depend on their demographic characteristics. It is often the poor, the less educated, minorities, and unemployed who are more frequently and continuously exposed to hazards and who are less likely to have cars or facilities for rapid evacuation.[1] The 1980 census shows many families below the poverty line in Grand and San Juan counties (within 200km of site).

None of these factors are taken into account in the RADTRAN II model.

4. Highway route types

The RADTRAN II model requires information about highway route types. Input is needed on the velocity of travel in each population density zone, and on the fraction of travel on freeways. For the national assessment (SAND84-1795) it appears that velocities were assumed as 2.46m/s, 1.12 m/s. and 0.67 m/s respectively, and 85% of rural and suburban travel was assumed to be on freeways. However, these assumptions are not discussed in the DEAs and we do not know if they were changed. The assumption about freeway travel may be particularly important for the regional risk assessment for Utah where roads are below freeway standards on many routes. It is important because both routine risk exposure and accident probabilities are higher on non-freeways given the same traffic density. For example, on freeways the maximum exposed individual is assumed to be 15m from the shipment, and only 3m on non-freeways.

1. Reported in many evacuation studies, e.g. Liverman and Wilson (1981).

This uncertainty in the use of RADTRAN II supports the comment on p 5-96 (L.C.D.E.A.) about the preliminary nature of the regional analysis.

5. Stop Times

The sensitivity of the radiological risk estimates to the assumptions about the "stop time" of shipments is emphasized in the Transportation Appendix of the DEAs (pA-20 L.C.D.E.A.) and in the SAND84-1795 reports (p 41). RADTRAN II requires information about the estimated time that shipments will be stopped in each transport mode, and the number of people at certain distances from the shipment. In the DEA (pA-20 L.C.D.E.A) it is claimed that the stop time estimates were chosen to produce a result "as high as can be considered plausible". This estimate is not given, and we can only assume that it is close to that given in the SANDIA (84-1795) report. This is 0.011 hr/km for trucks and 0.86 hr/km for rail transport. Apparently, these estimates are based on empirical studies. The RADTRAN II results are very sensitive to these assumptions. Halving the rail stop time reduces latent cancer fatalities from routine exposure by 45%.

Since it is very difficult to forecast truck and rail delays and nearby population exposure for the next 26 years, it is important to emphasize the sensitivity of the RADTRAN results to these stop time assumptions. RADTRAN II makes no assumption about where stops occur. If they occur more frequently in urban areas (rail marshalling yards), rush hour traffic, then radiological risk may be much higher.

D. ASSUMPTIONS ABOUT ACCIDENTS

1. Accident frequency rates

RADTRAN II estimates for radiological risk from transport accidents are very sensitive to assumptions about accident frequency rates. In the D.E.A.s, it is not clear whether regional accident data was used in the regional risk estimates. For the national estimates we assume that accident rates were the same as those used in the SAND84-1795 report. For trucks these were apparently developed from actual data for shipment of all goods are reported in SAND80-1721. They were revised in SAND80-2124 based on recent California data. They are 4.7×10^{-6} accidents per km in urban areas, 8.1×10^{-7} for suburban, and 4.0×10^{-8} for rural areas. For rail they are 1.5×10^{-5}, 1.9×10^{-6}, and 1.0×10^{-7}, respectively. Resnikoff (attached) points out that truck accident rates reduced considerably between the publication of the RADTRAN II user guide in February 1983 and the June 1983 SANDIA preliminary risk analysis. He points out that the use of these rates, if based on California, must be justified for national use. California has a well kept, modern highway system, possibly less vulnerable to meteorological hazards than highways in Colorado and Utah for example. The regional risk assessment in the DEAs should certainly use local data and recognize the seasonal nature of accident probabilities around the site. For example, Utah roads are frequently threatened by meteorological hazards than highways in Colorado and Utah for example. The regional risk assessment in the DEAs should certainly use local data and recognize the seasonal nature of accident probabilities around the site. For example, Utah roads are frequently threatened by meteorological hazards (snow, ice, floods, landslides) in the winter and spring, and in the summer they may have higher accident rates because of careless driving by tourists.

2. Accident Severity Categories

The initial versions of RADTRAN II had eight accident severity categories. The most recent version used in the D.E.A.s, and in the SAND84-1795 report has six categories. These categories and the characteristics and accident probabilities associated with each category were developed primarily at a May 1980 workshop on Spent Fuel Transportation Accident Scenarios (SAND80-2012 and SAND80-2124).

Resnikoff comments on the development of these accident severity categories on page 4 and 5 of his attached report. He points out that accidents of severity greater than those assumed in the DEAs are credible. In particular cask rupture greater than 1 square inch (the maximum credible accident used for category 6 in the DEAs) could occur. His comments are supported by our discussions with experts in the Department of Natural Resources in Wisconsin. Several people feel that the maximum accident could be much more severe.[1]

Not only are the estimates of possible accident severity conservative, but the estimation of the percent of accidents in each severity category may be cautions. 99% of all truck and rail accidents are assumed to occur in the two least severe categories. The real problem with these estimates is that there is virtually no actual accident data, and only a very few experiments, upon which to base judgments. The uncertainty and basis for these estimates is not elaborated in any public document. Yet the RADTRAN II risk estimates for accidents are quite sensitive to these assumptions. Shifting th percent of accidents in each category can change radiological risk estimates considerably.

We are unable to comment on the accuracy of the radiological characteristics associated with each category of accident although they obviously influence the final risk assessments.

3. <u>Ingestion Pathways</u>

Health effects from the release of radionucleides to the environment in accidents are evaluated for three pathways: groundshine, cloudshine, and inhalation. According the the SAND84-1795 report "the ingestion pathway is not included because Federal, state, and local authorities are assumed to intervene by impounding crops and cleaning up contaminated soil" p 25.

1. See also the papers on cask safety in Surrey (ed.) <u>The Urban Transportation of Irradiated Fuel</u>.

This is a critical assumption in the D.E.A.s and probably fairly unrealistic. Just to take two examples:

(a) In Utah and many other areas in the southwest cattle range freely in the vicinity of possible accident scenes. It may not be possible to identify exposed cattle or politically expedient to destroy them.

(b) In Wisconsin a train accident in the Mississippi corridor could involve releases to the river and wetlands with associated contamination of fish, waterfowl, and water sources. Again, clean up would be a formidable task.

RADTRAN II assumes that accidents will be cleaned up to an acceptable level whatever the cost and difficulty. This assumption is not discussed in the DEAs of background documents. If clean up is not complete, exposure to radiological risk via food or liquid ingestion could occur. In any case, attempts to clean up and identify exposed food and water sources will involve considerable economic costs which are not discussed in the EAs.

2. Emergency Response

As discussed above, and in section C.3 of this report, assumptions about emergency response are critical in the assessment of radiological risk and cost of accidents. The cost, effectiveness, and difficulty of emergency response is discussed in the previous section on Ingestion Pathways. It is also important in determining the number and vulnerability of populations exposed to both transportation and site accidents.

Therefore, in order to accept the risk assessments produced by RADTRAN II, and in the D.E.A.s, a State of local authority must be confident of the ability of individuals, institutions, and the public to respond as planned and appropriate to any accident. Considerable responsibility rests on those who arrive first at the scene of the accident. There are a number of cases where transport crews or local officials have not responded as planned, or as wisely as hoped, in hazardous material accidents.[1] The fear associated with nuclear materials can also influence emergency response.[2]

1. e.g. Ziegler _et al_ report on role conflict in the Three Mile Island and other accidents (p 79).

2. Ziegler _et al_ p 81.

5. Sabotage and Terrorism

The question of sabotage and terrorism is not investigated in the DEAs or background documents although it is obviously a concern to communities affected by nuclear waste transportation. The possibility of sabotage, however remote, can increase the probability and severity of the maximum credible accident used in the RADTRAN II model. For example, a SANDIA assessment of deliberate explosive attack (NUREG/OR-0743) in an urban area reports an upper estimate of latent cancer fatalities of 104.

NOTES

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APPENDIX I

COMMENTS ON COVERAGE OF AESTHETICS IN

DAVIS CANYON FINAL DRAFT ENVIRONMENTAL ASSESSMENT

Prepared by William Blair, JONES & JONES, 3/17/85.

for State of Utah High-Level Nuclear Waste Office

TABLE OF CONTENTS

Page ix: A list of the persons who prepared the EA should be added as an appendix. This list should identify the professional qualifications of these persons and the specific sections of the document for which they are responsible. The reason for this comment is that certain technical sections of the EA appear to have been prepared by persons without the appropriate professional expertise, while certain conclusionary sections of the EA do not appear to be supported by the information presented in the corresponding technical sections.

2. DECISION PROCESS AND PRELIMINARY CONCLUSIONS

2.2.4 Suitability of the Davis Canyon site for development as a repository

Page 6, last paragraph: The evidence presented in the EA is not adequate to support findings regarding the qualifying or disqualifying conditions of the preclosure technical guidelines that address concerns about environmental impacts, socioeconomics, and transportation. This is particularly true of the aesthetics component of these guidelines. The EA presents little data on aesthetic impacts, and the data that the EA does present are derived largely from a technical study (ONWI 454) that was based on incorrect assumptions about the visual characteristics of the repository. See the comments on section 4.2

2.2.5 Suitability of the Davis Canyon site for characterization

Page 7, first paragraph: The evidence presented in the EA is not adequate to support a finding regarding the suitability of the Davis Canyon site for characterization. This is particularly true of the aesthetics component of the preclosure guidelines: the EA presents little data on aesthetic impacts, and the data that the EA does present are largely derived from a technical study that was based on incorrect assumptions about the visual characteristics of the repository (see the comments on section 5.2). Moreover, there is a strong likelihood that site characterization activities at Davis Canyon would impose significant adverse aesthetic impacts and related adverse impacts on recreation, transportation, and cultural resources (also discussed in the comments on section 5.2). Therefore, the failure to adequately assess aesthetics in the EA could lead to the imposition of significant adverse impacts if the EA were not revised and if it were used as a basis for a decision to go ahead with site characterization at Davis Canyon.

3. THE SITE

Page 9, second paragraph: Most of the proposed repository site is managed for multiple use by BLM. The principal current uses are dispersed recreation and rangeland. The EA should acknowledge that the site abuts Canyonlands National Park, since it uses this word to describe the geographic relationship of the Lavender Canyon site to the Bridger Jack Mesa WSA (p. 6-22, for instance) and since the EA states that DOE would request a withdrawal area of approximately 8 square miles from BLM if the site were selected for characterization. This area appears to be larger than the nominal control zone shown on Figure 4-3, for example, and could easily extend to the park boundary if and when an actual withdrawal proposal is prepared.

Page 11, fifth paragraph: The EA should acknowledge that a PSD Class I area (Canyonlands National Park) abuts the site, since it uses this word to describe the geographic relationship of the Lavender Canyon site to the Bridger Jack Mesa WSA. The EA also states that DOE would request a withdrawal area of 5000 acres (approximately 8 square miles) from BLM if the site were selected for characterization. This area appears to be larger than the nominal control zone shown on the site layout maps in Chapter 5 and could extend to the park boundary. At this preliminary stage of repository design, it is questionable whether there is enough information to fix the location of the control zone (see Comment...).

Page 11, last paragraph: The EA text should recognize the national significance of the aesthetic values in the vicinity of Davis Canyon. This significance is stated by the preamble of the Congressional Act that established Canyonlands National Park to preserve its "superlative scenic, scientific, and archeologic features for the inspiration, benefit, and use of the public" (78 Stat. 934) and is confirmed by the legislative history of the Act.

4. EFFECTS OF SITE CHARACTERIZATION

Page 12, eighth paragraph: The text should be consistent with the figures and state that the characterization program would last from seven to nine years at a minimum, depending on if the site were to be selected as an actual repository site or if it were to be closed and reclaimed (labor diagrams in Chapter 4).

Page 13, fourth paragraph: State of Utah reviewers question the methodology and assumptions used in the air-quality modeling. Fugitive dust, exhaust plumes from the underground suitability testing, and site illumination for 24-hour activity could all have significant adverse visibility and/or aesthetic impacts on Air Quality Related Values (AQRV's) in Canyonlands National Park. See the comments on section 4.2.

Page 13, fifth paragraph: The EA seriously understates the visibility of the surface facilities associated with the repository, apparently relying on an outdated visibility study (ONWI 454). That study tested the visibility of only one location on the proposed site, which is not representative of the entire site and which does not correspond to the reference site layout for site characterization facilities (Figure 4-6). It also failed to test the visibility of the many ancillary facilities necessary for site characterization and site investigations, which include meteorological towers, numerous boreholes, roads, and seismic clearings spread over a very wide area that extends well beyond Davis Canyon itself (Figures 4-3, 4-4, and 4-14, for example). Other than the incomplete analysis of visibility, the EA does not systematically assess the aesthetic impacts of site characterization and field investigations, and does not reference any data to support the claim that standard mitigation measures would be able to reduce aesthetic impacts to acceptable levels in this environmentally sensitive area, other than a BLM contrast rating of four proposed boreholes. Considering the extent of the facilities and actions that would be involved in site characterization and site investigation, including the likely need to upgrade Utah 211, it appears probable that the adverse aesthetic impacts would be significant. Without data to support a finding to the contrary, the likelihood of aesthetic impacts should be considered as a potentially adverse condition, under the terms of the definition in section 960.2 of the repository siting guidelines, and in accordance both with section 960.5-2-5(c)(2) and with section 960.5-2-7(c)(4) of the guidelines.

Page 13, sixth paragraph: State review (Johnson et al., 1985 Appendix D) indicates that the conclusory statement that only a small percentage of visitors to Canyonlands National Park would be affected by visual intrusion is incorrect. The statement appears to be based on the incomplete visibility analysis contained in ONWI 454. It also ignores the fact that the only road access to the Needles District of Canyonlands National Park is Utah 211, and that the last 13 miles of the road were built by the National Park Service specifically as an entry parkway, under the authority of the Congressional Act establishing the park. The characterization program, including the considerable amount of traffic that it would generate, would have an adverse aesthetic impact on the percentage of park visitors who would travel through the Indian Creek valley to enter the park. This paragraph also fails to mention that some of the people engaged in dispersed recreation on BLM lands in the vicinity would also be affected by visual intrusion. A considerable amount of ORV, camping, and hiking use occurs on these lands, motivated in part by the aesthetic values of the canyons and rims (DEA pages 3-148 and 3-152; Barnes, 1977; Barnes, 1978a; Barnes 1978b).

Page 13, last paragraph: The SHPO and the federal Advisory Council on Historic Preservation have the authority to determine that site characterization would have adverse effects on archeologic or historic resources by introducing "visual, audible, or atmospheric elements that are out of character with the property or its setting" (36 CFR Part 800.3(b)(3)). Newspaper Rock, for example, is listed on the National Register; it could be subjected to adverse effects by noise and visual impacts associated with improvements to Utah 211 that would accommodate characterization activities. There are also numerous archeologic features on BLM land in Davis Canyon, including ruins, that are outside the Salt Creek Archeological District, but that appear eligible for nomination to the Register. The criteria of adverse effect quoted above could also apply to these features; for example, the exploratory shaft facility could be visually prominent from one or more eligible features. The possibility of a determination of adverse effect on historic or archeologic resources should be considered a potentially adverse condition under section 960.5-2-5(c)(2) and/or section 960.5-2-7(c)(4) of the repository siting guidelines.

5. REGIONAL AND LOCAL EFFECTS OF REPOSITORY DEVELOPMENT

Page 15, fourth paragraph: State of Utah reviewers question the methodology and assumptions used in the air-quality modeling. Fugitive dust, vapor plumes from the underground repository exhaust system, and site illumination for 24-hour activity could all have significant adverse visibility and/or aesthetic impacts on Air Quality Related Values in Canyonlands National Park during repository construction and operation. See the comments on section 5.2.

Page 15, fifth paragraph: As noted in regard to characterization activities (comment on EA page 13, fifth paragraph), the EA seriously understates the visibility of the surface facilities associated with the repository, apparently relying on an outdated visibility study (ONWI 454). That study tested the visibility of only one location on the proposed site, which is not representative of the entire site and which does not correspond to the reference site layout for the repository facilities (Figure 5-2). It also failed to test the visibility of many of the ancillary facilities required for repository access and service. These include improvements to Utah 211, a truck entrance road on entirely new alignment, electrical transmission lines, and the southern portion of the railroad spur line that would lead to the site:

If any one of these ancillary facilities were proposed separately in this landscape context, it could be determined to be a major federal action requiring a full EIS under NEPA regulations. In such a case, one of the major issues would be aesthetic impacts. An example of the controversy that could be expected and the level of aesthetic assessment that could be required is provided by one of the studies prepared for the Alton Coal Project, which was proposed to the south of Bryce Canyon (Sheppard and Tetherow, 1983). In contrast, the EA fails to systematically assess the aesthetic impacts of the total repository development. While the EA cites several visual studies of components of the repository development in addition to ONWI 454, these studies are also incomplete and the EA makes no attempt to integrate them into a whole. See the comments on section 4.2.

Neither the EA or the studies that it cites contain any evidence to support the EA assertion that standard mitigation measures would be able to reduce aesthetic impacts to acceptable levels in this area. At the least, aesthetic impacts should be considered as a potentially adverse condition, in accordance with section 960.5-2-5(c)(2) of the repository siting guidelines.

Page 15, seventh paragraph: The conclusory statement that the project would have only a small effect on tourism appears unjustified. It again appears to be based on the assumption that only a small percentage of visitors to Canyonlands National Park would be affected by visual intrusion, traceable to the incomplete visibility analysis contained in ONWI 454 (compare to Johnson, 1983 and Johnson et al., 1985) and lack of any visitory survey dealing with the issue. Again, the EA also ignores the impact of the heavy car and truck traffic that would be clearly visible to all park visitors who would travel through the Indian Creek valley to enter the park. This paragraph also apparently fails to consider that persons engaged in dispersed recreation on BLM lands in the vicinity would also be affected by visual intrusion.

Page 16, fifth paragraph: The highway and railroad development described in this paragraph could cause significant adverse aesthetic impacts. The environmental impacts of transportation facilities associated with repository development are included in a separate DOE siting guideline, section 960.5-2-7(c)(4). As indicated in a previous comment, the aesthetic impacts of these facilities should be identified as a potentially adverse condition.

6.3.2 Environment, socioeconomics and transportation

Page 20, second paragraph: Given the national significance of the aesthetic resources in the vicinity of the Davis Canyon site, the potential adverse aesthetic impacts of repository development at this location also have special significance for the corresponding system guideline regarding environment, socioeconomics and transportation (10 CFR Part 960.3-1-4-4). The lack of evidence in the EA on the aesthetics component of the systems guideline suggests that no finding is possible on this system guideline at this time. The siting guidelines also state that if assumptions are used because of lack of information on site conditions or characteristics, "the use of such assumptions should not lead to an exaggeration of the ability of the site to meet the qualifying condition" (10 CFR 960.3-1-4-3). Based on State review the finding reported in this EA paragraph appears to violate this provision.

Chapter 1

PROCESS FOR SELECTING SITES FOR GEOLOGIC REPOSITORIES

1.2.2.2 <u>Bedded Salt in Davis Canyon and Lavender Canyon, Utah</u>

Page 1-9, last paragraph: The second sentence should be revised to indicate that the aesthetic values in the vicinity of Davis Canyon have a national significance that is stated by the preamble of the Congressional Act that established Canyonlands National Park to preserve its "superlative scenic, scientific, and archeologic features for the inspiration, benefit, and use of the public" (78 Stat. 934).

2.2.3 Location-to-Potentially Acceptable Sites Screening

Page 2-10, fifth paragraph: The third sentence should be revised to indicate that the aesthetic values in the vicinity of Davis Canyon have a national significance that is stated by the preamble of the Congressional Act that established Canyonlands National Park to preserve its "superlative scenic, scientific, and archeologic features for the inspiration, benefit, and use of the public" (78 Stat. 934).

2.4.2 Evaluation of Paradox Basin Preclosure Discriminating Technical Guidelines

Page 2-22, Figure 2-6: The data on the area from which the Davis Canyon and Lavender Canyon sites would be visible is inaccurate and misleading, because it is based on a single target location at each site, rather than a representative set of locations. In the case of Davis Canyon, the chosen target location is at the extreme inside corner of a natural cul-de-sac formed by a spur of South Sixshooter Peak. It seriously under-represents the extent to which the site is visible outside of Davis Canyon.

The distance from nominal boundary of the Davis Canyon site to Canyonlands National Park should be reported as 0 km. At this preliminary stage of repository design, it is misleading to fix the location of the control zone with such apparent precision, just short of the park boundary.

2.4.2.2 Environment, Socioeconomics, and Transportation Guideline Group

2.4.2.2.1 Environmental Quality (960.5-2-5).

Page 2-25, second paragraph: The last two sentences in the paragraph are ambiguous, but appear to state that aesthetic impacts at the Davis Canyon site could be mitigated to an insignificant level, through the application of reasonable measures. The EA presents no data, in this section or elsewhere, that would substantiate this assertion. On the contrary, this review indicates that adverse aesthetic impacts would be likely to be significant and would be difficult to mitigate to an insignificant level in this setting. Therefore, the favorable condition specified in the siting guideline that is under discussion in this part of the EA should be reexamined.

Page 2-25, fifth paragraph: The estimate of the area from which the Davis Canyon site would be visible is inaccurate and misleading, because it is based on a single target location, rather than a representative set of locations. The target location chosen for Davis Canyon is at the extreme inside corner of a natural cul-de-sac formed by a spur of South Sixshooter Peak. It seriously under-represents the extent to which the site is visible outside of Davis Canyon. (see Appendix D)

Chapter 3

THE SITE

3.1 LOCATION, GENERAL APPEARANCE AND TERRAIN, AND PRESENT USES

Page 3-1, last paragraph: Add a sentence to the description of the candidate area indicating that dispersed recreation is a principal use of BLM lands in the area, including Davis Canyon, Lavender Canyon, Cottonwood Canyon, Harts Draw, and Harts Point (for example, see Barnes, 1977, 1978a, and 1978b).

3.4 ENVIRONMENTAL SETTING

3.4.1 Land Use

3.4.1.3.2 Recreation.

Page 3-147, last paragraph: Add a sentence to the end of the paragraph indicating that dispersed recreation is a principal use of BLM lands in the area, including Davis Canyon, Lavender Canyon, Cottonwood Canyon, Harts Draw, Harts Point, and Lockhart Basin (for example, see Barnes, 1977, 1978a, and 1978b).

Page 3-148, first paragraph: Change the description of management for "the Salt Creek area" to "the Salt Creek Archeological District, which abuts the candidate site area".

Page 3-148, third paragraph: This description of the Needles District of Canyonlands National Park should be modified to indicate that the Park Service extension of Utah 211 outside the park is 13 miles long, passes Davis Canyon, and is the principal access route to the Needles District.

Page 3-152, fifth paragraph: This description of recreation in the Indian Creek area should indicate that Davis Canyon is one of the overflow camping areas to which NPS staff directs visitors when the designated camping areas in Canyonlands National Park are full (per a notice on the Needles Ranger Station bulletin board, March 1985). The description should also note that Davis Canyon, Lavender Canyon, Cottonwood Canyon, Harts Draw, Harts Point, and Lockhart Basin are well-known areas for ORV driving, hiking, and sightseeing (for example, see Barnes, 1977, 1978a, and 1978b).

3.4.3 Air Quality and Meteorology

3.4 3.1 Existing Air Quality

Page 3-166, third paragraph: Correct the description of the relationship of the PSD Class I area (Canyonlands National Park) to the candidate site as follows: from "is located approximately 1 mile from the site", to "is immediately adjacent to the site".

3.4.5 Aesthetic Resources

Page 3-169, last paragraph: Preface the paragraph by stating the national significance of the aesthetic values in the vicinity of Davis Canyon. This significance is stated by the preamble of the Congressional Act that established Canyonlands National Park to preserve its "superlative scenic, scientific, and archeologic features for the inspiration, benefit, and use of the public" (78 Stat. 934) and is confirmed by the legislative history of the Act. Modify the second sentence of the paragraph to indicate that existing "cultural modifications" in the area are rural in character and are generally compatible with the landscape (Meiiji Resource Consultants, 1980); the presence of these modifications has been incorporated in the scenic quality ratings for the BLM lands in the vicinity of the site.

Page 3-170, second paragraph: Preface the paragraph by stating that the existing scenery is one of the principal resources that attracts recreation to the area. Add the Indian Creek valley, Cottonwood Canyon, Lavender Canyon, Davis Canyon, Harts Draw, and Harts Point to the list of scenic attractions in the vicinity of the candidate site.

Page 3-170, third paragraph: To the list of areas that may be affected by project activities, add Indian Creek Canyon, Cottonwood Canyon, Lavender Canyon, Beef Basin, Harts Point, and Lockhart Basin. These areas would all be affected by site characterization and field investigation activities, as well as by potential repository development and operation activities.

Page 3-170, fourth paragraph: Add a statement to this paragraph indicating that all BLM lands in the area have scenic values and are accessible by a network of four-wheel drive roads that afford viewing access to recreational visitors (Barnes, 1978a and 1978b).

Page 3-170, fifth paragraph: The EA description of federal agency visual assessment systems could be interpreted to imply that the National Park Service (NPS) is not concerned with the management of scenic values. The fact is that when a project appears likely to affect the scenic values of NPS lands, the agency handles visual impact assessment on a site-specific basis.

Page 3-170, seventh paragraph: Without further explanation, the rating of most BLM lands in the vicinity as VRM Class II could be read as implying that significant aesthetic values are not associated with these lands. The text should explain that VRM Class I is reserved for special areas, such as wilderness areas, which are generally designated by legislation; Canyonlands National Park would be a VRM Class I area if it were managed by BLM (p. 37 and Fig. 5-7, ONWI 454). Accordingly, VRM Class II is the most restrictive classification that is possible for non-wilderness BLM lands.

3.5 TRANSPORTATION AND UTILITIES

3.5.1 Roads

Page 3-179, second paragraph: A map should be added to the Final EA that locates the end of the section of Utah 211 that is maintained by the state and the beginning of the section that is maintained by the National Park Service. This map should include topography and locate the 9-mile section of Utah 211 that is cited as having alignment problems in the next paragraph of the EA. This is important, because the EA is ambiguous about the improvements to Utah 211 that appear to be necessary to support characterization and/or development activities. State review indicates that these improvements could have significant adverse environmental impacts.

3.6 SOCIOECONOMIC CONDITIONS

3.6.2.4 Tourism

Page 3-193, Figure 3-52: This figure should be revised to show the full length of the Park Service extension of Utah 211 (see section 3.5.1, page 3-179) and to indicate the percentage of park visitors who travel this road. This figure and Figure 3-53 should also be revised to indicate river recreation use. Persons engaged in river recreation are also visiting Canyonlands National Park and could be affected by the ancillary facilities necessary for the repository.

Chapter 4

EXPECTED EFFECTS OF SITE CHARACTERIZATION ACTIVITIES

4.1 SITE CHARACTERIZATION ACTIVITIES

4.1.1 Field Studies

4.1.1.1 Geologic and Hydrologic Studies

4.1.1.2.2 3-D Seismic Survey.

Page 4-19, first paragraph: This survey would cover a very large area (8 square miles) and would require a closely spaced grid of cleared survey lines. The extent of surface disturbance would be considerable. The EA should have included a map of the preliminary survey layout so that the potential for environmental impacts could be assessed.

4.1.3 Other Activities

4.1.3.1 Environmental Field Studies

4.1.3.1.3 Meteorology and Air Quality.

Page 4-69, second paragraph: The proposed meteorological tower heights are very close to the threshold (200 feet) at which the FAA routinely requires marking and lighting for aircraft safety. The EA should have adopted the conservative assumption that all three of the 60-meter towers (Figure 4-14) would be marked with alternating red and white stripes and red warning lights.

4.1.3.1.7 Aesthetic Resources.

Page 4-71, second paragraph: The EA states that field studies will be conducted to determine the potential visual impacts of site characterization and repository development and operation activities. Since these studies would be conducted at the same time as site characterization activities, (Figure 4-24, page 4-125) they would provide an opportunity to document the actual impacts of site characterization and field investigation, but would be of no help in planning these activities to minimize impacts.

Field studies of aesthetic resources should have been completed and incorporated in the DEA. Without them, it is not possible to adequately assess the adverse aesthetic impacts of site characterization and field investigations, which appear likely to be significant, and it is unlikely that mitigation measures will be effective in reducing these impacts to acceptable levels. The incomplete state of the aesthetics analysis in the EA invalidates the subsequent EA findings on the probable significance or insignificance of the aesthetic impacts that would be caused by repository development and operation, and on the likelihood that these impacts could be mitigated to acceptable levels.

4.1.3.1.8 Archeological, Cultural, and Historical Resources.

As proposed in the EA, it appears that intensive cultural resource surveys would be conducted too late to identify or adequately mitigate the adverse effects of site characterization and field investigation activities on these resources. Newspaper Rock, as only one of several examples, is listed on the National Register; it could be subjected to adverse effects by noise and visual impacts associated with improvements to Utah 211 that appear necessary to accommodate the large vehicles and heavy traffic volumes associated with characterization. Such impacts could be determined to have adverse effects on archeologic or historic resources by introducing "visual, audible, or atmospheric elements that are out of character with the property or its setting", contravening the Historic Preservation Act of 1966 (36 CFR Part 800.3(b)(3)). There are also numerous archeologic features on BLM land in Davis Canyon, including ruins, that are outside the Salt Creek Archeological District, but that appear eligible for nomination to the Register (see Appendix J). The criteria of adverse effect quoted above could also apply to these features; for example, the exploratory shaft facility could be visually prominent from one or more eligible features. The possibility of a determination of adverse effect on historic or archeologic resources should be considered a potentially adverse condition under section 960.5-2-5(c)(2) and/or section 960.5-2-7(c)(4) of the repository siting guidelines.

4.2 EXPECTED EFFECTS OF SITE CHARACTERIZATION

4.2.1 Expected Effects on the Natural Environment

4.2.1.1 Effects on Land Use and Mineral Resources

Page 4-77, second paragraph: Here, the EA identifies the possibility that surface uses of the entire protected area (approximately 5,000 acres, per p. 4-76) could be precluded. This should be resolved, because preclusion of existing surface uses would have impacts on recreation, viewer access, and park use, as well as on grazing (the only effect identified in the EA).

4.2.1.3 Air Quality Effects

Page 4-81, first paragraph: Although State of Utah reviewers question the methodology and assumptions used in the air-quality modeling, this EA section does begin to address the issues of Air Quality Related Values (AQRV's) in Canyonlands National Park. Thus, the EA identifies fugitive dust and exhaust plumes from the underground suitability testing as having the potential to cause adverse effects on AQRV's. In addition, site illumination for 24-hour characterization activities could have an adverse effect on the brightness of the night sky and the corresponding visibility of stars (an effect sometimes called "light pollution"). This effect is currently discussed in EA section 4.2.1.7; because it is due to atmospheric scattering of artificial illumination and because its extent would increase with total suspended particulate levels (TSP's), it should also be considered as a potential adverse effect on AQRV's in Canyonlands National Park.

The consequences of all three types of effects are aesthetic impacts that raise particular regulatory issues when the impacts affect lands within a PSD Class I area, such as a national park. The expertise for the modeling necessary to identify the extent and severity of these effects is the province of atmospheric scientists. Therefore, the assumptions and results of the modeling should continue to be located in this section of the EA, along with the geographic relationship of these effects to Canyonlands National Park. The visual simulations of these effects and the assessment of their aesthetic impacts, including effects on viewers located both inside and outside the park, should be included in the section of the EA that deals with aesthetics. A digest of the aesthetic impacts should be incorporated into the discussion of AQRV's in this section of the EA.

4.2.1.3.2 Air Quality Consequences

<u>Impact on Park AQRV's</u>

Page 4-89, last paragraph: See the comment on EA page 4-81, first paragraph.

Visibility

Page 4-93, third paragraph: As the EA notes, there are two separate but related issues here: 1) visual range, and 2) plume visibility. The EA attempts to distinguish these issues, but does not entirely succeed. The following comments attempt to clarify the issues involved to serve as a basis for revising the EA.

1) The first issue is the general reduction in visual range that could be caused by increased TSP's or other atmospheric constituents that are dispersed relatively evenly through all or part of the atmosphere, i.e., what is commonly referred to as haze or smog. To establish baseline conditions, the National Park Service has been monitoring atmospheric visibility distances in Canyonlands National Park, as reported in EA section 3.4.3.1 and Figure 3-46. The EA claims a) that the site characterization activities would not cause increases in atmospheric constituents such as TSP's that would trigger PSD review, and b) that the attendant reduction in visual range would not be perceptible. The assumptions for the modeling on which these conclusions are based are not sufficiently clear for State reviewers to replicate the modeling. Therefore, the State reserves judgment as to whether the conclusions are warranted until the assumptions are clarified.

One key assumption is the location of the viewpoints from which visual range is modeled. The determination of effects on visual range is dependent on the proximity of the test viewpoint to the emission source and the nature of the views from the test viewpoint. In accordance with EPA regulations regarding AQRV's in PSD Class I areas, the National Park Service (NPS) has proposed three "integral vistas" in Canyonlands National Park (Wylie and Kitchell, 1980). These vistas are all located at viewpoints in the Island In The Sky District, from which extremely long-distance views are available. The locations of the proposed integral vistas and their view azimuths are:

1.	Buck Canyon Overlook	0 to 80 degrees	(north to east)
2.	Grandview Point	80 to 205 degrees	(east to southwest)
3.	Murphy Point	205 to 360 degrees	(southwest to north)

Although final designation of these integral vistas has not yet occurred, these are the logical points from which to test the effects of site characterization on existing visual range in Canyonlands National Park. The primary source of atmospheric emissions would be the proposed repository site. Therefore, the Grandview Point vista is the view that should be used in visual range modeling.

The EA simply reports numeric results for visual range modeling. This is a "black box" approach that does not provide any direct evidence for assessing the aesthetic impacts of visual range reduction. Aesthetic assessments conducted without visual simulations that are both demonstrably accurate and credible (realistic in appearance) are simply not reliable (Feimer at al., 1979; Sheppard, 1983). Computer-assisted techniques have been developed for simulating the visual effects of haze or plumes on images of actual views such as that from Grandview Point (Treiman et al., 1979). These techniques should be readily available to DOE, since they were developed in one of the National Laboratories. The State wishes to review the assumptions used in the visual range modeling and requests that DOE then prepare visual simulations of the effects of site characterization activities (and subsequently, repository development and operation) on the Grandview Point vista. These simulations should also be used in the assessment of aesthetic impacts from this critical view location (or key observer point (KOP), in BLM terminology).

2) The second issue is plume visibility. Emissions that would be visible as a discrete plume could cause adverse aesthetic impacts on high-quality views, regardless of the length of these views. Thus, if the exploratory shaft facility were to emit a vapor or Nox plume that could be seen from the Squaw Flat Campground inside Canyonlands National Park, the plume would constitute a visual intrusion despite the (relatively) short range of the view from the campground. Again, visual simulations should be prepared from one or more KOP's such as the campground or Pothole Point, using a technique similar to that described by Treiman et al. (1979) to illustrate the effects of site characterization activities and subsequent repository development and operation. These simulations should then be used in the assessment of aesthetic impacts to determine the degree of visual intrusion. Plumes should also be simulated in one or more KOP's outside the park boundary, such as the turnout on Utah 211 directly east of the repository site.

State review of the EA indicates that emissions during characterization and/or repository development may well create plumes visible from inside the park. Very preliminary State of Utah calculations suggest that under some atmospheric conditions, plume rise could range from approximately 100 to 700 feet, with associated plume widths of 50 to 1500 feet. In this connection, the general level of the mesa tops above the floor of Davis Canyon and to the west is 400 to 500 feet, not 800 feet as stated in this section of the EA (see the topography on Figure 4-15).

3) This section of the EA should also include a discussion of light pollution or increased night sky brightness, as seen from Squaw Flat Campground. Currently, the technical description of this issue is included in EA section 4.2.1.7. The assumptions behind the modeling presented there should be explained and the particulate loadings should be correlated to the emission analysis reported in this section.

Again, visual simulations are needed to support an aesthetic assessment of increased night sky brightness; Figure 4-21 is too diagrammatic to achieve reliable results. One possibility is to use a plainsphere diagram to illustrate the effects on visibility of faint stars. Thus, as sky brightness increases, only the higher magnitude stars would be visible, or none at all. An alternative and even more reliable type of simulation would be a series of eyelevel views of the eastern horizon from Squaw Flat Campground (where most views are oriented east, toward North Sixshooter Peak). See the final version of the Yocke, Hogo, and Lundberg report for preliminary examples; for aesthetic assessment, these computer-drawn illustrations could be used as a basis to retouch nighttime photographs of the same views.

For each of the three types of air quality related values discussed above, the values that could be affected are aesthetic in nature, while the causes of the effects would be physical.

Thus increases in air-borne particulates, even though well below the threshold of possible health effects, could reduce the visual range in and near Canyonlands National Park and therefore could cause adverse aesthetic impacts on the vistas that are one of the acknowledged values of the park. Under certain weather conditions, emissions from repository facilities could form visible plumes and therefore could cause adverse aesthetic impacts on archeological resources that are another of the acknowledged values of the park. Artificial lighting for the exploratory shaft facility or repository could be scattered by increased particulates in the atmosphere and therefore could chance the likelihood of adverse aesthetic impacts on the night sky.

In each case, the atmospheric effects should be modeled and discussed in this section of the EA, while the aesthetic impacts of these effects should be simulated and assessed in the aesthetics section of the EA.

4.2.1.5 Noise Effects

Page 4-99, third paragraph: The stated distance from the repository site to camping areas is not correct. When all designated camping spaces are filled in the Needles District of Canyonlands National Park, park rangers direct campers to BLM lands in the Indian Creek Valley outside the park, including Davis Canyon itself (notice on Needles Ranger Station bulletin board, March 1985). Note that Canyonlands National Park is immediately adjacent to the proposed controlled area.

4.2.1.7 Effects on Aesthetic Resources

Pate 4-104, first paragraph: The aesthetics analysis reported in the EA for the characterization phase consists of four elements: A) a line-of-sight viewshed analysis, B) an analysis of the effects of artificial lighting, C) a discussion of BLM contrast rating procedures, and D) a discussion of potential mitigation measures. All of these analyses are incomplete. Moreover, they do not form a coherent whole and fail to provide any credible evidence to support findings on the probable aesthetic impacts of site characterization and field investigation activities. Without such evidence, the State believes that it is not possible to reach findings on the suitabilility of the Davis Canyon site for characterization or repository development. In short, the EA aesthetics analysis is completely inadequate and fails to meet the requirements of the repository siting guidelines, 10 CFR 960.5-2-5 (c) (d).

These comments on section 4.2.1.7 begin with a series of line-by-line comments on the EA text, organized under the four headings given above. Then, because the EA analysis appears to lack the coherent methodology necessary for an adequate assessment, a study plan is recommended to correct and complete the aesthetic assessment. This plan identifies the elements that need to be studied to determine the probably aesthetic impacts of site characterization and field investigation activities. A similar plan of study is included in the comments on EA section 5.2 to determine the aesthetic impacts of repository development and operation. The level of effort that the study plan proposes is similar to that required by other major projects in sensitive settings (Sheppard and Tetherow, 1983). The level of effort is appropriate for a large industrial facility that involves extensive utility and transportation development, all close to the entrance of a national park. Further, the studies outlined here would be essential to develop the direct, visual evidence that would be necessary to allow for complete review by the State and other interested parties.

A. EA Viewshed Analysis

Page 4-104, second through sixth paragraphs: The viewshed analysis reported in the EA is misleading. The analysis tested the visibility of a single location on the site of the exploratory shaft facility (ESF).

According to the EA, five tall structures would be located on or near the ESF site: a 225-foot headframe over one shaft, a somewhat lower headframe over a second shaft, and three 197-foot meteorological towers. In addition, there would be a large spoil pile of excavated salt. The location of these features is illustrated on EA Figures 4-6, 4-7, and 4-14. The viewshed analysis should have tested the visibility of all of these features. Instead, it tested the visibility of a single location that does not correspond to any of the features (ONWI-454). Thus, all of the EA information on the visibility of site characterization and field investigation activities is incomplete, and all of the conclusions based on this information are invalid.

For example, the visibility of the ESF site from Utah 211 should have been immediately apparent to DOE investigators from site visits; it is possible to look directly into the site for more than a mile along the entry road to Canyonlands National Park. Moreover, the State of Utah performed an independent viewshed analysis (Johnson, 1983) Appendix D, which demonstrated that the Davis Canyon site would indeed be visible to large numbers of viewers in the vicinity. A second State review of DOE-sponsored viewshed studies has also been conducted (Johnson, etc. al., 1985), which provides additional detail on the problems associated with the EA viewshed analysis. The EA analysis should be redone to test the visibility of key features and representative locations associated with site characterization and field investigation activities.

Pages 4-106, last paragraph, and 4-107, first paragraph: The EA contains a list of "key observation points" within the study area. These points are stated to be unaffected because the presumed location of the headframe structure would not be visible from them. As noted in the previous comment, the viewshed analysis used is an incorrect location for this structure. Moreover, the viewshed analysis failed to consider project features such as the meteorological towers, improvements to Utah 211, and possible ESF emission plumes. Therefore, the discussion of site visibility from the key observation points listed in the EA is without substance.

B. EA Analysis of Artificial Lighting

Page 4-107, second and third paragraphs: The EA analysis of the effects of site illumination indicates that characterization activities at Davis Canyon could have significant adverse aesthetic impacts on the brilliant night sky that is one of the established values of Canyonlands National Park. The assumptions used in the modeling of night sky brightness are unclear and undocumented. This modeling should have been related to particulate loads that would actually be caused by site characterization and field investigation activities. The modeling assumptions and results should have been included in the section of the EA that deals with air quality related values (page 4-89). The diagrams in Figure 4-21 should also have been included in that section. While those diagrams begin to give some idea of the magnitude of effects on sky brightness, they are inadequate as a basis for assessing the aesthetic impacts of these effects. Visual simulations that illustrate these effects on actual night views from Squaw Flat Campground should be prepared; the types of simulations that would be appropriate have been discussed in the comments on Pages 4-89 and 4-93.

Page 4-107, fourth paragraph: The comment on the likelihood of air-navigation warning lights is misleading. FAA was not informed that one of the meteorological towers would be located on the top of Harts Point. Moreover, the EA acknowledges that site security measures have not yet been established. Based on observations of security measures at the Hanford Nuclear Reservation and the Trans-Alaska Pipeline, it appears likely that stringent security measures would be implemented. Since site characterization could involve tests with radioactive materials, security could be necessary during the characterization phase. This and other field investigation activities could well require frequent use of helicopters in the vicinity of the site. Therefore, a conservative assumption would be that the meteorological towers and shaft headframes would all require air-navigation warning lights and daytime marking. This marking would require the structures to be painted with alternating bands of international safety orange and white to ensure high contrast and visibility for air safety.

C. EA Discussion of BLM Contrast Rating Procedures

Page 4-107, fifth and sixth paragraphs: The EA discusses previous contrast ratings for four geotechnical boreholes (BLM, 1982). These are the only formal contrast ratings cited in relation to the Davis Canyon site. These boreholes represent only a small proportion of the aesthetic impacts likely to be caused by site characterization and field investigation activities. The discussion of probable contrast ratings in the sixth paragraph of the EA is completely speculative, based on incomplete viewshed data, and fails to acknowledge many features that would be required for site characterization, such as the meteorological towers and improvements to Utah 211. Therefore, this discussion is both incomplete and misleading.

D. EA Discussion of Potential Mitigation Measures for Aesthetic Impacts

Page 4-109, second paragraph: The EA discusses possible mitigation measures to reduce visual impacts. While some of these mitigation measures might prove to be appropriate, they are by no means complete; for example, they do not address the potential aesthetic impacts of improvements to Utah 211. Furthermore, there is no analytic basis for assuming that these mitigation measures could reduce the residual impacts of site characterization and field investigation activities to acceptable levels.

Page 4-109, third paragraph: The EA summary of the aesthetic impacts of the characterization phase is inconsistent and misleading. It states that the duration of these impacts would be approximately five years; while other portions of the EA indicate that characterization and site reclamation activities would last from 7 to 9 years (Figures 4-1, 4-8, and 4-13).

ROCOMMENDED STUDY PLAN TO ASSESS THE AESTHETIC IMPACTS OF SITE CHARACTERIZATION AND FIELD INVESTIGATION ACTIVITIES AT DAVIS CANYON

The EA purports to use the Bureau of Land Management (BLM) Visual Resource Management (VRM) system to assess the aesthetic impacts of site characterization and field investigation activities at Davis Canyon. The following brief summary of the VRM system is intended to help explain why the EA aesthetics assessment is inadequate and how it should be corrected.

BLM uses the VRM system to assess the visual resources of its lands and the level of probable viewer concern for those resources; with this information, BLM subdivides its lands into Visual Resource Management Classes. BLM then uses the concept of visual contrast to manage the visual resources of the lands within each VRM class, on the presumption that "the degree to which a management activity adversely affects the visual quality of the landscape depends on the amount of visual contrast that is created between the activity and the existing landscape character: (BLM, 1978). For each VRM Class, BLM has specified a maximum level of acceptable visual contrast. If the visual contrast of a proposed action would be greater than that specified for the VRM Class of the surrounding lands, BLM would consider the aesthetic impact to be significant (BLM, 1982).

The BLM manual for the VRM system includes a series of parameters for rating the visual contrast of a proposed action (BLM, 1978). However, the manual does not specify the evidence on which the contrast rating is to be based or the procedure to be used to develop this evidence. In practice, the extent and quality of evidence that is developed for a project assessment can vary widely; the reliability and validity of the contrast rating and associated aesthetic impact assessment will vary accordingly.

A contrast rating could be conducted by a single person trying to imagine the appearance of a proposed action by looking at engineering plans and a photograph of the site. This approach may be sufficient for routine evaluations of simple actions of limited extent, but its reliability and credibility are poor. That is, the likelihood that the results can be replicated by a second evaluator is low, and there is no direct, demonstrable connection between the project information and the results of the evaluation. In short, this is a "black box" approach. Acceptance of the results is dependent on faith both in the visualization abilities and in the objectivity of the evaluator.

For this reason, BLM has advocated the preparation of visual simulations for assessing the aesthetic impacts of proposed actions that are complex and large in scale (BLM, 1980). The simulations prepared for the Alton Coal Project proposed on BLM lands near Bryce Canyon National Park are an example (Sheppard and Tetherow, 1983). When such proposed actions are located in scenic areas, the contrast rating procedure should - and often does - include thorough viewshed analysis to determine key observation points, systematic identification of all the visual features of an action, careful simulation of the appearance of these features as they would be seen from the key observation points, and evaluation of the degree of contrast in these simulations by carefully constituted panels of experts or representative groups of citizens. This type of assessment approach is necessary to develop contrast ratings that are reliable and credible (Feimer etc al., 1979).

Thus, the BLM Visual Resource Management system does not specify in detail how the aesthetic impacts of a particular project are to be assessed. Furthermore, the EA analysis and coverage of aesthetic impacts does not conform to the standards set by BLM assessments of the aesthetic impacts of other major projects.

To help identify how the EA coverage of aesthetic impacts could be corrected, the following portion of the comments presents a step-by-step study plan, which is based on an approach to visual impact assessment that was developed under the auspices of the Federal Highway Administration (FHWA, 1981). This approach was designed to comply with NEPA and other federal environmental legislation, such as the Historic Preservation Act of 1966. It was also designed to accommodate the evaluation techniques of federal land-managing agencies, such as the BLM contrast rating technique. It comprises these basic steps:

1) Define the visual environment of the project;
2) Identify key views for visual assessment;
3) Analyze existing views and viewer response;
4) Depict the visual appearance of project alternatives;
5) Assess the visual impacts of project alternatives;
6) Determine ways to mitigate adverse visual impacts.

Please note that the level of effort associated with the recommended study plan is similar to that involved in aesthetic assessments of other major federal actions in acknowledged scenic areas. Also note that the level of information about the characteristics of the proposed action in the EA and the time available for the preparation of the EA both appear to have been sufficient for the implementation of this study plan or a similar plan.

1) Define the Visual Environment of the Project

This first step defines the physical limits of the affected environment for the purpose of assessing aesthetic impacts. It is analogous to mapping the watersheds or airsheds that could be affected by the project. The EA aesthetic impact assessment is largely confined to this step, which, however, has not been carried out correctly.

A. IDENTIFY THE MAJOR VISUAL FEATURES OF THE CHARACTERIZATION PHASE

The EA aesthetic impact assessment for the characterization phase fails to consider many of the major visual features of this phase. Based on EA section 4.1, the following visual features could be prominent during the characterization phase:

- the physical features associated with geotechnical investigations, such as access roads, seismic survey lines, boreholes, trenches, and foundation borings;
- meteorological towers, including aircraft warning marking and lighting;
- improvements to Utah 211, including cuts and fills for sections to be realigned and/or widened;
- fugitive dust associated with site clearing;

- the Exploratory Shaft Facility (ESF), including buildings and headframes;
- salt storage piles, retention ponds, and other cleared or paved areas;
- vehicles and mobile equipment, such as cranes;
- emission plume(s) from ESF ventilating or cooling equipment; and
- site lighting, including the light standards and luminaries, as well as the sky glow caused by atmospheric scattering of artificial light.

Note that this list includes facilities to be erected or constructed during the characterization phase, equipment that will be present for extensive periods during that phase, and visible effects of various activities during characterization.

B. IDENTIFY THE LANDSCAPES THAT COULD BE AFFECTED

The EA and the studies that it summarizes do not contain enough information about the landscapes that would or could be affected by the aesthetic impacts of the characterization phase to place those impacts in context. We cannot assess the visual impacts of a project until we understand how the project's immediate visual environment is related to the visual environment of the geographic region. Moreover, we need a framework for comparing the aesthetic impacts of alternatives and mitigation measures on different landscapes within the project's immediate visual environment. Dividing this environment into areas of distinct aesthetic character - "landscape units" - and mapping these areas provides such a framework (This is in many ways analogous to soils mapping or vegetation mapping).

The Davis Canyon aesthetics assessment should identify and differentiate the landscape units that could be affected by the characterization phase. For a start, it is obvious that there are considerable differences in visual resources, view orientation, and viewers among the following major areas that would probably be affected by the characterization phase:

- Dead Horse Point State Park
- the eastern half of the Island-in-the-Sky District of Canyonlands National Park;
- the Needles District of Canyonlands National Park;
- the Maze District of Canyonlands National Park;
- the Canyon Rims recreation area (Hatch Point);
- Beef Basin;
- Kane Springs Canyon;
- Lockhart Basin;
- the Indian Springs Basin;
- the main Colorado River canyon, from Potash to The Confluence.

It could also be useful to subdivide some of these areas further. For example, the Indian Creek Basin could be divided into the Lower Canyon (where the Wilderness Study Area is located), the Middle Valley (where Davis Canyon and Lavender Canyon are located), Harts Draw, and the Upper Canyon (where Indian Creek State Park is located). Each of these units would be subjected to aesthetic impacts by particular activities during the characterization phase. Thus, the aesthetics of Middle Indian Creek Valley would be affected by the impacts of the Exploratory Shaft Facility and traffic on Utah 211, while Upper Indian Creek Canyon would be affected by the improvements to Utah 211.

C. MAP THE VIEWSHEDS OF THE MAJOR VISUAL FEATURES OF THE PROJECT

A viewshed is the surface area visible from a point or a series of points; it is also the area from which that point or series of points may be seen. Put another way, a viewshed is a tool for identifying the views that a project could actually affect. Together, the composite viewshed of all the visual features associated with site characterization and field investigation activities would comprise the project viewshed for the characterization phase. The EA only analyzed the viewshed of one feature associated with the characterization phase: the shaft headframe for the main exploratory shaft, and the location of that feature in the viewshed study (ONWI-454) was incorrect.

The first step in this analysis would be to select representative test points for all the visual features identified in task 1A. For facilities such as the meteorological towers or the shaft headframes, single points would be sufficient. For linear or real features, representative points would be required. For example, test points could be located at half-mile intervals along access roads or at the four corners of a rectangular salt stockpile. For each test point, the proposed or projected height of the associated visual feature must also be identified.

The next step would be to map the viewsheds of these features, using a numeric model of the terrain surrounding the project and a computer program such as VIEWIT. The EA numeric terrain model failed to include all areas where site characterization and field investigation activities would be carried out, together with sensitive viewing areas from which these activities might well be seen. Thus, the viewshed analysis area mapped in EA Figure 4-20 is too small; compare it to Figure 4-4. For example, the viewshed analysis area should have included all the areas where geotechnical investigations would be conducted, such as Beef Basin and the railroad route(s). The viewshed analysis area should also have included important viewing areas such as Dead Horse Point State Park, Indian Creek State Park, all of the Needles District and the eastern half of the Island-in-the-Sky District in Canyonlands National Park, the major viewpoints associated with the BLM Canyon Rims recreation area, Harts Point, and the lands adjacent to the portions of Utah 211 that would be upgraded. At the least, the revised viewshed analysis area should include the entire eastern half of the area mapped at 1:62,500 as "Canyonlands National Park and Vicinity, Utah" (PUSGS, 1968), plus the Butler Wash Wilderness Study Area and the portions of Beef Basin and the Manti-La Sal National Forest that are all included on this map.

The revised viewshed analysis should be comprehensive, addressing all the features that would be feasible during each major period of the characterization phase, rather than separating these features into categories of activities assessing each category in isolation. Instead, a time sequence of composite viewshed maps should be prepared for the characterization phase. Each of these should include test points for all the visual features that would be associated with site characterization and field investigation activities during that period of time.

Visual assessment units for the characterization phase should be delineated by overlaying the landscape unit and viewshed maps. The visual assessment units would then be the portions of the landscape units from which the visual features of the characterization phase would be visible. The delineation of these units would be helpful in carrying out subsequent steps of the aesthetics assessment and in interpreting the results of those steps. For example, key observation points should be selected, in part, to make sure that effects on important visual assessment units are represented. In turn, when the aesthetic impacts on key views are evaluated, these evaluations could then be allocated to the corresponding visual assessment units.

2) Identify Key Views for Visual Assessment

It is not possible to examine all views of a project; certain key views must be chosen to display the visual effects of alternative actions and assess the impacts of those actions. When there is a high degree of concern over the potential aesthetic impacts of a project, the credibility of the impact assessment is dependent on the logic behind the choice of those key views; they must be demonstrably representative of viewing conditions in the vicinity of the project.

A. COMPILE DESIGNATED AND/OR WELL-KNOWN VIEWPOINTS IN PROJECT VICINITY

The first step in identifying key views for visual assessment is to compile a list of already designated or well-known viewpoints from which the visual features of the project might be seen. The EA text contains a list of such views, but it omits several important viewing points and back-country travel routes. These include the Colorado, Confluence, and Pothole Point overlooks in Canyonlands National Park; the Harts Point, Lockhart Basin, and Beef Basin jeep trails; and the Colorado River itself. Viewpoints, viewer concentrations such as campgrounds and residences, and backcountry travel routes should all be mapped for this step. The State and the federal land-managing agencies should be formally consulted regarding additions to this map.

B. COMPARE VIEWSHEDS OF MAJOR VISUAL FEATURES OF CHARACTERIZATION PHASE

Next, the mapped compilation of existing viewpoints, viewing areas, and travel routes should be compared to the composite viewshed maps for the characterization phase. This step would allow the conclusive elimination of all viewpoints from which the visual features of the characterization phase would not be visible.

C. IDENTIFY AND DOCUMENT CANDIDATE OBSERVATION POINTS

The next step should be to identify candidate observation points for key views of site characterization and field investigation activities. These points should be selected to ensure that all visual features of the characterization phase are represented, as well as all potentially affected landscape units, without preconceptions as to viewing distance or numbers of viewers. Field visits should then be conducted to all these candidate viewpoints for the purpose of obtaining preliminary photography (preferably 35mm slides and Polaroid prints) and characterizing viewing conditions toward the visual features associated with characterization (direction, distance, elevation, subtended angle of view, etc.). Alternate viewing locations may be discovered in the field; these should not be ignored. The candidate viewpoints and photography should be carefully documented with written records and maps.

D. SELECT KEY OBSERVATION POINTS

The final selection of key observation points should be a decision based on the record. Consultation with State and federal agencies should be done in a workshop setting, with all the documentation of the preceding steps available to the participants. Viewing conditions from each of the key observation points should be documented, including information on viewers at these locations. In total, the set of views from the key observation points should meet the following criteria:

- complete discussion of the appearance of the major visual features associated with the characterization phase (including effects on air quality related values within Canyonlands National Park, such as night sky brightness and integral vistas);
- inclusion of at least one view for potentially affected landscape

units, or a surrogate view from a similarly affected unit;

- inclusion of important background features characteristic of views toward the project from each represented landscape unit (e.g., the La Sal Mountains).

Review of the EA and other information about the Davis Canyon area suggests the following preliminary list of key observation points for the characterization phase, as an example of the potential results of this step.

KEY OBSERVATION-TION POINT	DIRECT-TION	VISIBILITY OF CHARACTERIZATION PHASE FEATURES Geo.	Met.	211	ESF	Salt	Veh.	Plm.	Lght.	Sky
Dead Horse Point	E	X	-	-	-	-	X	-	-	-
Anticline O/L	NNW	X	-	-	-	-	X	-	-	-
Canyonlands O/L	NW	X	-	-	-	-	X	-	-	-
Buck Canyon O/L	E	X	-	-	-	-	X	-	-	-
Grandview Point	SE	X	X	-	-	-	X	X	-	-
Needles O/L	SW	X	X	X	-	-	X	X	-	-
Squaw Flat C/G	E	-	X	-	-	-	-	X	-	X
Utah 211, E/B	E	X	X	X	-	-	X	-	-	-
Utah 211, N/B	W	X	X	X	X	X	X	X	X	-
Harts Point	W	X	X	X	X	X	X	X	X	-
Newspaper Rock	S	X	-	X	-	-	X	-	-	-
Beef Basin	W	X	-	-	-	-	X	-	-	-

Notes:
Geo. = geotechnical investigations
Met. = meteorological towers
211 = improvements to Utah 211
ESF = exploratory shaft facility, including surface structures
Salt = excavated salt stockpiles
Veh. = vehicles and mobile equipment
Plm. = emission plume (s)
lght = site lighting
Sky = increased night sky brightness

X = feature potentially visible

3) Analyze Existing Views and Viewer Reponse

The aesthetic relationship of the key views to the affected visual environmental is the next major task. The VRM system documentation would provide much of the necessary information for views from BLM lands. However,comparable information should be developed for views from State parks and from Canyonlands National Park, in consultation with the managing agencies. If the BLM contrast rating is to be used to assess impacts, the information should parallel the VRM system and should include visual resource information (scenic quality ratings and existing visual character analysis) and viewer response information (viewer numbers, distance, and degree of concern for visual resources).

4) Depict the Visual Appearance of Project Alternatives

An adequate assessment of the aesthetic impacts of characterization at Davis Canyon must be based on visual simulations -- accurate and realistic depictions of the appearance of the visual features of site characterization and field investigation activities as they would actually be seen from representative viewpoints. Criteria for the preparation of adequate visual simulations are presented in Blair et. al., 1982 and Sheppard, 1983, both of which also contain references to many other useful studies. The following portion of the recommended study plan is based on these documents.

A. OBTAIN LARGE-FORMAT PHOTOGRAPHS OF KEY VIEWS

Once the final key observation points have been selected for the characterization phase, a visual analyst would visit these points with a professional photographer. The key views should be photographed in good weather conditions with color print film, using a camera such as a 4" x 5" view camera or a 2" x 2" single lens reflex to provide fine detail in large-format photographic prints. Note that some of the key views include clear night sky conditions; these should be taken before moonrise. The visual analyst would be responsible for locating the viewpoints, orienting the photographer, and documenting the details of the photography (lens focal length, camera location and bearing, film type, etc.).

The key views should then be printed at a size sufficient to replicate the angular field of view experienced in the field. Thus, if the acceptance angle of the camera lens is approximately 40 degrees, the photographs should be enlarged to a minimum size of 16" x 20" so that they would subtend the same visual angle when held at arm's length (see appendices in Jones & Jones, 1976). This is the smallest size that is usable for hearings. Extra prints should be obtained to allow retouching and to retain one print in original, unretouched condition.

B. CHECK/DEFINE CHARACTERISTICS OF MAJOR VISUAL FEATURES

The next step would be to check the information on the visual features of the project and supply any missing information. Since the BLM VRM system assesses visual contrast in terms of form, line, color, and texture, information on these visual elements must be developed for every visual feature. In addition, a number of visual features would occur as side effects of characterization activities; examples include road cuts, emission plumes, and effects on night sky brightness. Project information on these types of features must be reviewed and developed or refined as necessary to fully illustrate the appearance of the project.

C. GENERATE PERSPECTIVE VIEWS OF MAJOR VISUAL FEATURES

Accurate perspective diagrams of the visual features associated with the characterization phase must then be generated, corresponding to the exact location, view direction, and subtended angle of each key view photograph. This task could be performed with the assistance of a computer program, such as MOSAIC, specifically designed to calculate and plot perspective diagrams to match photographs. A program with similar capabilities was used to plot perspective diagrams of rail routes associated with repository development (Stearns-Roger, 1983b). Similar diagrams must be generated for each key view, but that includes all visual features associated with the characterization phase. Note that these diagrams would not qualify as visual simulations because they would not be realistic; they would be line drawings, and would not convey form, color, or texture.

D. A MAJOR VISUAL FEATURE TO PHOTOGRAPHS OF KEY VIEWS

In the next step, a commercial artist or illustrator experienced in retouching color photography should be retained to prepare the finished simulations. Photographic dyes should be used to do the retouching because they do not shift in apparent color when re-photographed. The artist should work closely with an experienced visual analyst who is familiar with the key view locations, the perspective diagrams, and all the visual features associated with the characterization phase. The simulations should be reviewed for accuracy and realism by the project engineers, the State, and the federal land-managing agencies. Several review iterations are usually necessary before such simulations are completed.

E. REPHOTOGRAPH KEY VIEWS

After the simulations are judged to be complete, each one should be rephotographed by a professional photographer and reprinted at the same size as the original print to make the retouched areas -- which appear matte on the artwork -- blend with the rest of the scene. Black-and-white prints and color slides should be obtained at the same time for public information purposes.

<u>5) Assess the Visual Impacts of Project Alternatives</u>

Accurate and realistic visual simulations provide the necessary evidentiary basis for the assessment of visual impacts. However, the assessment process must also be carefully conducted to preserve the reliability and validity that are the overall objectives of this recommended study plan. While the VRM system has the advantage of having been formally adopted by a federal agency (BLM), research has indicated that the reliability of assessments by individual evaluators is low. The recommended solution is to use trained panels of evaluators to conduct aesthetic assessments based on photographic simulations (Feimer etc al., 1979).

A. CONSTITUTE ASSESSMENT PANEL

The first step should be to constitute an assessment panel of professionals trained in such fields as landscape architecture, regional planning, outdoor recreation, geography, or environmental psychology (an alternative would be to recruit random samples of affected publics). The membership of this panel should be nominated by the State of Utah, the National Park Service, and BLM, as well as by DOE. Two or three representatives should be nominated by each agency, for a total panel of from eight to twelve evaluators. The members of the panel should have some familiarity with the Davis Canyon area.

B. TRAIN PANEL IN THE CONTRAST RATING TECHNIQUE

Assuming that the VRM system is to be used to assess the aesthetic impacts of the characterization phase, the members of the assessment panel should be trained in the contrast rating technique. BLM has developed training materials for this purpose. These materials should be supplemented by marker scenes from the BLM Moab District; that is, the members of the panel should perform contrast ratings of various land management actions in landscapes similar to those in the Davis Canyon area and compare their results to the corresponding BLM visual assessments of those actions. Approximately half a day should be allocated for the training. Some additional time may also be required to adapt the BLM contrast rating technique to the assessment of effects on air quality related values in Canyonlands National Park, such as visual intrusion by emission plumes and effects on integral vistas.

C. CONDUCT CONTRAST RATINGS OF KEY VIEWS

Once the panel was trained, it would perform contrast ratings of the simulations of the characterization phase at Davis Canyon. These could be conducted by a silent voting approach or by the "nominal group technique". The latter method, which is probably preferable, would allow structured group discussion of the contrast ratings but would also allow individual evaluators to make their own final determinations with a minimum of group pressure. The overall ratings for the assessment panel would be comprised of the arithmetic means of the individual ratings.

D. ALLOCATE AESTHETIC IMPACTS OF CHARACTERIZATION PHASE

To the extent that the simulations of the characterization phase are representative of the affected landscapes in the vicinity of Davis Canyon, it would then be possible to allocate the aesthetic impacts that were assessed in the key views to the landscape units identified earlier.

6) Determine Ways to Mitigate Adverse Visual Impacts

The process of identifying and evaluating mitigation measures would be generally similar to the initial simulation and evaluation of aesthetic impacts.

A. IDENTIFY POTENTIAL AESTHETIC IMPACT MITIGATION MEASURES

The first step would be to identify mitigation measures that would address the causes of significant adverse impacts that were assessed in the contrast rating procedure. The assessment panel could assist with this step at the conclusion of the contrast rating procedure.

B. SIMULATE APPEARANCE OF MITIGATION MEASURES

To provide an evidentiary basis for evaluating the effectiveness of the mitigation measures identified for the characterization phase, the appearance of these measures should be depicted in one or more sets of revised visual simulations.

C. ASSESS RESIDUAL IMPACTS OF CHARACTERIZATION PHASE

Next, the assessment panel would be reconvened to conduct contrast ratings of the simulated mitigation measures and determine the residual impacts of the characterization phase. The magnitude of these residual impacts would indicate the effectiveness of the mitigation measures; if the residual impacts were reduced below the maximum contrast levels specified by the VRM system for the affected landscape units, the mitigation measures could be regarded as effective.

4.2.1.8 Effects on Archaeological, Cultural and Historical Resources

Pages 4-113 and 114: The EA assessment of effects on these resources fails to acknowledge the potential for indirect impacts covered in 36 CFR Part 800.3(b)(3). These adverse effects include "visual, audible, or atmospheric elements that are out of character with the historic property or its setting". Project features such as improvements to Utah 211 and project impacts such as elevated particulate levels could well cause these types of adverse effects on archaeological, cultural or historic resources.

4.2.1.10 Effects on Transportation and Utilities

Page 4-117: It appears that site characterization and field investigation activities may require significant improvements to Utah 211. In the vicinity of Indian Creek Canyon and Newspaper Rock, these improvements could have significant adverse effects on sites that are listed in the National Register of Historic Places or that are eligible for such listing. Since this portion of Utah 211 is a state highway that is presumably a part of the federal-aid highway system in Utah, the improvements could also conflict with Section 4(f) of the Department of Transportation Act. This section was amended by the

Federal-aid Highway Act of 1968 to read: "It is hereby declared to be the national policy that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites...The Secretary shall not approve any program or project which requires the use of any publicly-owned land from a public park, recreation area, or wildlife and waterfowl refuge..., or any land from an historic site...unless (1) there is not feasible and prudent alternative..., and (2) such program includes all possible planning to minimize harm to such park, recreational area, or wildlife and waterfowl refuge, or historic site resulting from such use."

Furthermore, this assessment of effects on transportation and utilities fails to acknowledge that Utah 211 is the principal access route to Canyonlands National Park and that increased traffic and risk of vehicle accidents could have an adverse impact on the aesthetic experience of visitors approaching the park.

4.2.1.11 Effects on Tourism and Recreation

Page 4-118, fourth paragraph: Since the EA fails to adequately address the aesthetic impacts of site characterization and field investigation activities, the assessment of the effects of these impacts on tourism and recreation is also inadequate. Note that the EA fails entirely to acknowledge the adverse aesthetic impacts of site characterization and field investigation on the park entry experience; the EA appears to assume that visitors will entirely forget about these activities once they have driven past and have entered the park. On the contrary, the entry experience is an important component of the total recreation experience at Canyonlands National Park, (Schreyer, et. al., 1985).

4.2.2.1.12 Summary of Impacts to Canyonlands National Park

Page 4-123, fourth paragraph: State reviewers have questioned the adequacy of the EA analysis of the effects of site characterization and investigation on air quality related values in the park. See the comments on EA section 4.2.1.3.

Page 4-123, ninth paragraph: The EA assessment of daytime aesthetic impacts is inadequate. See the comments on EA section 4.2.1.7.

Page 4-124, first paragraph: The EA analysis of effects on nighttime aesthetics is also inadequate. See the comments on EA section 4.2.1.7. Note that field investigation activities would require three tall meteorological towers, with aircraft warning lights, in addition to the shaft headframe mentioned in the EA text. Also note that the remarks on the visibility of the shaft headframe are based on an incorrect viewshed analysis, (see Appendix D).

Page 4-124, third paragraph: The EA analysis of effects on transportation and utilities fails to acknowledge the need for improvements to Utah 211 and the associated aesthetic impacts on recreation lands and historic sites. The EA also fails to assess the aesthetic impacts of increased traffic and risk of accidents on the entry experience of visitors to Canyonlands National Park.

Page 4-137, Table 4-31: Item 8 in this summary table fails to adequately identify the impacts of geologic field studies on aesthetic resources; this is because EA Section 4.2.1.7, which it summarizes, failed to assess these impacts. Item 9 fails to identify the likelihood of indirect impacts on National Register sites and eligible sites under the criteria of adverse effect listed in 36 CFR Part 800. Item 11 fails to identify the potential conflicts of transportation improvements to Utah 211 with Section 4(f) of the Department of Transportation Act.

Page 4-139, Table 4-31: The comments on items 8, 9, and 11 on page 4-137 also apply to the corresponding items on this part of the table.

Page 4-141. Table 4-31: see the comments on items 8 and 9 on page 4-137.

Page 4-142, Table 4-31: The comments on item 11 on page 4-137 also apply to item 11 on this part of the table.

Chapter 5

REGIONAL AND LOCAL EFFECTS OF LOCATING A REPOSITORY AT THE SITE

5.1.2.2 Offsite Development

Page 5-21, second paragraph: Contrary to this paragraph, EA Figure 5.8 shows that the representative transmission line route does not follow the access road corridor to the repository.

5.2 EXPECTED EFFECTS ON THE PHYSICAL ENVIRONMENT

5.2.3 Land Use

Page 5-43, eighth paragraph: Contrary to the introduction in this paragraph, EA section 5.2.3 does not appear to include any discussion of the effects of the repository on recreation use. It appears that repository development and operation could preclude recreation access to Davis Canyon from Utah 211. It also appears that transportation corridors associated with repository development could preclude recreation access to lands north of the repository site; compare the second paragraph under 5.2.3.2, Agriculture.

5.2.5 Air Quality

Page 5-50, third paragraph: The EA states that the methodology and assumptions for assessing air quality impacts related to repository development and operations are the same as those used for site characterization. For comments on the methodology and assumptions, please see the comment on EA section 4.2.1.3.

5.2.5.5 Impacts

5.2.5.6 Sensitive Receptors

Page 5-65, seventh paragraph: As indicated in the comments on EA section 4.2.1.3, there are three sets of air quality related values that must be considered in relation to Canyonlands National Park: the effects of reductions in visual range on park vistas that extend beyond the boundaries of the park, the effects of visible plumes on scenic views within the park, and the effects of repository site lighting on views of the night sky within the park. In each case, the atmospheric effects of repository development and operation should be modeled and discussed in this section of the EA, while the aesthetic impacts of these effects should be simulated and assessed in the aesthetics section of the EA.

Page 5-66, second paragraph: State reviewers have been unable to replicate the results stated by the EA and question the assumptions that were used in obtaining these results. The effects on visual range should be simulated in actual views, as well as modeled mathematically, using the techniques cited in the comments on EA Section 4.2.1.3.

Page 5-66, fourth paragraph: Contrary to the statement in the EA, the general height of the mesa tops above the floor of Davis Canyon is approximately 400-500 feet. Therefore, a plume approximately 1,000 feet in height would probably be visible from inside Canyonlands National Park at locations such as Squaw Flat Campground, which is oriented directly toward North and South Sixshooter Peaks. Of course, such a plume would also be visible from Utah 211 and other areas outside the park.

5.2.6 Aesthetic Conditions

Page 5-66, paragraph 7: The comments on EA Section 4.2.1.7 noted that the EA assessment of the aesthetic impacts of site characterization and field investigation activities is inadequate and fails to meet the requirements of the repository siting guidelines. This evaluation also applies to the EA assessment of the aesthetic impacts of repository development and operation. As reported in EA Section 5.2.6, this assessment is confused and incoherent. It consists of the following elements: A) a line-of-sight viewshed analysis of the repository itself, B) a discussion of BLM contrast rating procedures related to the repository, C) a discussion of access road and utility corridor visibility and contrast, D) a general discussion of mitigation strategies for aesthetic impacts, E) a general discussion of the possible aesthetic impacts of repository decommissioning, F) a general discussion of the effects of site lighting on night sky brightness, G) a general discussion of railroad route visibility and contrast, and H) a summary of aesthetic impacts.

These comments on section 5.2.6 begin with a series of line-by-line comments on the EA text, organized under the headings given above. Then, because the EA analysis appears to lack the coherent methodology necessary for an adequate assessment, a study plan is recommended to correct and complete the aesthetics assessment. This plan identifies the elements that need to be studied to determine the probable aesthetic impacts of repository development and operation. A similar plan of study is included in the comments on EA Section 4.2.1.7 to determine the effects of site characterization. The studies outlined here would be essential to develop the direct, visual evidence that would be necessary for meaningful State participation and comment.

A) EA Repository Viewshed Analysis

Page 5-66, eighth and ninth paragraph: The EA viewshed analysis was based on one site location that no longer corresponds to any of the principal features of the repository. The repository viewshed analysis should be redone, considering both shaft headframe locations, the meteorological tower or towers, the waste handling building, the excavated salt stockpile, and the complete routes of the new railroad, truck highway and electrical transmission line that would serve the repository site. As noted in the comments on EA section 4.2.1.7, a visit to Davis Canyon should be sufficient to make it evident that the repository site and the associated access and utility corridors would be visible from the entry route to Canyonlands National Park along Utah 211.

B) EA discussion of BLM Contrast Rating Procedures Related to Repository Site

Page 5-67, second paragraph: The EA discusses possible contrast ratings in relation to the repository site. This discussion is based on incorrect information regarding the repository viewshed and is completely speculative. No visual simulations appear to have been developed for the repository, other than the computer-plotted perspective diagrams included in Stearns-Roger, 1983b. There is no analytic basis for the claim that the aesthetic impact of the repository would be minimal; this statement is unsupported opinion and does not represent the application of conservative assumptions that is required by DOE repository siting guidelines.

C) EA Discussion of Access and Utility Corridor Visibility and Contrast

Page 5-67, third paragraph: The EA discussion of the possible visibility of access roads and utiltity corridors should have been integrated with Item A, discussed above. The statement that the visual contrast and impact of these features would be minimal is not supported by any evidence and should be deleted.

D) EA Discussion of Potential Mitigation Strategies

Page 5-67, fourth paragraph: It is unclear to which repository elements the EA discussion of impact mitigation strategies is meant to refer. The list of strategies is incomplete and the EA presents no analytic basis for assuming that these strategies could reduce the residual impacts of repository development and operation to acceptable levels.

E) EA Discussion of Repository Decommissioning

Page 5-67, fifth paragraph: This discussion is insufficient to identify the aesthetic impacts of repository decommissioning and permanent site marking. It also fails to identify the visual features associated with ongoing site security measures (See EA page 5-35).

F) EA Discussion of Artificial Lighting

Page 5-67, sixth paragraph: As discussed in the comments on EA section 4.2.1.7, visual simulations of actual night sky views are necessary to assess the aesthetic impacts of artificial lighting for repository construction and operation. Also as discussed in the comments on section 4.2.1.7, the statement regarding FAA requirements for navigation warning lights and daytime marking of tall structures associated with the repository is misleading. The EA should be revised to incorporate the conservative assumption that warning lights and red-and-white stripes would be required on all structures 200 feet or more in height.

G) EA Discussion of Railroad Visibility and Contrast

Page 5-67, seventh and eighth paragraphs, and page 5-68, first paragraph: The EA discussion of the representative railroad route should have been incorporated in Item A above. The discussion of possible visual contrast and mitigation measures is without analytic basis. The EA neither offers nor cites any evidence to justify the claim that the residual aesthetic impacts of the railroad route would be acceptable.

H) EA Summary of Aesthetic Impacts

Page 5-68, second paragraph: The EA summary of the aesthetic impacts of repository development and operation is incomplete and misleading. It assumes that the aesthetic impact of access and utility corridors can somehow be separated from the aesthetic impacts of the repository itself. Full assessments of the aesthetic impacts of the "representative" routes for these support facilities should have been integrated with the assessment of the aesthetic impacts of the repository. Contrary to the statement in the EA that "daytime visual impact observed by visitors to the project area will be minimal", the aesthetic impacts of the entire facility, including its utility and access routes, remain to be quantified The comment that visual impacts would be "semi-permanent" is misleading. These impacts should be described as long-term, since they would continue for a period as long as the design life of a major highway or building complex.

RECOMMENDED STUDY PLAN TO ASSESS THE AESTHETIC IMPACTS OF REPOSITORY DEVELOPMENT AND OPERATION AT DAVIS CANYON

The EA purports to use the Bureau of Land Management (BLM) Visual Resource Management (VRM) system to assess the aesthetic impacts of repository development and operation at Davis Canyon. However, as already explained in the critique of the characterization phase assessment, the EA approach to aesthetics assessment is inadequate. The BLM Visual Resource Management system does not specify in detail how the aesthetic impacts of a particular project are to be assessed. Furthermore, the EA analysis and coverage of aesthetic impacts does not conform to the standards set by BLM assessments of the aesthetic impacts of other major projects.

To help identify how the EA coverage of aesthetic impacts could be corrected, the following portion of the comments presents a step-by-step study plan for assessing the aesthetic impacts of repository development and operation.

1) Define the Visual Environment of the Project

This general task should be carried out along the lines recommended for the characterization phase.

A. IDENTIFY THE MAJOR VISUAL FEATURES OF REPOSITORY DEVELOPMENT

The EA aesthetic impact assessment for repository development fails to consider many of the major visual features of this phase. Based on EA section 5.1, the following visual features could be prominent during repository development and operation:

- the waste handling building;
- mine support facilities (headframes, salt stockpiles, retention ponds, etc);
- administration and support buildings;
- site utilities and utility support (steam plant, tank farm etc.)
- meteorological tower(s), including aircraft warning marking and lighting;
- improvements to Utah 211, including cuts and fills for sections to be realigned and/or widened;
- new railroad line to repository;
- new truck highway to repository;

- electrical transmission line to repository;
- vehicles and mobile equipment, such as cranes;
- dust clouds associated with site clearing
- emission plume(s) from repository ventilation equipment; and
- site lighting, including light standards and luminaires, as well as the sky glow caused by atmospheric scattering of artificial light.

As with characterization, note that this list includes facilities to be erected or constructed during the repository development phase, equipment that will be present for extensive periods during that phase, and visible effects of various activities during repository development.

B. IDENTIFY THE LANDSCAPES THAT COULD BE AFFECTED

The Davis Canyon aesthetics assessment should identify and differentiate the landscape units that could be affected by the repository development phase, to the extent that these would differ from the landscapes affected by the characterization phase. This could involve additional areas to the east of the landscapes discussed for characterization, in the vicinity of U.S. Highway 191.

C. MAP THE VIEWSHEDS OF THE MAJOR VISUAL FEATURES OF THE PROJECT

The composite viewshed of all the visual features associated with site characterization and field investigation activities would comprise the project viewshed for the repository development phase. The EA viewshed analysis addressed only a limited selection of the features associated with repository development and operation; this analysis should be expanded.

Again, the first step in this analysis would be to select representative test points for all the visual features identified in task 1A. The next step would be to map the viewsheds of these features, using a numeric model of the terrain surrounding the project and a computer program such as VIEWIT. The EA numeric terrain model should be expanded along the lines indicated in the comments on the characterization phase.

The revised viewshed analysis should be comprehensive, addressing all the features that would be visible during repository development and operation, rather than separating these features into categories of activities and assessing each category in isolation. Instead, a time sequence of composite viewshed maps should be prepared for the repository development and operation phase.

D. DELINEATE VISUAL ASSESSMENT UNITS FOR REPOSITORY DEVELOPMENT

As with the characterization phase, the visual assessment units would be the portions of the landscape units from which the visual features associated with the repository would be visible.

2) Identify Key Views for Visual Assessment

The procedure for identifying key views would be the same as that for the characterization phase. There could well be some changes in the key views appropriate for the repository development phase. Review of the EA and other information about the Davis Canyon area suggests the following preliminary list of key observation points for the repository development phase. Note that the visual features listed for this phase are only a partial list of such features.

KEY OBSERVATION-TION POINT	DIRECT-TION	VISIBILITY OF REPOSITORY DEVELOPMENT FEATURES HF	Salt	211	RR	Hwy.	T/Lh.	Plm.	Lght.	Sky
Colorado River	S	-	-	-	X	-	-	-	-	-
Dead Horse Point	E	-	-	-	X	-	-	-	-	-
Anticline O/L	NW	-	-	-	X	-	-	-	-	-
Canyonlands O/L	NW	-	-	-	X	-	-	-	-	-
Buck Canyon O/L	E	-	-	-	X	-	-	-	-	-
Grandview Point	SE	-	-	-	X	X	X	X	-	-
Needles O/L	SW	-	-	X	X	X	X	X	-	-
Squaw Flat C/G	E	-	-	-	-	-	-	x	-	X
Utah 211, E/B	E	-	-	X	X	X	X	-	-	-
Utah 211, N/B	W	X	X	X	X	X	X	X	X	-
Harts Point	W	X	X	X	X	X	X	X	X	-
Newspaper Rock	S	-	-	X	-	-	-	-	-	-

Notes:
HF = shaft headframes and other surface structures
Salt = excavated salt stockpiles
211 = improvements to Utah 211
RR = railroad to repository
Hwy. = truck highway to repository
T/L = transmission line to repository
Plm. = emission plume (s)
lght = site lighting
Sky = increased night sky brightness

X = feature potentially visible

3) Analyze Existing Views and Viewer Response

The analysis of the aesthetic relationship of the key views to the affected visual environment would be similar to the same step for the characterization phase.

4) Depict the Visual Appearance of Project Alternatives

An adequate assessment of the aesthetic impacts of repository development at Davis Canyon must be based on visual simulations. The procedure for developing these simulations would be similar to that for the characterization phase.

5) Assess the Visual Impacts of Project Alternatives

The assessment procedure would again be similar to that for the characterization phase and the two assessments would probably be performed at the same time.

6) Determine Ways to Mitigate Adverse Visual Impacts

The process of identifying and evaluating mitigation measures would also be similar to that for the characterization phase, as well as to the initial simulation and evaluation of aesthetic impacts.

5.2.7 Noise

Page 5-73, second paragraph: The statement that "no impact is anticipated as a result of increased traffic noise" fails to acknowledge that this effect is one of the types of adverse effects prescribed by 36 CFR Part 800. It appears likely that Newspaper Rock would be subject to adverse effects described in these regulations; other sites eligible for the National Register of Historic Places could also be subject to similar effects.

5.2.8 Cultural Resources

Page 5-74, second paragraph: As noted earlier in regard to EA section 4.2, federal regulations regarding archaeological, cultural, and historic resources include provisions that prescribe adverse indirect impacts on such resources (36 CFR Part 800). The EA analysis in section 5.2.8 fails to address these provisions.

5.2.10. Tourism and Recreation

Page 5-75, first paragraph: The EA fails to adequately address the aesthetic impacts of repository development and operation; therefore, the assessment of the effects of these impacts on tourism and recreation is also inadequate. In particular, the EA fails to acknowledge the aesthetic impacts of repository development and operation on tourists traveling to Cayonlands National Park. The EA appears to assume that park visitors will entirely forget about the repository once they have driven past and have entered the park. On the contrary, the entry experience is an important component of the total recreation experience at Canyonlands National Park and appears likely to suffer significant aesthetic impacts if the repository were built, (Schreyer, et. al., 1985).

5.2.11. Summary of Impacts to Canyonlands National Park

Page 5-83, Table 5-10: The summary table of impacts to Canyonlands National Park includes a summary of air quality impacts. This summary fails to discuss impacts on air quality related values in Canyonlands National Park. See the comments on EA sections 4.2.1.3 and 5.2.5.

Page 5-87, Table 5-10: Because of the reasons noted throughout this review, the discussion of aesthetic impacts in the summary table is incorrect. The conclusions are not based on analytic evidence and represent the exercise of unsupported opinion. They should be deleted.

Page 5-89, third paragraph: As noted in previous comments on EA section 5.2.6, the statement that "daytime aesthetics will be minimally affected" inside the park represents the exercise of opinion and is not supported by evidence presented or cited in the EA. As demonstrated in Johnson, 1983, and Johnson et. al., 1985, the viewshed analysis of the repository is incomplete and incorrect. Even it if were correct, the viewshed analysis would represent only the first step in an adequate aesthetic impact assessment.

Page 5-89, third paragraph: The EA assessment of the aesthetic impacts of increased sky brightness due to artificial illumination at the repository site is incomplete. However, the EA does acknowledge elsewhere that these impacts could be significant (page 4-109, for example).

5.3.1 <u>Environmental Effects of Improvements to Transportation Corridors</u>

5.3.2.1 Roadways

5.3.2.1.6 <u>Aesthetic Conditions</u>

Page 5-102, tenth paragraph: The EA states that the "visual impacts of the representative transportation corridor have not been evaluated." It is essential that these impacts be evaluated and incorporated in an aesthetic assessment of the entire repository facility. The representative highway appears likely to have significant aesthetic impacts on the visual resources of Harts Draw and also appears likely to be quite visible from Utah 211, Needles Overlook, and the four-wheel drive routes on Harts point (Appendix D).

5.3.2.2 Railroads

Page 5-103, third to fifth paragraphs: The assessment of the aesthetic impacts of the railroad access route for the repository is so brief as to be meaningless. This route is an essential element of the repository and the EA should have assessed its impacts in conjunction with the entire repository facility. It appears likely that the aesthetic impacts of the railroad alone would be significant. The study plan for aesthetic impacts proposed in the comments on EA section 5.2.6 would integrate the consideration of the aesthetic impacts of transportation routes with the aesthetic impacts of the repository itself.

5.5 IMPLICATIONS OF AN ALTERNATIVE REPOSITORY DESIGN CONCEPT

Page 5-133, tenth paragraph: The aesthetic assessment of the alternative repository design concept is insufficient to support conclusions on its aesthetic impacts.

5.6 SUMMARY OF REPOSITORY IMPACTS AT DAVIS CANYON SITE

Page 5-136, Table 5-27: Item 9 in this summary table fails to adequately identify the impacts of repository construction on air quality related values in Canyonlands National Park. Item 10, aesthetic resources should acknowledge the probable significant impacts of repository construction on aesthetic resources.

Page 5-137, Table 5-27: This summary table contains conclusory statements about the aesthetic impacts of repository construction on Canyonlands National Park that are not supported by analysis. An example is the claim "daytime and nighttime aesthetics (would be) minimally affected".

Page 5-140, Table 5-27: This portion of the summary table deals with the probable impacts of repository operation. Item 10, its summary of impacts on aesthetic resources, is inaccurate and contains conclusory statements that are unsupported by analysis. See the comments on EA section 5.2.6 for more detail. Item 12 fails to address the likelihood of indirect impacts on National Register sites and eligible sites. Similarly, item 13 fails to address the potential significant impacts of repository operation on air quality related values in Canyonland National Park. Item 15, transportation and utilities, completely fails to address the probable adverse environmental impacts including aesthetic impacts of these facilities in the vicinity of Davis Canyon.

Page 5-141, Table 5-27: Item 23, tourism and recreation, in this summary table fails to address the adverse aesthetic impacts of the repository on the experience of tourists traveling to Canyonlands National Park along Utah 211.

Page 5-143, Table 5-27: This portion of the summary table reports the probable impacts of repository decommissioning and closure on various resource categories. The conclusions "no additional impacts" for item 10, aesthetics, are not justified by any description or analysis in the body of the EA.

Chapter 6

SUITABILITY OF THE DAVIS CANYON SITE FOR SITE CHARACTERIZATION AND FOR DEVELOPMENTS AS A REPOSITORY

6.1 THE DOE SITING GUIDELINES

6.2 THE SUITABILITY OF THE SITE FOR DEVELOPMENT AS A REPOSITORY UNDER GUIDELINES NOT REQUIRING SITE CHARACTERIZATION

6.2.1.6 Environmental Quality Technical Guideline, 10 CFR Part 960.5-2-5

Page 6-25, Table 6-2: The EA discussion of the projected ability of the Davis Canyon site to meet the requirements of the Clean Air Act does not adequately discuss the probable effects of the repository on air quality related values in Canyonlands National Park. For a proposed study plan that would adequately address these values, see the comments on EA sections 4.2.1.3, 4.2.1.7, 5.2.5, and 5.2.6.

Page 6-38, Table 6-2: This summary of the projected ability of the Davis Canyon site to meet the requirements of the National Historic Preservation Act of 1966 fails to consider the possible determination that the project would have adverse indirect effects on sites listed on the National Register of Historic Places, or on sites that are eligible for such listing. Adverse effects could include "visual, audible, or atmospheric elements: (36 CFR Part 800.3(b)).

Page 6-39c, Table 6-2: This table of statutory/regulatory authorities and requirements relating to the Davis Canyon site fails to include Section 4(f) of the Department of Transportation Act. See the comments on EA section 4.2.1.10 on page 4-11.

Page 6-39f, Table 6-4: The discussion of measures to control potential adverse environmental impacts in this summary table is inadequate for air quality because if fails to address the issue of air quality related values in Canyonlands National Park. The discussion of such measures for cultural resources is also inadequate because it fails to address the criteria of adverse effect contained in 36 CFR Part 800.

Page 6-39h, Table 6-4: This summary discussion of measures to control potential adverse environmental impacts is inadequate for the category of "visual aesthetics" because it misstates the probable extent and potential severity of adverse aesthetic impacts. The referenced sections of the EA (4.2.1.7 and 5.2.6) are incomplete. There is no evidence in those sections to support the effectiveness of the control measures that is listed in this summary table. There is also no evidence in those sections to support the DOE belief that "visual aesthetics impacts can be mitigated to an acceptable degree". On the contrary, the State believes that the residual impacts are likely to be significantly adverse and unacceptable.

6.2.1.6.2 <u>Analysis of Favorable Conditions</u>

Pages 6-40 and 6-41: The EA analysis of the projected ability of the Davis Canyon site to meet environmental requirements concludes that the Davis Canyon site may be found to have adverse effects on air quality related values in Canyonlands National Park. This analysis should also cite the possibility of agency determinations that the Davis Canyon repository and its supporting facilities would violate the provisions of Section 4(f) of the Department of Transportation Act and the criteria of adverse effect on historic resource in 36 CFR Part 800.

6.2.1.6.3 Analyis of Potentially Adverse Conditions

Page 6-42, paragraph five: The EA indicates that DOE does not believe the Davis Canyon site would pose major conflicts with applicable environmental requirements. On the contrary, as indicated in the comments on section 6.2.1.6.2, the State believes that the site could conflict with federal requirements regarding air quality related values in Canyonlands National Park, protection of archaeological and historic resources, and recreation lands. Therefore, the concluding sentence of this subsection should be modified to indicate that the potentially adverse condition may be present.

Page 6-43, first paragraph: The EA evaluation of the potential of the Davis Canyon site to cause significant adverse environmental impacts that cannot be avoided or mitigated should be modified. There is inadequate support for the statement that the placement and design of these facilities can reduce visual impacts to acceptable levels. Thus, there is inadequate support for the concluding statement that all significant environmental impacts can be mitigated. The final sentence should be modified to indicate that the potentially adverse condition is present.

Page 6-44, first paragraph: The proximity of the upgraded portions of Utah 211 to Newspaper Rock suggests the potential for significant adverse environmental of this potentially adverse condition states clearly that Utah 211 will be upgraded.. It fails, however, to address the Federal criteria for determining if a project would have adverse effects on a site listed in the National Register of Historic Places, as specified in 36 CFR Part 800. The Utah SHPO or the Federal Advisory Council on Historic Preservation could find that upgrading Utah 211 would cause such adverse effects on Newspaper Rock. Therefore, the concluding statement should be modified to indicate that the potentially adverse condition is present.

Page 6-44, third paragraph: This EA subsection also deals with the potential effects of improvements to Utah 211 on cultural sites such as Newspaper Rock. For the reasons given in the comments or the preceding paragraph, the conclusion of this subsection should be that the potentially adverse condition (i.e., an adverse impacts on a site of unique cultural interest) is present.

6.2.1.6.4 Analysis of Disqualifying Conditions

Page 6-45, fourth paragraph: The EA analysis is not adequate to reach a determination on the disqualifying condition regarding protection of the quality of the environment. This is particularly true of the EA assessment of aesthetic impacts; previous comments on EA sections 4.2.1.7 and 5.2.6 have demonstrated that the EA assessment is both incomplete and incorrect. There is no analytical evidence in the EA that justifies the DOE assertion that projected aesthetic impacts can be mitigated to an acceptable degree or that aesthetic impacts on Canyonland National Park would be insignificant. The paucity of evidence regarding these impacts should not be interpreted as justifying Level 1 finding that "the evidence does not support a finding that the site is disqualified." The only finding that is warranted is that no finding is possible with the evidence at hand. The Level 1 finding proposed by DOE could subject the Davis Canyon area to the considerable adverse environmental impacts of site characterization and field investigation activities.

Page 6-46, second paragraph: Based on the previous comments on EA sections sections 4.2.1.7 and 5.2.6, the statement that the presence of the repository at Davis Canyon "would not be expected to conflict irreconcilably with the previously designated use" of Canyonlands National Park cannot be justified. The repository and the associated transportation and utility corridors appear likely to impose significant adverse aesthetic impacts on the park and on air quality related values within the park. While the EA may not contain enough evidence to support a finding that the site is disqualified, the lack of evidence cannot logically be used as a basis for site nomination. Instead, the EA should state that the current level of evidence on the Davis Canyon site is insufficient to reach a finding on this disqualifying condition.

6.2.1.6.5 Conclusion for the Qualifying Condition

Page 6-46, fourth paragraph: The qualifying condition for the Davis Canyon site is paraphrased here as "reasonable assurance that requirements for the protection of the quality of environment can be met." The EA fails to provide reasonable assurance.

Page 6-46, sixth paragraph: The EA erroneously states that the only potentially adverse condition present at Davis Canyon is the conflict with air quality related values in Canyonlands National Park. This is incorrect. Although the EA fails to provide adequate evidence on issues such as aesthetic impacts, site characterization and repository development both appear likely to cause, A) major conflicts with applicable environmental requirements, B) significant adverse environmental impacts that cannot be avoided or mitigated to insignificant levels, C) significant adverse effects on State-protected resource areas, and D) significant adverse effects on Native American or unique cultural resources.

Page 6-47, first paragraph: State reviewers believe that disqualifying conditions may be present for environmental quality at the Davis Canyon site. The EA fails to demonstrate that the quality of the environment in the affected area can be adequately protected, contrary to the statement in this section of the EA. The EA also fails to demonstrate that the restricted area and repository site support facilities will not conflict irreconcilably with resource-preservation use of federal or State lands dedictaed to resource preservation.

Page 6-47, third paragraph: The lack of evidence in the EA regarding key components of the System Guideline's Qualifying Condition for Environment, Socioeconomics and Transportation is insufficient to support any finding. It is illogical and contrary to the repository siting guidelines to interpret DOE failures to develop and present data on important environmental issues as justifying the nomination of the Davis Canyon site. Therefore, the Level 3 finding is not warranted and should be deleted until adequate evidence is developed to reach a finding.

6.2.1.8 Transportation Guideline 10 CFR 960.5-2-7

6.2.1.8.5 Conclusion for the Qualifying Condition

Page 6-58, last paragraph: The statement that "several feasible highway and railroad access routes to the site have been identified that do not irreconcilably conflict with a National Park ..." is not supported by the necessary evidence in EA chapters 4 and 5.

Pages 6-64 to 6-66, Table 6-7: The discussion of potentially adverse conditions related to siting guideline 960.5-2-5 in this summary table should be revised as indicated in the preceding comments on EA pages 6-42 to 6-47.

Page 6-78, Table 6-8: The discussion of transportation in relation to system guideline 960.5-1(a) (2) in this summary table should be revised as indicated in the preceding comments on EA page 6-58.

COMPARATIVE EVALUATION OF SITES PROPOSED FOR NOMINATION

7.3.2 ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION

Pages 7-74 to 7-76, Table 7-13: The findings for the Davis Canyon site in this summary table regarding siting guideline 960.5-2-5 should be revised as indicated in the preceding comments on EA pages 6-42 to 6-47. There is insufficient evidence in the EA to warrant any finding on the qualifying condition. Potentially adverse conditions 1,2,4, and 5 should be reported as present (P). There is also insufficient evidence in the EA to warrant any finding on disqualifying conditions 1 and 3.

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APPENDIX J

FOR INTERNAL USE ONLY

Review and Assessment of Expected Impacts of the Proposed Nuclear Waste Repository Construction on Cultural and Paleontological Resources in the Gibson Dome Area of Southeastern Utah

April, 1984

By

La Mar W. Lindsay, James L. Dykman,
David B. Madsen, James H. Madsen Jr.,
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