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Design Analysis Cover Sheet

Complete only applicable items.

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2. DESIGN ANALYSIS TITLE Geology of the Exploratory Studies Facility TS Loop	
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1. PURPOSE

The purpose of this design analysis is to present a summary of the Exploratory Studies Facility (ESF) Topopah Spring (TS) Loop geology based upon currently available data. The ESF TS Loop consists of the TS North Ramp, the TS Main Drift, and the TS South Ramp. Specifically, it presents a description of the geologic conditions expected to be encountered during the tunnel boring machine (TBM) excavation of the ESF. These conditions include significant geologic features, rock and rock-mass properties, and hydrogeologic conditions.

Because the process of gathering and analyzing data is ongoing, the conclusions presented herein are based on present knowledge and may change or be updated as additional data becomes available. This design analysis will be revised as new data and interpretations become available.

2. QUALITY ASSURANCE

The items covered in this design analysis are not specifically discussed in the Determination of Importance Evaluation (DIE) for ESF Design Package 2C, Doc. No. BAB000000-01717-2200-00005, REV. 04 (Reference 5.12). This analysis carries TBV-063-DD until the DIE is revised to incorporate geology or procedural steps are undertaken allowing for the removal of this TBV.

3. METHOD

The computer modeling software, LYNX Version 3.06, described in Section 6 of this analysis was used to analyze the United States Geological Survey (USGS) LYNX geology model YMP.R2.0. The geologic cross sections presented in this analysis, as well as estimates for distances to intersections of the ESF with significant geologic features, are based upon data contained within the USGS LYNX geology model YMP.R2.0 (Reference 5.56).

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

The following design inputs were used in this design analysis:

- United States Geological Survey LYNX Geology Model (preliminary), YMP.R2.O is presented in Reference 5.56 (TBV-061-DD). YMP.R2.0 was updated from the previous release (YMP.R1.1) to include data from NRG-7/7A, SD-9, and SD-12 and is considered at the present to be the most complete model available. The modeling effort is an ongoing process with updates undertaken as warranted by the availability of pertinent data. The TBV-061-DD will be carried until the USGS model is finalized.

- Sandia National Laboratories data transmittals for rock mechanical properties sample test results and rock mass mechanical properties estimates (Reference 5.22).

4.2 CRITERIA

There are no design requirements applicable to this analysis specified in the ESFDR (YMP/CM-0019, Rev 1, January 19, 1995 and ICN 2, (Reference 5.57) specifically pertaining to the geologic analysis of the ESF.

4.3 ASSUMPTIONS

The following assumption was made in this design analysis:

- ESF TS Loop invert design coordinates, elevations, and percent slopes were used to construct the LYNX engineering model of the ESF used in Figures 1, 2, and 3a through 3c, and in discussion throughout this report. This assumption is based on the ESF Layout Calculations, Doc. No. BABEAD000-01717-0200-00003, Rev. 02 (Reference 5.15 [TBV-062-DD]).

4.4 CODES AND STANDARDS

Not applicable.

5. REFERENCES

5.1 Angell, M.M., 1994. "Bedrock Geology of Exile Hill," TDIF 30318, report prepared by Geomatrix Consultants Inc., San Francisco, California, for Sandia National Laboratories, Albuquerque, New Mexico.

5.2 Bieniawski, Z.T., 1979. Engineering Rock Mass Classification, *Wiley-Interscience Publication*, John Wiley and Sons, New York.

5.3 Brechtel, C.E., D.S. Kessel, M. Lin, E. Martin, 1994. "Yucca Mountain Site Characterization Project: Geotechnical Characterization of the North Ramp of the Exploratory Studies Facility," SLTR94-0008, Rev. 0, Albuquerque, New Mexico.

5.4 Buesch, D.C., R.W. Spengler, T.C. Moyer, J.K. Geslin (in press). "Revised Stratigraphic Nomenclature and Macroscopic Identification of Lithostratigraphic Units of the Paintbrush Group Exposed at Yucca Mountain, Nevada," *U.S. Geological Survey Open-File Report 94-469*, U.S. Department of the Interior.

5.5 Carr, W.J., 1992. "Structural Model for Western Midway Valley Based on RF Drillhole Data and Bedrock Outcrops: in Gibson, J.D., F.H. Swan, J.R. Wesling, T.F. Bullard, R. C.Perman, M. M. Angell, L. A. DiSilvestro, Summary and Evaluation of Existing Geological and Geophysical Data near Prospective Surface Facilities in Midway Valley, Yucca Mountain Project, Nye County, Nevada," *SAND90-2491*, Appendix A, Sandia National Laboratories, Albuquerque, New Mexico, 1992.

5.6 Daley, T.M. and E.L. Majer, 1994. "Interim Report for Activity: 8.3.1.4.2.2.5 3GGF142M, Analysis Paper: Data Reduction NRG-6/WT-2 VSP: Report to U.S. Department of Energy from United States Geological Survey (Lawrence Berkeley Laboratory)," January 13, 1994.

5.7 Diehl, S.F. and M.P. Chornack, Stratigraphic Correlation and Petrography of the Bedded Tuffs, Yucca Mountain, Nye County, Nevada, U.S. Geological Survey Open-File Report 89-3, 1990.

5.8 DOE-YMP, DH/SS Video Survey w/Gyro, UE25-NRG-2B, 0-328.89 feet, October 5, 1993.

5.9 Elayer, R.W., November 1994. TS North Ramp Geology Design Analysis, DI: BABEA0000-01717-0200-00009.

5.10 Fenix & Scisson, NNWSI Hole Histories, UE-25a #1, #3, #4, #5, #6 and #7, November 1986.

5.11 Fenix & Scisson, NNWSI Hole Histories, USW G-1, G-2, G-3, G-4, GA-1, GU-3, June 1987.

5.12 Gwyn, D.W., Febrauary 1995. Determination of Importance Evaluation for ESF Package 2C, DI: BAB000000-01717-2200-00005, Rev. 04.

5.13 Hardy, M.P. and S.J. Bauer, 1991. "Drift Design Methodology and Preliminary Application for the Yucca Mountain Site Characterization Project," *SAND89-0837*, Sandia National Laboratories, Albuquerque, New Mexico.

5.14 Hoek, E., P.K. Kaiser, W.F. Bawden, 1995. "Support of Underground Excavations in Hard Rock," A.A. Balkema, Rotterdam, Netherlands, pp 84-98.

5.15 Kennedy, W.R. ESF Layout Calculation, BABEAD000-01717-0200-00003, Rev. 02 [TBV-062-DD].

5.16 Lappin, A.R., R.G. VanBuskirk, D.O. Enniss, S.W. Butters, F.M. Prater, C.B. Muller, J.L. Bergosh, 1982. "Thermal Conductivity, Bulk Properties, and Thermal Stratigraphy of Silicic Tuffs From the Upper Portion of Hole USW-G1, Yucca Mountain, Nye County, Nevada," *SAND81-1873*, Sandia National Laboratories, Albuquerque, New Mexico.

5.17 Lipman, P.W., R.L. Christiansen, and J.T. O'Connor, 1966. "A Compositionally Zoned Ash-Flow Sheet in Southern Nevada," *U.S. Geologic Survey Professional Paper 524-F*, U.S. Department of the Interior.

5.18 Moyer, T.C. and Geslin, J.K., (in press). "Lithostratigraphy of the Calico Hills Formation and Prow Pass Tuff (Crater Flat Group) at Yucca Mountain, Nevada," *U.S. Geological Survey Open-File Report 94-460*, U.S. Department of the Interior.

5.6 Daley, T.M. and E.L. Majer, 1994. "Interim Report for Activity: 8.3.1.4.2.2.5 3GGF142M, Analysis Paper: Data Reduction NRG-6/WT-2 VSP: Report to U.S. Department of Energy from United States Geological Survey (Lawrence Berkeley Laboratory)," January 13, 1994.

5.7 Diehl, S.F. and M.P. Chornack, Stratigraphic Correlation and Petrography of the Bedded Tuffs, Yucca Mountain, Nye County, Nevada, U.S. Geological Survey Open-File Report 89-3, 1990.

5.8 DOE-YMP, DH/SS Video Survey w/Gyro, UE25-NRG-2B, 0-328.89 feet, October 5, 1993.

5.9 Elayer, R.W., November 1994. TS North Ramp Geology Design Analysis, DI: BABEA0000-01717-0200-00009.

5.10 Fenix & Scisson, NNWSI Hole Histories, UE-25a #1, #3, #4, #5, #6 and #7, November 1986.

5.11 Fenix & Scisson, NNWSI Hole Histories, USW G-1, G-2, G-3, G-4, GA-1, GU-3, June 1987.

5.12 Gwyn, D.W., Febrauary 1995. Determination of Importance Evaluation for ESF Package 2C, DI: BAB000000-01717-2200-00005, Rev. 04.

5.13 Hardy, M.P. and S.J. Bauer, 1991. "Drift Design Methodology and Preliminary Application for the Yucca Mountain Site Characterization Project," *SAND89-0837*, Sandia National Laboratories, Albuquerque, New Mexico.

5.14 Hoek, E., P.K. Kaiser, W.F. Bawden, 1995. "Support of Underground Excavations in Hard Rock," A.A. Balkema, Rotterdam, Netherlands, pp 84-98.

5.15 Kennedy, W.R. ESF Layout Calculation, BABEAD000-01717-0200-00003, Rev. 02 [TBV-062-DD].

5.16 Lappin, A.R., R.G. VanBuskirk, D.O. Enniss, S.W. Butters, F.M. Prater, C.B. Muller, J.L. Bergosh, 1982. "Thermal Conductivity, Bulk Properties, and Thermal Stratigraphy of Silicic Tuffs From the Upper Portion of Hole USW-G1, Yucca Mountain, Nye County, Nevada," *SAND81-1873*, Sandia National Laboratories, Albuquerque, New Mexico.

5.17 Lipman, P.W., R.L. Christiansen, and J.T. O'Connor, 1966. "A Compositionally Zoned Ash-Flow Sheet in Southern Nevada," *U.S. Geologic Survey Professional Paper 524-F*, U.S. Department of the Interior.

5.18 Moyer, T.C. and Geslin, J.K., (in press). "Lithostratigraphy of the Calico Hills Formation and Prow Pass Tuff (Crater Flat Group) at Yucca Mountain, Nevada," *U.S. Geological Survey Open-File Report 94-460*, U.S. Department of the Interior.

5.19 O'Neill, J.M., J.W. Whitney, and M.R. Hudson, 1992. "Photogeologic and Kinematic Analysis of Lineaments at Yucca Mountain, Nevada; Implications for Strike-Slip Faulting and Oroclinal Bending," *U.S. Geological Survey Open-File Report 91-623*, U.S. Department of the Interior.

5.20 Ortiz, T.S., R.L. Williams, F.B. Nimick, B.C. Whittet, and D.L. South, 1985. "A Three-Dimensional Model of Reference Thermal/Mechanical and Hydrological Stratigraphy at Yucca Mountain, Southern Nevada," *SAND84-1076*, Sandia National Laboratories, Albuquerque, New Mexico.

5.21 Raytheon Services Nevada, Daily Operations Report Yucca Mountain Project, USW NRG-7/7A, March 4, 1994.

5.22 Sandia National Laboratories, Data Transmittal Packages for Mechanical Properties Data and Rock Mass Mechanical Properties Estimates from NRG Drilling Program. [TDIF No.: 301485, 301671, 301703, 301785, 301881, 302038, 302205, 302207, 302231, 302417, 303003, 303121, 303167, 303340, 303384, 303849, 304095, 304135, 304141]

5.23 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-1, February 4, 1995. [TDIF No.: 304083]

5.24 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-2, February 4, 1995. [TDIF No.: 304084]

5.25 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-2A, February 4, 1995. [TDIF No.: 304085]

5.26 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-2B, February 4, 1995. [TDIF No.: 304086]

5.27 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-3, February 4, 1995. [TDIF No.: 304087]

5.28 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-4, February 5, 1995. [TDIF No.: 304088]

5.29 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole UE25 NRG-5, February 4, 1995. [TDIF No.: 304090]

5.30 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole USW NRG-6, February 4, 1995. [TDIF No.: 304091]

5.31 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole USW NRG-7/7A, February 4, 1995. [TDIF No.: 304092]

5.32 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole SD-9, March 14, 1995. [TDIF No.: 304226]

5.33 Sandia National Laboratories, YMP Geology and Rock Structure Log for Drillhole SD-12, March 14, 1995. [TDIF No.: 304230]

5.34 Sawyer, D.A., R.J. Fleck, M.A. Lanphere, R.G. Warren, D.E. Broxton, M.R. Hudson, 1994. "Episodic Caldera Volcanism in the Miocene Southwestern Nevada Volcanic Field: Revised Stratigraphy Framework, ^{40}AR/^{39}Ar Geochronology, and Implications for Magmatism and Extension," *Geol. Soc. of America Bulletin*, v. 106, October 1994.

5.35 Scott, R.B. and J. Bonk, 1984. "Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections," *U.S. Geological Survey Open-File Report 84-494*, U.S. Department of the Interior.

5.36 Serafim, J.L. and J.P. Periera, (np). "Considerations of the Geomechanical Classification of Bianiawski," Proceedings, International Symposium on Engineering Geology and Underground Construction, 1983.

5.37 Spengler, R.W., F.M. Byers, Jr., and J.B. Warner, 1981. "Stratigraphy and Structure of Volcanic Rocks in Drill Hole USW-G1, Yucca Mountain, Nye County, Nevada," *U.S. Geological Survey Open-File Report 81-1349*, U.S. Department of the Interior.

5.38 Spengler, R.W., C.A. Braun, R.M. Linden, L.G. Martin, D.M. Ross-Brown, and R.L. Blackburn, 1993. "Structural Character of the Ghost Dance Fault, Yucca Mountain, Nevada," High Level Radioactive Waste Management, Proceedings of the Fourth Annual International Conference, Las Vegas, Nevada, April 26-30, 1993. American Nuclear Society, Inc., LaGrange Park, Illinois.

5.39 Spengler, R.W., C.A. Braun, L.G. Martin, and C.W. Weisenberg, 1994. "The Sundance Fault: A Newly Recognized Shear Zone at Yucca Mountain, Nevada," *U.S Geological Survey Open-File Report 94-49*, 1994.

5.40 Swadley, W.C., D.L. Hoover, and J.N. Rosholt, 1984. "Preliminary Report on Late Cenozoic Faulting and Stratigraphy in the Vicinity of Yucca Mountain, Nye County, Nevada," *U.S. Geological Survey Open-File Report 84-788*, U.S. Department of the Interior.

5.41 Transmittal Ezra, C.E. to Kennedy, B., "Existing Borehole Information," Tracking designator: NR95030701, Product No.: YMP-95-133.0

5.42 U.S. Geological Survey, 1983. "A Summary of Geologic Studies Through January 1, 1983, of a Potential High-Level Radioactive Waste Repository Site at Yucca Mountain, Southern Nye County, Nevada," *U.S. Geological Survey Open-File Report 84-792*, U.S. Department of the Interior.

5.43 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-1, Ver. 1.1, November 22, 1993. [DTN: GS931008314211.046]

5.44 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-2, Ver. 1.1, October 11, 1993. [DTN: GS931008314211.039]

5.45 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-2A, Ver. 1.1, October 11, 1993. [DTN: GS931008314211.038]

5.46 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-2B, Ver. 1.1, October 11, 1993. [DTN: GS931108314211.041]

5.47 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-2C, Ver. 1.1., March 17, 1994. [DTN: GS940308314211.012]

5.48 U.S. Geological Survey Graphical Lithologic Log of Borehole UE-25 NRG-2D, Ver. 1.1., March 17, 1994. [DTN: GS940308314211.013]

5.49 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-3, Ver. 1.1, October 15, 1993. [DTN: GS931008314211.037]

5.50 U.S. Geological Survey, Graphical Lithologic Log of Borehole UE-25 NRG-4, Ver. 1.1, October 14, 1993. [DTN: GS931108314211.042]

5.51 U.S. Geological Survey Graphical Lithologic Log of Borehole UE-25 NRG-5, Ver. 1.1, October 12, 1993. [DTN: GS931108314211.043]

5.52 U.S. Geological Survey, Graphical Lithologic Log of Borehole USW NRG-6, Ver. 1.1, November 21, 1993. [DTN: GS931008314211.045]

5.53 U.S. Geological Survey, Graphical Lithologic Log of Borehole USW NRG-7/7A, Ver. 1.1, April 6, 1994. [DTN: GS940408314211.020]

5.54 U.S. Geological Survey, Graphical Lithologic Log of Borehole USW SD-9, Ver. 1.0, November 15, 1994. [DTN: GS941108314211.052]

5.55 U.S. Geological Survey, Graphical Lithologic Log of Borehole USW SD-12, Ver. 1.0, September 27, 1994. [DTN: GS940908314211.045]

5.56 U.S. Geological Survey, (Preliminary). "Distribution of Lithostratigraphic Units within the Central Block of Yucca Mountain, Nevada: A Three-Dimensional Computer-Based Model, Version YMP.R2.0," U.S. Geological Survey, Milestone 3GGU510M, Draft 2.0. [TBV-061-DD].

5.57 Yucca Mountain Site Characterization Project, "Exploratory Studies Facility Design Requirements," YMP/CM-0019 Rev. 1, ICN 2, May 8, 1995.

5.58 Yudhbir, W.L. and F. Prinzl, 1983. "An Empirical Failure Criteria for Rock Masses, 5th International Congress on Rock Mechanics," International Society for Rock Mechanics, Melbourne, Australia, 1983.

5.59 Scott, R.B., 1990. "Tectonic Setting of Yucca Mountain, Southwest Nevada," *Geol. Soc. of America Memoir 176*.

6. USE OF COMPUTER SOFTWARE

Some of this design analysis was developed using Lynx Version 3.06 (LYNX), acquired from Lynx Geosystems Inc., Vancouver, British Columbia, Canada. LYNX is run on a Unix-based Silicon Graphics Iris Indigo 2 workstation using IRIX 5.2 operating system. The Computer Software Configuration Item (CSCI) number for LYNX is B00000000-01717-1200-30018. LYNX is the appropriate software for this application and was used within the range of validation. LYNX was obtained from the Software Configuration Management (SCM) in accordance with appropriate procedures.

Microsoft Excel Version 5.0 was used to compute the mean and standard deviations for intact rock mechanical properties sample test results presented in Attachments I, II, and III, and summarized in Section 7.5.

6.1 The following input was utilized by the Lynx System to develop this design analysis:

- USGS Lynx Geology Model YMP.R2.0: "Distribution of Lithostratigraphic Units within the Central Block of Yucca Mountain, Nevada, Version YMP.R2.0." (Reference 5.56) [TBV-061-DD]. The generation and use of this input file is discussed in Sections 7.4 and 7.4.1.

- ESF Layout Calculation, BABEAD000-01717-0200-00003, Rev. 02 (Reference 5.15) [TBV-062-DD]. The use of this input file is discussed in Section 7.4.1.

6.2 From this input, the following outputs were developed in the Lynx System:

- Subsurface engineering volume model for the ESF excavation (M.ESF) used in Figures 1, 2, and 3a through 3c, and in determining ESF station references presented in Table 3 and discussed in 7.4.2.
- Geology volume model along the ESF centerline (G.ESF) used in Figures 3a through 3c and in determining ESF station references presented in Table 3 and discussed in 7.4.2.
- Distances for the ESF subsurface engineering and geology models presented in Table 3 and discussed in 7.4.2.

6.3 All modeling for this design analysis was performed under the Lynx project YMP.R2.M. After completion of the design analysis, the project was saved to a 1/4 inch HD6150 tape for archiving.

7. DESIGN ANALYSIS

7.1 INTRODUCTION — GEOLOGY OF THE ESF

This analysis presents both the site stratigraphy in terms of lithostratigraphic and thermal/mechanical (T/M) units and the major geologic structures expected to be encountered during ESF excavation. The USGS LYNX geology model, YMP.R2.0 (Reference 5.56), was used to create geologic cross-sections and for determining station

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- Geology volume model along the ESF centerline (G,ESF) used in Figures 3a through 3c and in determining ESF station references presented in Table 3 and discussed in 7.4.2.
- Distances for the ESF subsurface engineering and geology models presented in Table 3 and discussed in 7.4.2.

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7.2 ESF BOREHOLES

North Ramp Geology (NRG) and Systematic Drilling (SD) boreholes were drilled along the planned ESF alignment specifically for gathering stratigraphic and geotechnical information to support engineering design. The location of the NRG- and SD-series boreholes are presented in Table 1 (Reference 5.41) and, along with additional boreholes drilled in the ESF vicinity, shown in Figures 1 and 2. The NRG and SD-series boreholes were logged by the USGS (References 5.43 through 5.55) and Sandia National Laboratories (SNL) (References 5.23 through 5.33). SNL conducted geotechnical analysis of selected rock samples (Reference 5.22) collected from the NRG and SD-series boreholes.

Table 1. NRG- and SD-Series Borehole Coordinates

NRG- and SD-Series Borehole Coordinates[1]			
Borehole	**Northing**	**Easting**	**Elevation**
NRG-1	233282	173676	1144.4
NRG-2	233421	173490	1157.2
NRG-2A	233386	173432	1152.3
NRG-2B	233406	173497	1158.7
NRG-2C	233408	173489	1158.6
NRG-2D	233424	173472	1155.8
NRG-3	233554	173223	1165.4
NRG-4	233807	172767	1249.5
NRG-5	234053	172142	1251.5
NRG-6	233699	171965	1247.3
NRG-7/7A	234355	171598	1282.3
SD-7[2]	231328	171066	1363.0
SD-9[3]	234086	171242	1302.4
SD-12[3]	232245	171178	1323.7

1. All coordinates are expressed in metric units based upon a conversion factor of 0.30480061 meter per foot and are referenced to the Nevada State Plane Coordinate System, Central Zone (NAD27).
2. Analysis of SD-7 samples in progress, borehole data not finalized.
3. Analysis of SD-9 and SD-12 samples in progress.

7.3 GEOLOGIC SETTING

Yucca Mountain is the block faulted, erosional remnant of a volcanic plateau within the southwestern Nevada volcanic field of the Great Basin (Reference 5.17 and Reference 5.39). At Yucca Mountain a thick sequence of Tertiary volcanic rock overlie Paleozoic sedimentary strata (Reference 5.18). The volcanic rock consists of bedded and pyroclastic ash-flow tuffs originating from eruptions of the Timber Mountain-Oasis Valley Caldera Complex, north of Yucca Mountain, between 11.5 and 14 million years ago (Reference 5.3?). The block faulting subdivides Yucca Mountain into a series of 1 to 4 km wide, north-trending eastward-tilting fault blocks, separated by major west-dipping high angle normal faults (Reference 5.38).

The ESF is being excavated on the east flank of Yucca Mountain as can be seen in the topographic map, Figure 1. The ESF is almost completely located within the central structural block, which is bounded on the east by the Bow Ridge fault and on the west by the Solitario Canyon fault (Figure 2 [Reference 5.42]).

7.3.1 Site Stratigraphy

A detailed stratigraphic nomenclature of the Paintbrush Group has, with improved understanding of the rock units, undergone a continuous evolution since inception of the project and because of this a variety of nomenclature has been used. The most widely used nomenclature has been that of Scott and Bonk (Reference 5.35), who based their scheme on extensive geologic mapping of Yucca Mountain and on the outcrop characteristics of the various units. Recent work by the USGS, based upon both surface and subsurface investigations, has modified the stratigraphy by raising the Paintbrush and Timber Mountain Tuffs to group status, assigning the tuff unit "X" to the Paintbrush Group, and raising the Topopah Spring tuff to formation status (Reference 5.4).

Based upon a correlation of porosities and densities, a further stratigraphic nomenclature has been developed to describe the volcanic rocks at Yucca Mountain grouping them into units exhibiting similar thermal and mechanical properties important in geotechnical design. These units have been defined by Ortiz et al., (Reference 5.20) and are presented as used in the USGS LYNX geology model YMP.R2.0 in Table 2 (Reference 5.56).

7.3.1.1 Lithostratigraphy

ESF geology borings have penetrated three volcanic groups. From oldest to youngest these are: the Crater Flat Group, the Paintbrush Group, and the Timber Mountain Group. The top several meters of the Calico Hills Formation of the Crater Flat Group were penetrated by ESF borings NRG-7/7A, SD-9, and SD-12 (References 5.53, 5.54, and 5.55). Five distinct ash-flow tuffs, separated by thin bedded tuffs, comprise the Paintbrush Group. In ascending stratigraphic order the ash-flow tuffs are: the Topopah Spring Tuff, the Pah Canyon Tuff, the Yucca Mountain Tuff, the Tiva Canyon Tuff, and the tuff unit "X". The

Rainier Mesa Tuff and Pre-Rainier Mesa bedded tuff constitute the Timber Mountain Group present along the ESF alignment. A brief description of the lithostratigraphic units is presented below in ascending stratigraphic order. For ease of description the intervening bedded tuffs are discussed separately.

CRATER FLAT GROUP

Prow Pass Tuff - The Prow Pass Tuff in the Yucca Mountain region consists of four ash-flow units with an underlying interval of bedded tuffs (Reference 5.18). The formation was not penetrated by any of the ESF geology borings.

Calico Hills Formation - The Calico Hills Formation has recently been described by Moyer and Geslin (Reference 5.18) in the Yucca Mountain region as consisting of rhyolite lava flows, ash-flow and -fall deposits, and volcaniclastic sandstone. The formation is divided into seven lithostratigraphic units, including five nonwelded ash-flow units overlying an interval of bedded ash-fall tuffs and a basal sandstone consisting of reworked ash-flow deposits.

PAINTBRUSH GROUP

Topopah Spring Tuff - The Topopah Spring Tuff is one of the most widespread and voluminous compound ash-flow cooling units in the southwestern Nevada volcanic field. Its thickness varies markedly over short distances reflecting emplacement on irregular terrain having at least several hundred feet of local relief. In general the Topopah Spring Tuff consists of a thick, densely welded crystallized center with relatively thin, non- to densely welded glassy top, bottom, and distal edges. The densely welded portion of the flow constitutes its thickest portion, while the non- to moderately welded zones are generally less than 15 m thick at the base of the unit and even thinner at the top (Reference 5.17). In NRG-7/7A the unit was measured to be approximately 370 m thick (References 5.31 and 5.53).

Based upon crystal content, the Topopah Spring Tuff is divided into two members: the lower crystal-poor and upper crystal-rich members. Within these members the presence of lithophysae and/or degree of vitrification are used to distinguish separate zones. Further divisions of the zones into distinct subzones are made based upon the percent and size of lithophysal cavities, crystal content, and/or the degree of welding or vitrification (References 5.43 through 5.55).

Table 2. Lithostratigraphic Units used in USGS Model YMP.R2.0 with corresponding Thermal/Mechanical Units

Lithostratigraphic Units used in USGS Model YMP.R2.0 with corresponding Thermal/Mechanical Units

Lithostratigraphic Units[1]	**Symbol[2]**	**Thermal/Mechanical Units**
Rainier Mesa Tuff	*Tmr*	*UO* *(Undifferentiated overburden)*
Pre-Rainier Mesa Tuff bedded tuff	*Tmbt1*	
Rhyolite of Comb Peak (Tuff Unit "X")	*Tpki*	
Pre-Tuff Unit "X" bedded tuff	*Tpbt5*	
Tiva Canyon Tuff, crystal-rich [3]	*Tpcrv*	
Tiva Canyon Tuff; undifferentiated, devitrified	**Tpcun**	**TCw (Tiva Canyon welded)**
Tiva Canyon Tuff; crystal-poor, vitric, nonwelded	**Tpcpv**	**PTn** **(Upper Paintbrush nonwelded)**
Pre-Tiva Canyon Tuff bedded tuff **Yucca Mountain Tuff**	*Tpbt4* **Tpy**	
Pre-Yucca Mountain Tuff bedded tuff	**Tpbt3**	
Pah Canyon Tuff	**Tpp**	
Pre-Pah Canyon Tuff bedded tuff **Topopah Spring Tuff; crystal-rich, vitric, non- to moderately welded**	*Tpbt2* **Tptrv**	
Topopah Spring Tuff; crystal-rich, devitrified, *nonlithophysal (includes densely welded subzone)*	**Tptrn**	**TSw1** **(Topopah Spring welded, lithophysae-rich)**
Topopah Spring Tuff; crystal-poor, upper lithophysal	**Tptpul**	
Topopah Spring Tuff, crystal-poor, middle nonlithophysal *Topopah Spring Tuff, crystal-poor, lower lithophysal* **Topopah Spring Tuff; crystal-poor, lower nonlithophysal**	*Tptpmn* *Tptpll* **Tptpln**	**TSw2** **(Topopah Spring welded, lithophysae-poor)**
Topopah Spring Tuff; crystal-poor, densely welded subzone	**Tptpv3**	**TSw3** **(Topopah Spring welded, vitrophyre)**
Topopah Spring Tuff; crystal-poor, vitric, non- to moderately welded	**Tptpv1&2**	**CHn** **(Lower Topopah Spring nonwelded and Calico Hills Tuff)**
Pre-Topopah Spring Tuff bedded tuff **Calico Hills Formation (includes bedded tuff at base)**	*Tpbt1* **Tac**	
Prow Pass Tuff (includes bedded tuff at base)	**Tcp**	

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[1] Only bold items modeled in USGS Geology Model YMP.R2.0; italicized items grouped with subjacent units.

[2] Symbols after Buesch and others (Reference 5.4) and Moyer and Geslin (Reference 5.18)

[3] "Crystal-poor" indicates less than 5% crystals; "Crystal-rich" indicates greater than 10% crystals

The crystal-poor member consists of a basal vitric zone overlain by a sequence of mixed non-lithophysal and lithophysal zones. In ascending order these are the lower non-lithophysal zone; the lower lithophysal zone, the middle non-lithophysal zone, and the upper lithophysal zone. The upper lithophysal zone includes the cavernous lithophysal subzone, characterized by rubbelized core and large (greater than about 10 cm) oblate lithophysae, commonly larger than the core diameter (References 5.52 through 5.55). Finally, the top portion of the unit contains the crystal-rich non-lithophysal zone and the crystal-rich vitric zone, which is largely non-lithophysal. The proposed repository horizon is contained within the crystal-poor lower non-lithophysal zone, the crystal-poor lower lithophysal zone, and the lower subzone of the crystal-poor middle nonlithophysal zone (referenced as T/M unit TSw2).

Pah Canyon and Yucca Mountain Tuffs - The Pah Canyon and Yucca Mountain Tuffs are both nonwelded ash flows that form a significant break in the otherwise moderately to densely welded Paintbrush Group. The Pah Canyon ranges in thickness from 0 to about 23 m, while the Yucca Mountain Tuff is from 0 to 16 meters in thickness (Reference 5.3). These tuffs are separated by the pre-Yucca Mountain bedded tuff.

Tiva Canyon Tuff - The Tiva Canyon Tuff is very similar to the Topopah Spring Tuff. Like the Topopah Spring Tuff the Tiva Canyon Tuff is a compound cooling unit and contains several recognized flow units. In compositional zoning the two tuff formations both have crystal-poor units forming the lower members and crystal-rich the upper. The volumes of the two formations are also similar, however the Tiva Canyon Tuff was spread over a larger area and shows less variations in thickness. The Tiva Canyon Tuff forms the vast majority of surface outcrops at Yucca Mountain (References 5.17).

The unit in its entirety was penetrated only by NRG-4 (Reference 5.28 and 5.50), however, the unit was logged only from cuttings, since core was not recovered over approximately the first 114 m of drilling. Based upon the SNL geology and rock structure log of NRG-4 (Reference 5.28) the unit where preserved in its entirety appears to be approximately 100 m thick. Review of the logs from NRG-2A (Reference 5.25 and 5.45) and NRG-3 (References 5.27 and 5.49), which penetrated the unit from the crystal-rich vitric zone to the crystal-poor lower lithophysal zone, and NRG-6 (References 5.30 and 5.52), which began in the crystal-poor lower lithophysal zone and continued through the base of the unit, indicates that with the exception of non- to moderately welded tuffs found at the base and top of the Tiva Canyon, the unit consists mostly of densely welded and devitrified tuffs.

Tuff Unit "X" - Tuff unit "X" is a nonwelded ash flow preserved locally in the hanging wall block of the Bow Ridge fault and buried beneath alluvium in Midway Valley (Reference 5.5). This unit as exposed in the North Portal Duct Bank is generally well lithified, nonwelded, non-bedded, and poorly sorted (Reference 5.1). The unit was cored in its entirety by NRG-2B (References 5.26 and 5.46) with a measured thickness of 22.9 m. It was exposed in the trench excavation for the North Portal Duct Bank and was examined by Angell (Reference 5.1).

TIMBER MOUNTAIN GROUP

Rainier Mesa Tuff - The Rainier Mesa Tuff, along with the underlying pre-Rainier Mesa bedded tuff are locally preserved within the hanging wall of the Bow Ridge fault. Field observations within the ESF show an approximate 100 m offset down to the west, juxtaposing a wedge of the Rainier Mesa Member and underlying bedded tuff against the Tiva Canyon lower lithophysal zone. Limited surface outcrops of this unit are found along the west side of Exile Hill. An upper lithified and a lower nonlithified (soil-like) zone are distinguished by their degree of cementation (Reference 5.1).

The nonlithified tuffs were first examined from boreholes NRG-2 and NRG-2B. Borehole NRG-2A was drilled through this zone, but was not cored over this interval (References 5.25 and 5.45). Most of the core in borehole NRG-2 (References 5.24 and 5.44) was lost from a depth of 13.0 to 42.2 m, which is the interval over which the nonlithified zone should have been recovered. Borehole NRG-2B (References 5.26 and 5.46) was drilled near NRG-2 and penetrated the entire nonlithified zone from a depth of 15.6 to 32.0 m with non- to partially lithified material continuing to 45.7 m. Most of the core was recovered in NRG-2B. In the SNL geology and rock structure log of NRG-2B (Reference 5.25) the material was identified as being soil-like and consisting of pale yellowish-brown to pinkish-white pyroclastic ash-flow deposits. Much of the recovered material was loose, unconsolidated silty sand. Three beds of paleosols were identified in the bedded tuff below the Rainier Mesa unit. Based on the Unified Soil Classification System, most of the recovered material was classified as silty sand with minor amounts of silty sand to well-graded sand and silty sand to poorly-graded sand. Standard penetration tests conducted in the borehole showed 120 and 107 blows per foot within the bedded tuff section of the nonlithified zone. Examination of borehole video logs (Reference 5.8) for Borehole UE25 NRG-2B showed a smooth, almost featureless bore, with some 45° joints and horizontal fractures with minor breakout. In the video log, the material appeared stable.

The nonlithified zone was further examined in trench NRT-1 (Reference 5.1), which was dug just south of borehole NRG-2A. Field observations showed that the nonlithified material was capable of supporting vertical walls with only some very minor wind erosion occurring.

Bedded Tuffs

Bedded tuffs are found separating all of the ash-flow units of the Paintbrush and Timber Mountain Groups. These tuffs are typically nonwelded and contain a variety of ash-flow and ash-fall deposits, with minor reworked tuffaceous sandstones. Five of these bedded tuffs are recognized within the Paintbrush Group, and an additional one is found at the base of the Rainier Mesa Tuff. By convention these units are assigned to the overlying major ash flow units, while alpha numeric unit designators are keyed to the group and assigned in sequential order from the base of the group upward. For example, the lowermost Paintbrush Group bedded tuff underlies the Topopah Spring Tuff and is named the pre-Topopah Spring Tuff bedded tuff and assigned the alphanumeric designator Tpbt1. The remainder of the units are, in ascending order, the pre-Pah Canyon Tuff bedded tuff (Tpbt2), the pre-Yucca Mountain Tuff bedded tuff (Tpbt3), the pre-Tiva Canyon Tuff bedded tuff (Tpbt4), the pre-tuff unit "X" bedded tuff (Tpbt5), and within the Timber Mountain Group, the pre-Rainier Mesa Tuff bedded tuff (Tmbt1) (Reference 5.4).

Weakly-developed paleosol horizons are found in some areas, and a variety of ash-flow, ash fall, and reworked subunits are observed to vary considerably over short lateral distances. Detailed descriptions of the nonlithified pre-tuff Unit "X" bedded tuff and pre-Rainier Mesa Tuff bedded tuff are given by Angell (Reference 5.1). Further detailed research for these units on an area-wide basis is provided by Diehl and Chornack (Reference 5.7).

7.3.1.2 Thermal/Mechanical Stratigraphy

The T/M stratigraphy used in ESF and Repository design at Yucca Mountain strives to group the volcanic rocks (i.e., lithostratigraphic units) into a functional stratigraphy based on similarities in thermal and mechanical properties of the rock. The first attempt to define a functional stratigraphy based upon rock properties was proposed by Lappin, et al., (Reference 5.17), who based his work on bulk and thermal properties measured on tuff samples from drillhole USW G-1. Ortiz, et al., (Reference 5.20) developed a thermal/mechanical and hydrological reference stratigraphy for use in performance assessment and repository design studies involving material properties data. Ortiz, et al. define a stratigraphy, consisting of 16 units, based upon the correlation of porosity and grain density to thermal, mechanical, and hydrologic properties. Currently these units are defined based on thermal and mechanical properties only, while unit definitions based on hydrologic properties follow a different nomenclature.

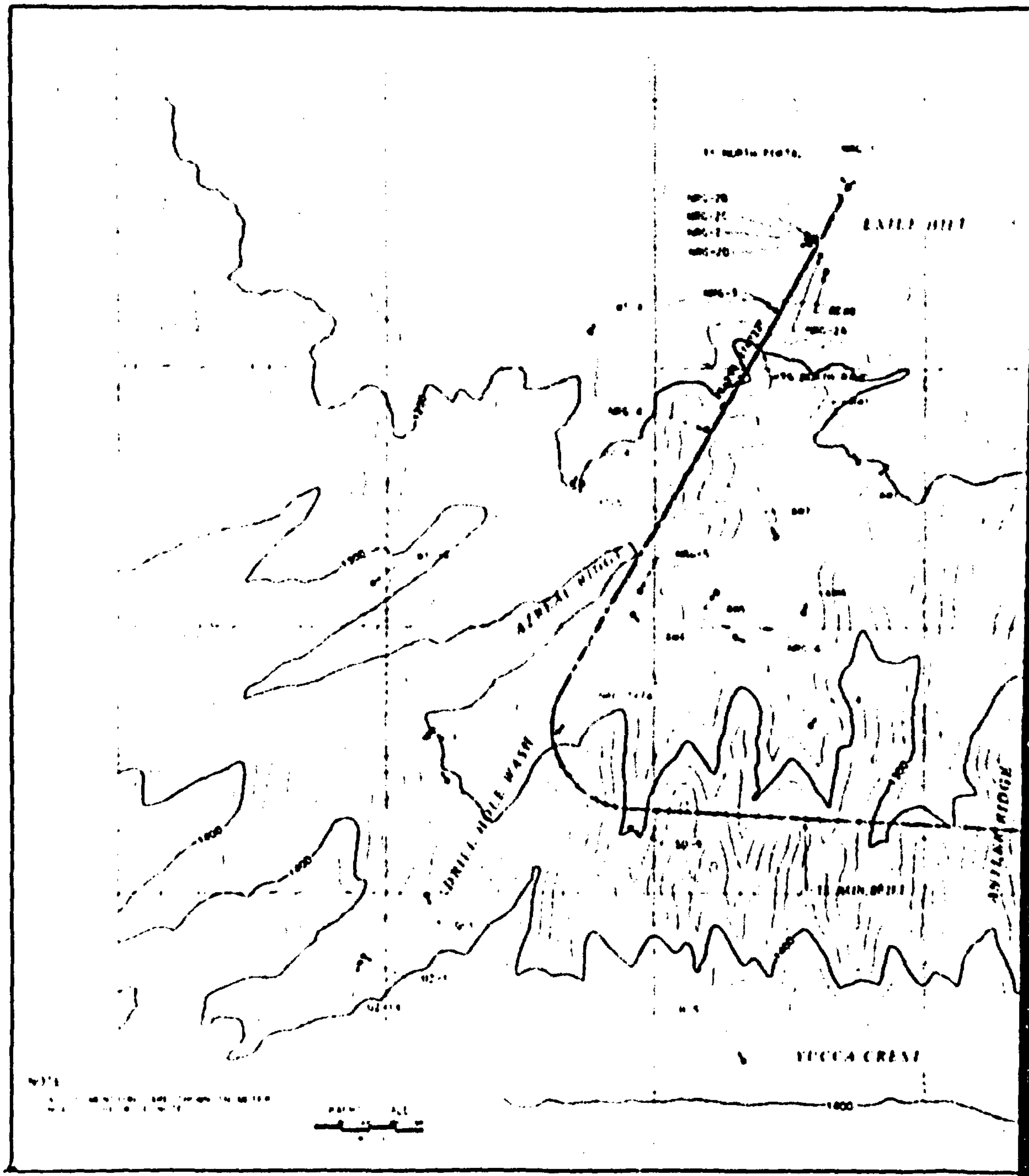
The thermal/mechanical stratigraphy as currently defined at Yucca Mountain consists in descending order of the following units:

- UO (undifferentiated overburden)
- TCw (Tiva Canyon welded)
- PTn (Upper Paintbrush nonwelded)
- TSw1 (Topopah Spring welded, lithophysae-rich)
- TSw2 (Topopah Spring welded, lithophysae-poor)
- TSw3 (Topopah Spring welded, vitrophyre)
- CHn (Lower Topopah Spring nonwelded and Calico Hills Tuff).

Both porosity and grain density are primarily a function of the degree of welding. The porosity of the T/M units decreases with increased degree of welding from non- to densely-welded tuffs. Within the welded units, the variable which most affects the thermal-mechanical properties is the percent of lithophysal cavities and the effect this has on total porosity values. The degree of welding present within the rocks of the Paintbrush and Timber Mountain Groups ranges from nonwelded bedded tuffs that can be crumbled by hand to densely welded ash-flow tuffs and vitrophyres. The percent of lithophysal cavities is described as either lithophysal-poor (less than 10%) or lithophysal-rich (greater than 10%).

As the degree of welding and the percent of lithophysal cavities vary vertically within an ash-flow unit, T/M unit boundaries reflect the boundaries between these zones. Since the T/M stratigraphy generally groups several lithostratigraphic units into a single T/M unit, the unit boundaries are generally correlatable to a lithostratigraphic boundary. However, because the TM units are based on thermal and mechanical properties of the rock, the units do not necessarily correlate to formational boundaries. For instance, the Upper Paintbrush nonwelded T/M unit (PTn) was created to group the nonwelded ash-flows of the Yucca Mountain and Pah Canyon Tuffs and nonwelded portions of the Topopah Spring and Tiva Canyon Tuffs, thus crossing formational boundaries. The T/M units are correlated with equivalent lithostratigraphic units in Table 2.

On-going ESF and repository design efforts are based on T/M units. The NRG- and SD-series boreholes penetrated seven of the T/M units from the UO (undifferentiated overburden) through the CHn (Calico Hills and lower Topopah Spring nonwelded) as presented in Table 2. The proposed repository host rock is identified as T/M unit TSw2 (Topopah Spring welded, lithophysae-poor). The ESF excavation will penetrate five of these units from the UO through the TSw2.


EXILE HILL
AZREAL RIDGE
DRILL HOLE WASH
ANTLER RIDGE
YUCCA CREST
1800

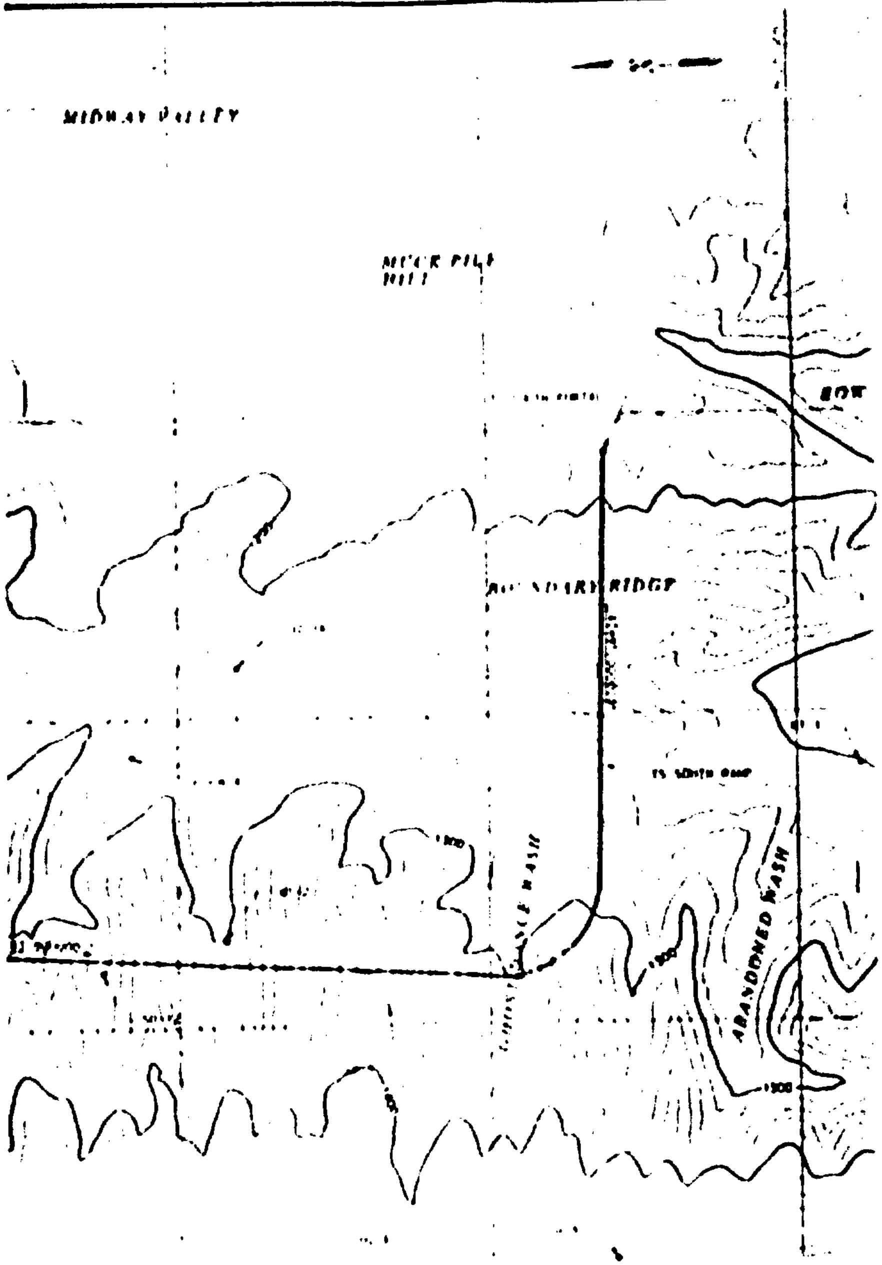


FIGURE 1
TOPOGRAPHIC MAP OF THE ESF

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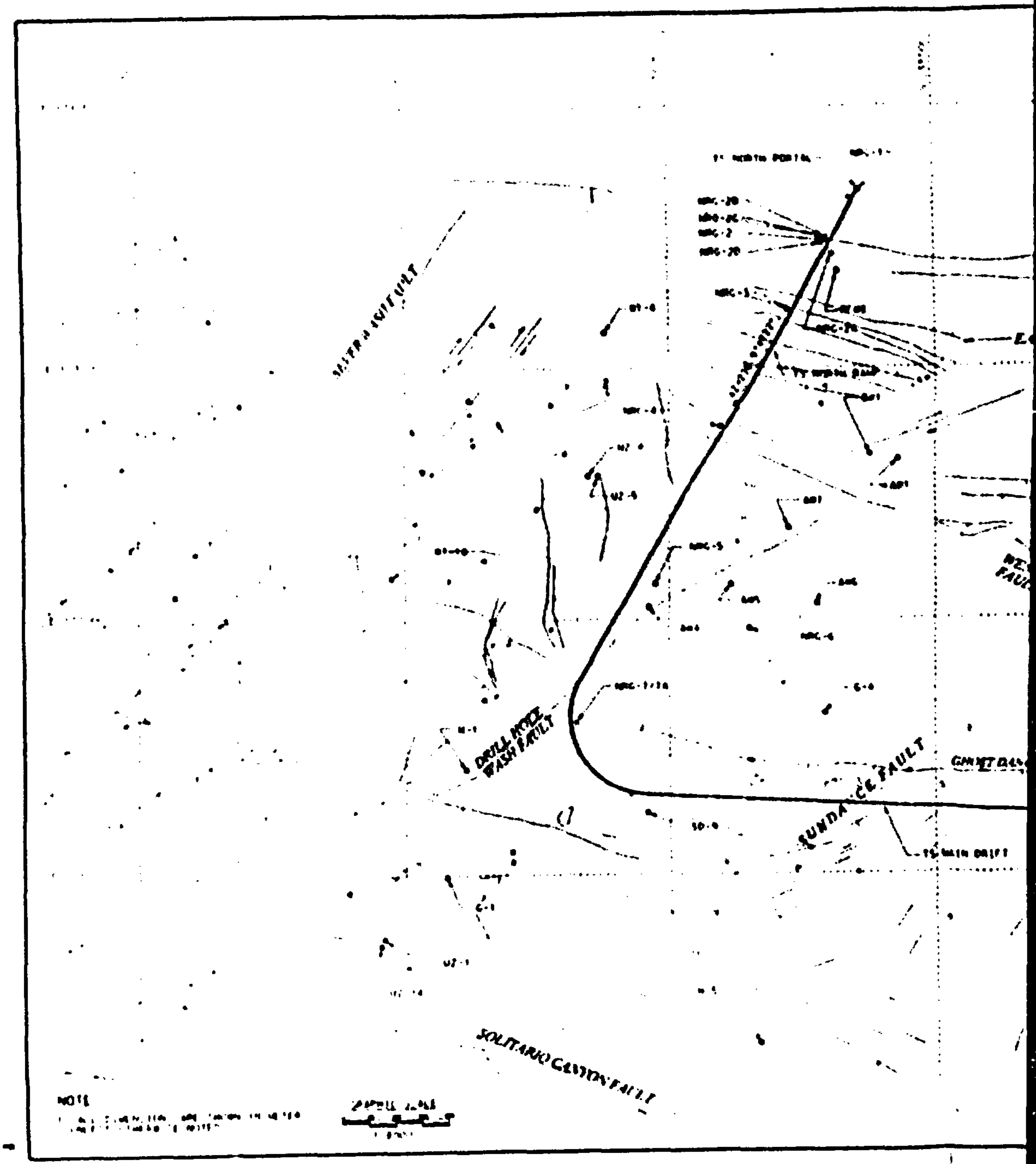
Also Available on Aperture Card

Ti

DO


TS NORTH PORTAL
NRG-5
NRG-6
UZ-6
UZ-5
DRILL HOLE WASH FAULT
GHOST DAN
SUNDANCE FAULT
TS MAIN DRIFT
G-1
UZ-1
SOLITARIO CANYON FAULT
NOTE
GRAPHIC SCALE

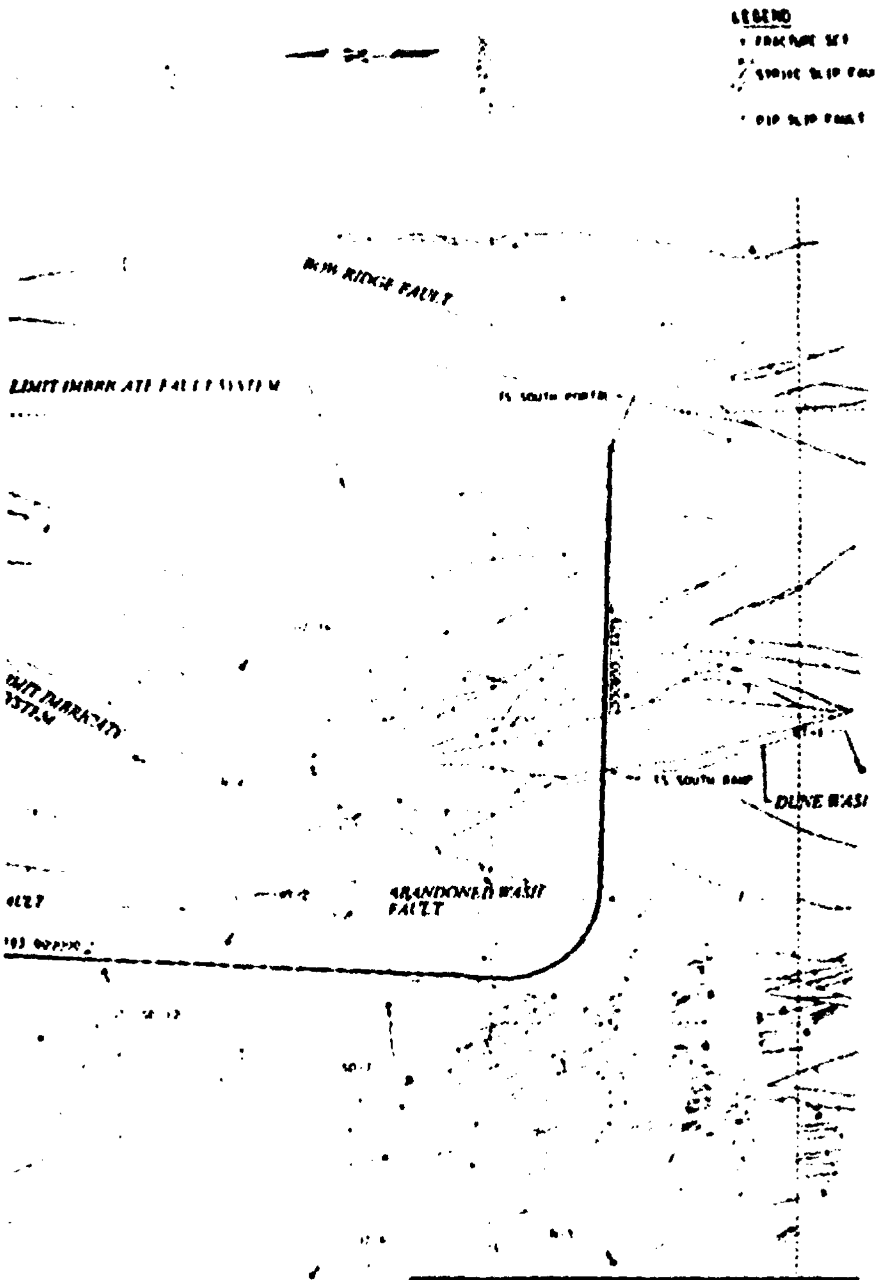


FIGURE 2
GEOLOGIC STRUCTURE MAP OF THE E
(SCOTT & BONK, 1984, REFERENCE 5.25)

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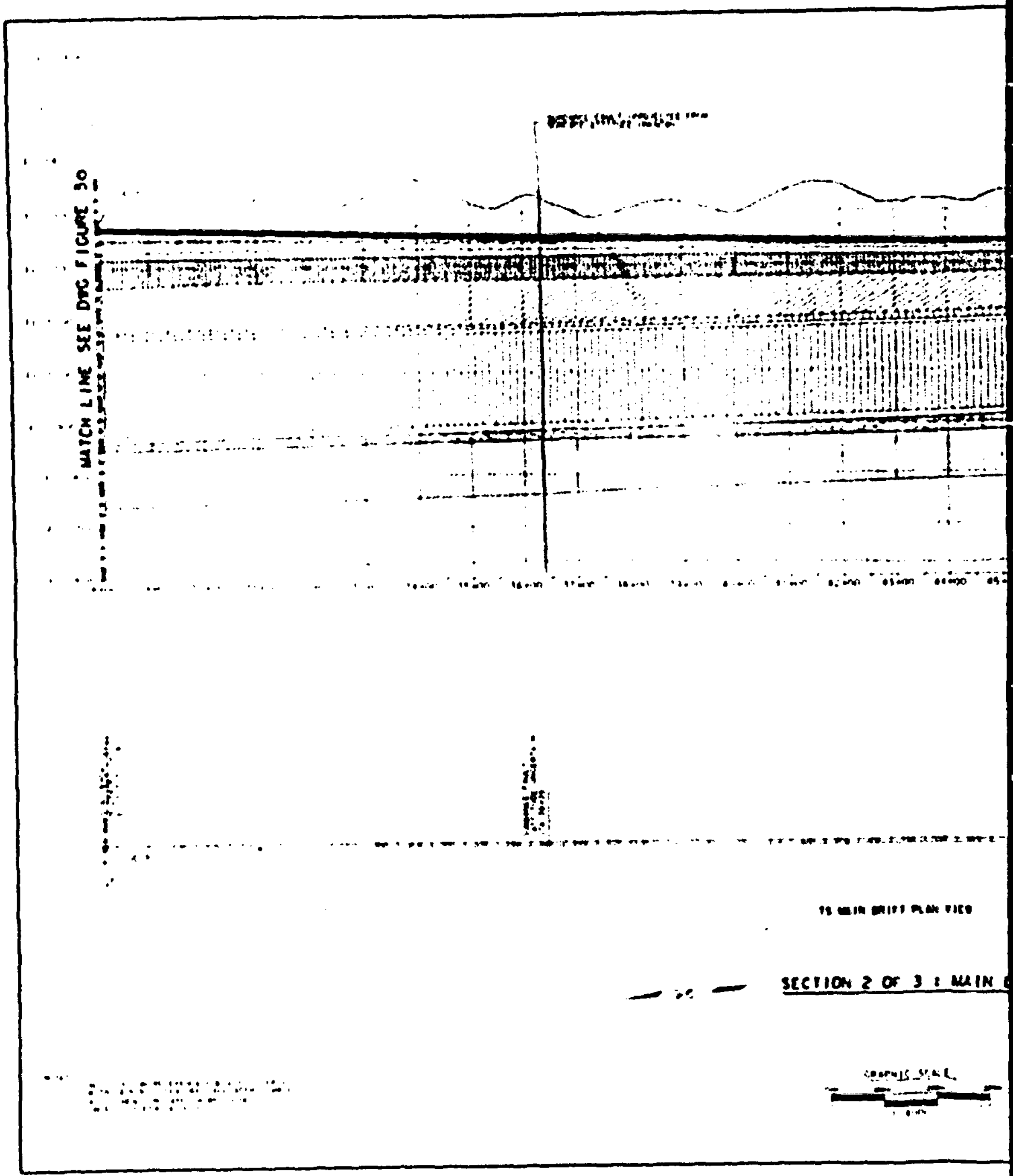
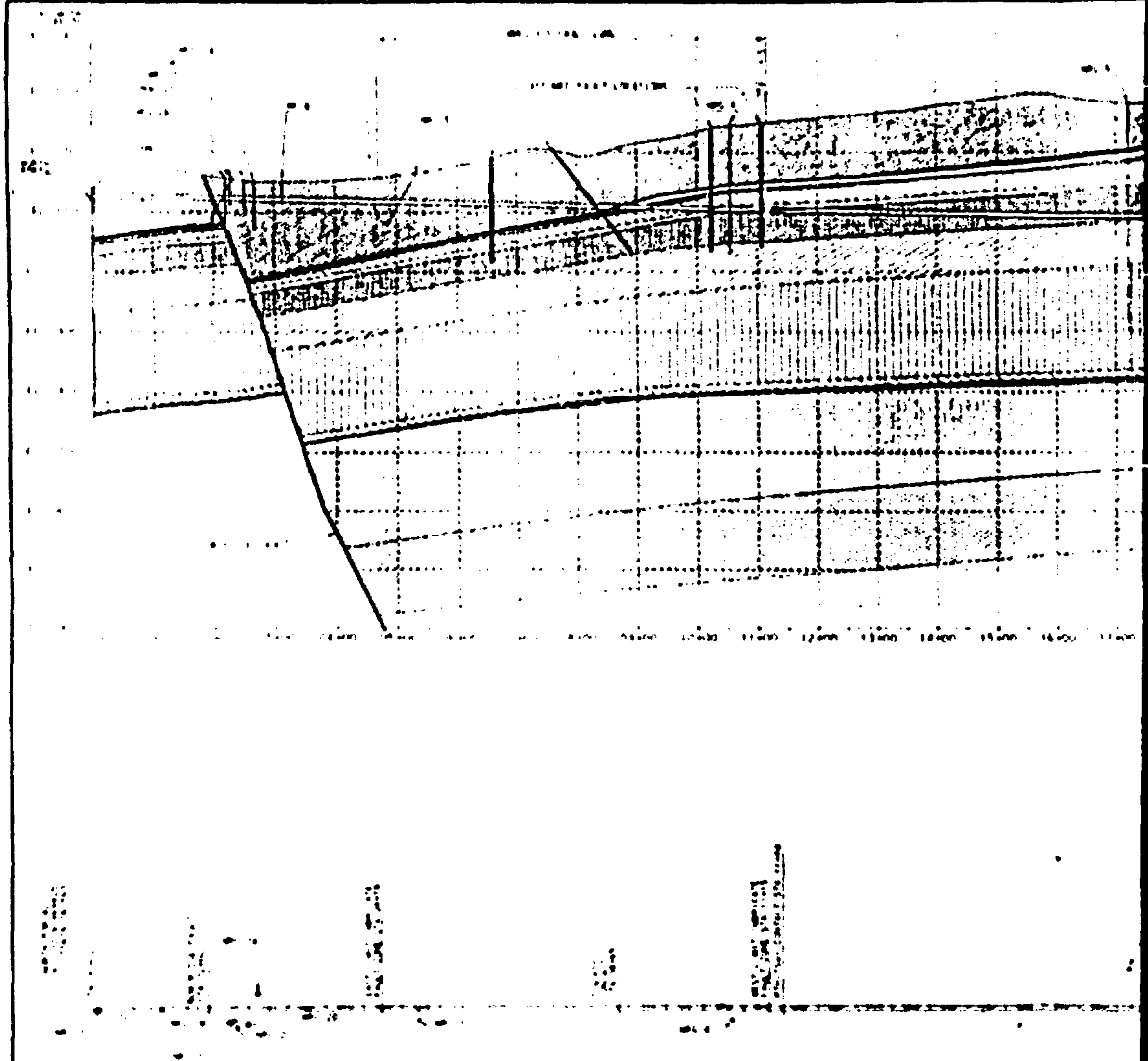


SECTION 2 OF 3 : MAIN



SECTION 1 OF 3 :TS NORTH RAMP

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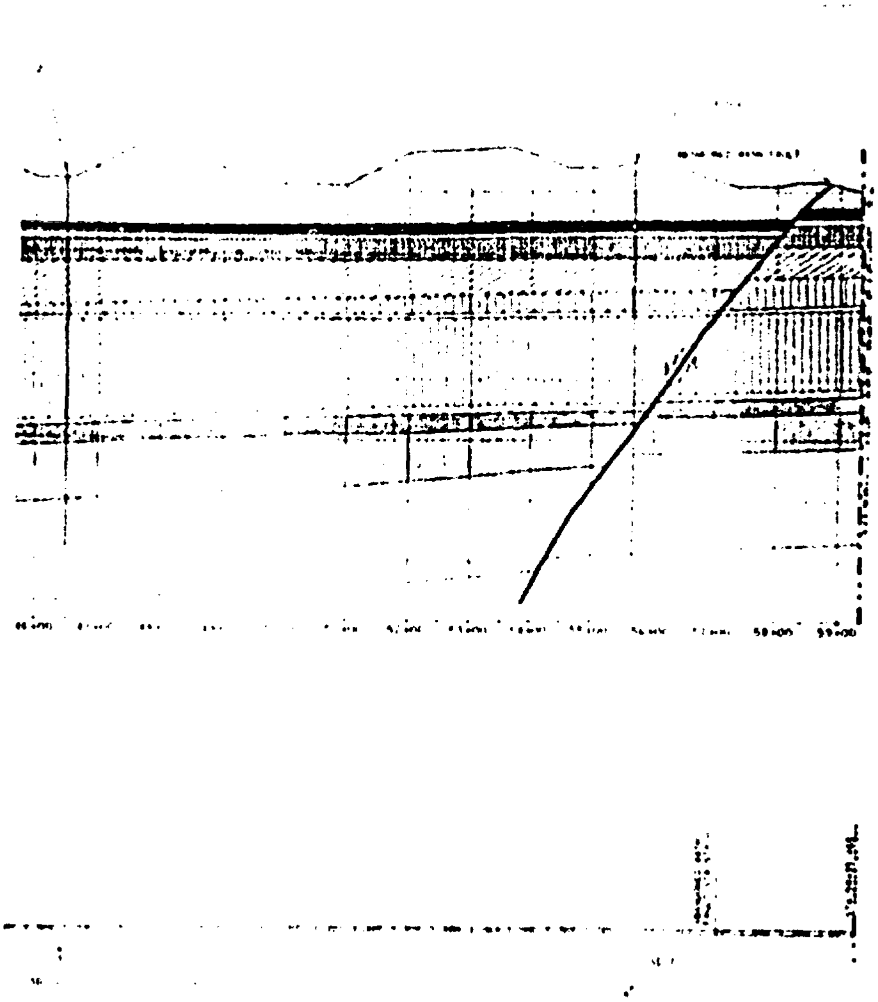

FIGURE 3D
GEOLOGIC CROSS SECTION OF THE
[illegible]

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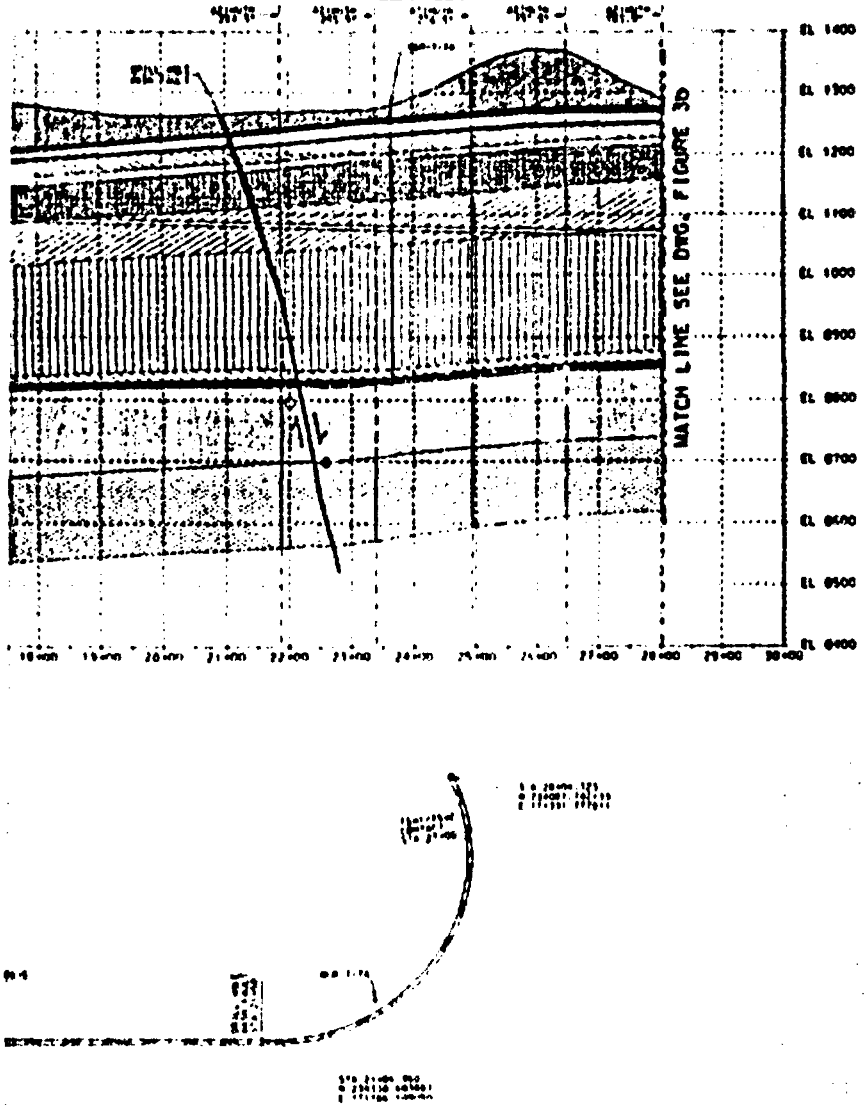

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FIGURE 3a
GEOLOGIC CROSS SECTION OF THE E

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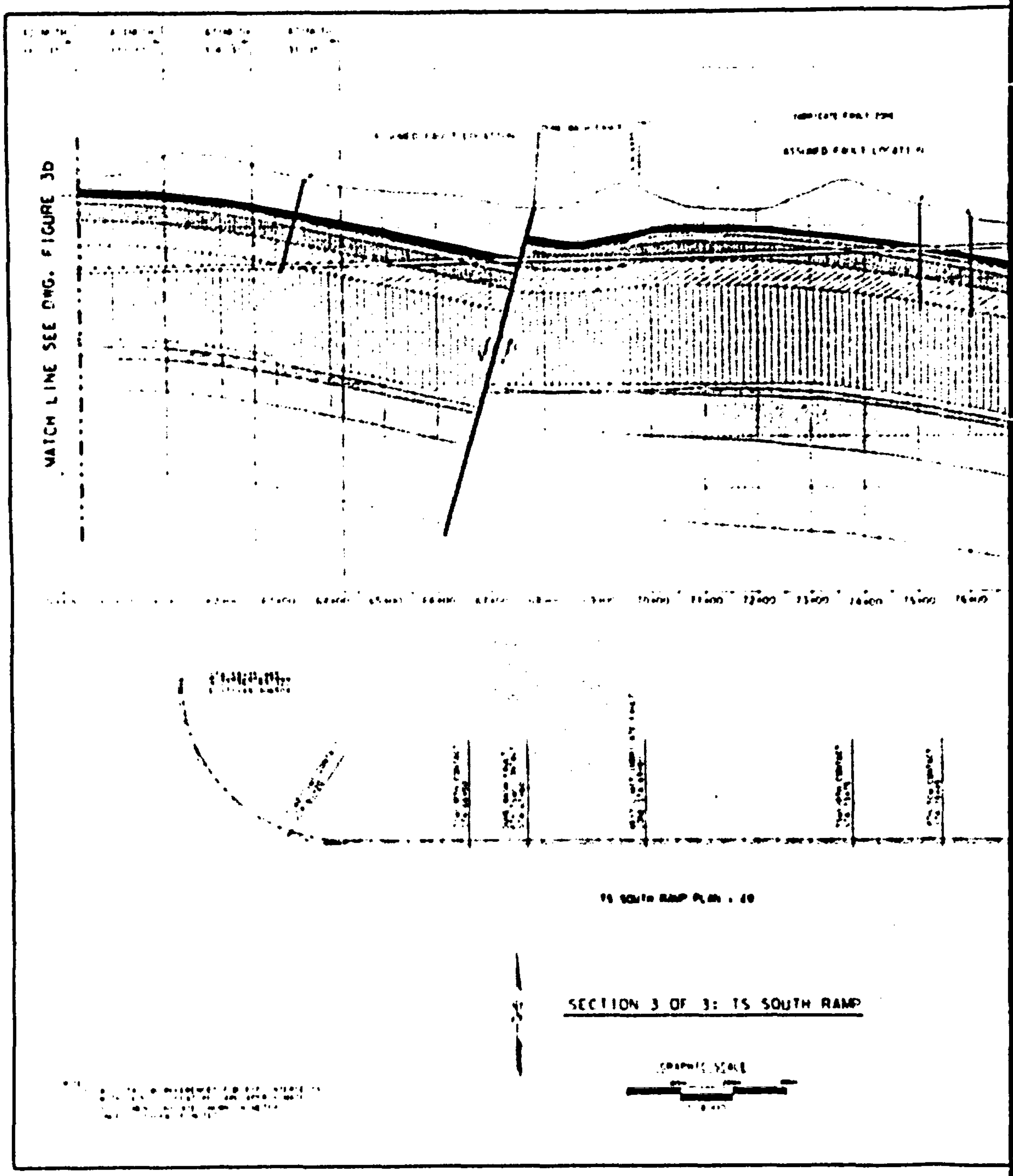


SECTION 3 OF 3: TS SOUTH RAMP

Title: GEOLOGY OF THE EXPLORATORY
STUDIES FACILITY TS LOOP

DOCUMENT IDENTIFIER BAB000000-01717-0002-00002 Rev 00C **Page:**

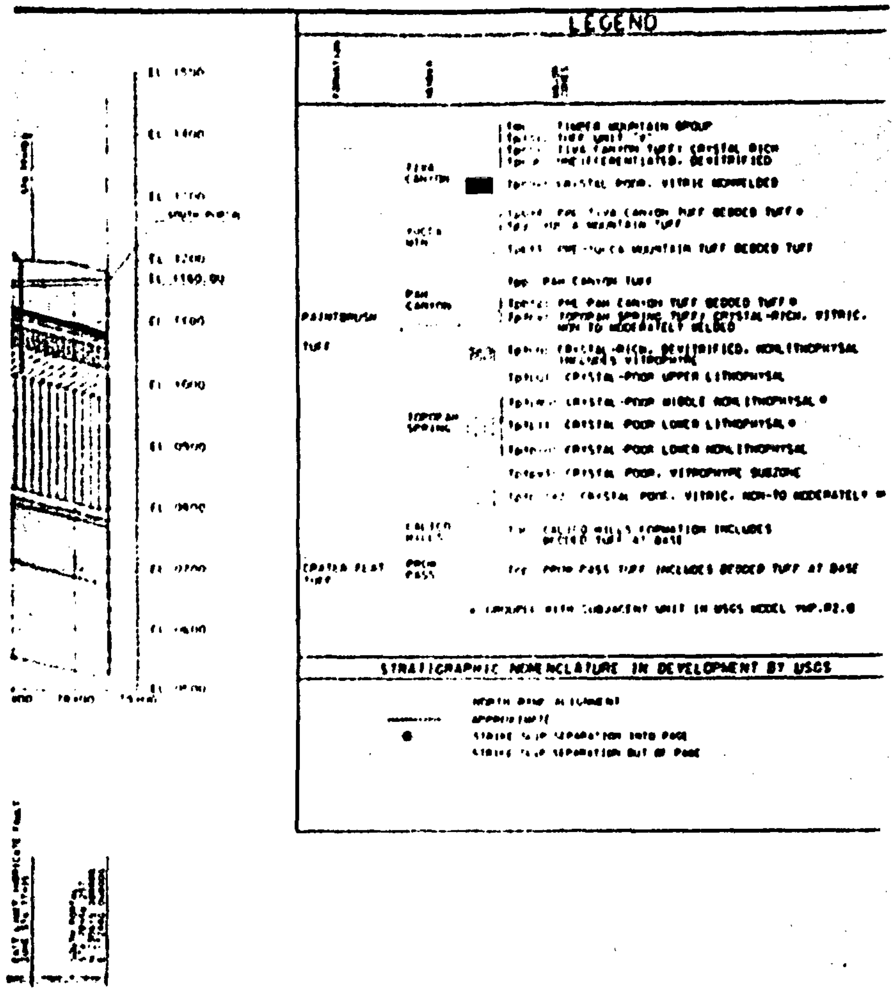


FIGURE 3c
GEOLOGIC CROSS SECTION OF THE
[illegible] GEOLOGY MODEL, YMP.02.0, REFERENCE

9506140156-05

Imbricate Fault System

A system of north to northwest trending imbricate faults consisting of numerous steep, west-dipping, closely spaced, normal faults with typically less than 3 m of offset is expected to be encountered by both the TS North and South Ramps (Figure 2). Scott and Bonk (Reference 5.35) show at least eight faults belonging to this system along the TS North Ramp and nine along the TS South Ramp. However, it should be noted that faulting in this area, which has been described by Scott (Reference 5.59) as consisting of swarms of normal faults, is probably much more pervasive then can be accurately measured or depicted. Along the TS North Ramp the system attains an approximate width of 650 m with the first associated faults encountered west of the Bow Ridge fault. Along the TS South Ramp the system should be encountered east of the Dune Wash fault and may continue to near the South Portal for a total width of approximately 750 m (Reference 5.35). The cross sections (Figures 3a and 3c) show several of these relatively minor faults. In addition to those shown, several more may be anticipated along the alignments.

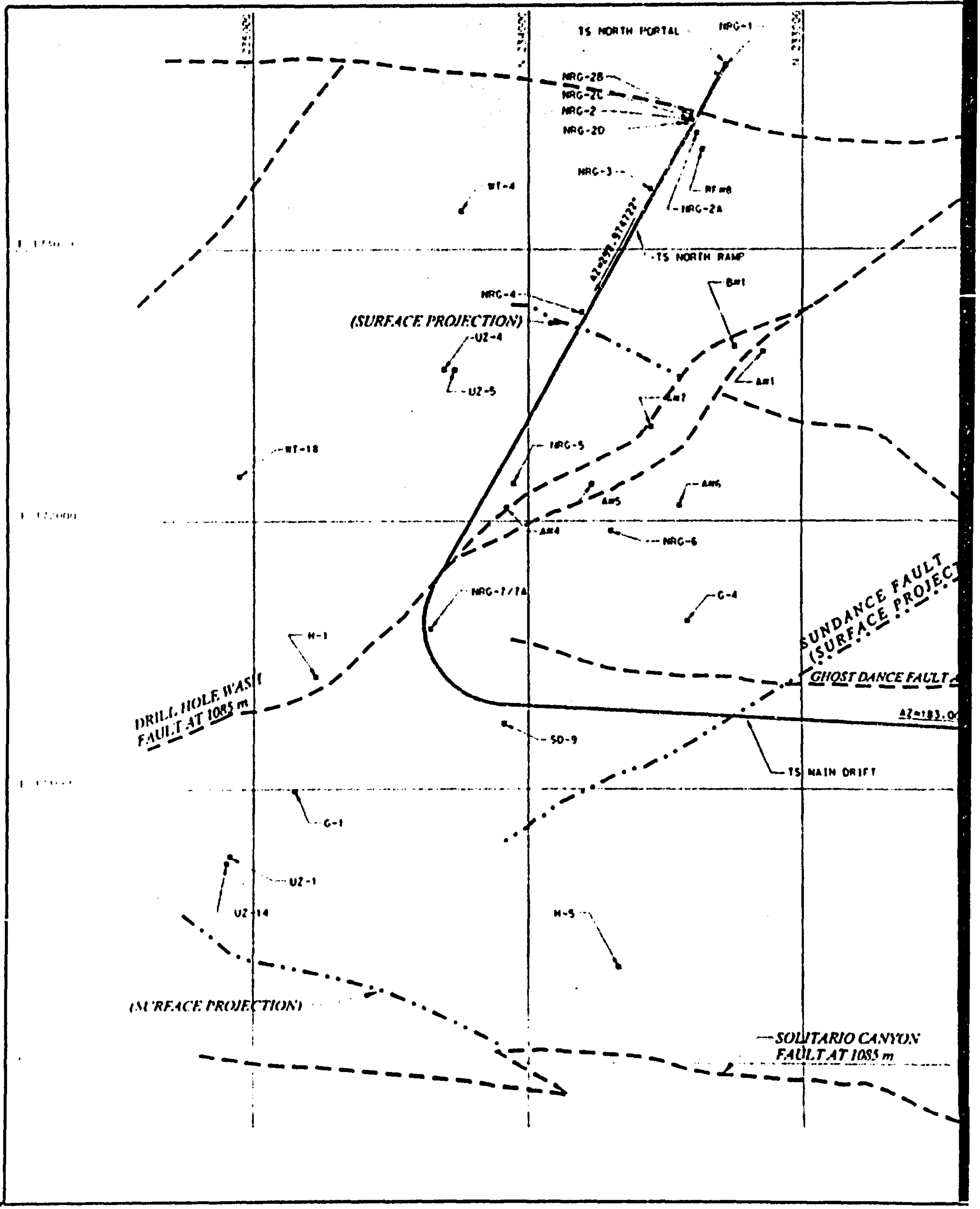
Drill Hole Wash Fault

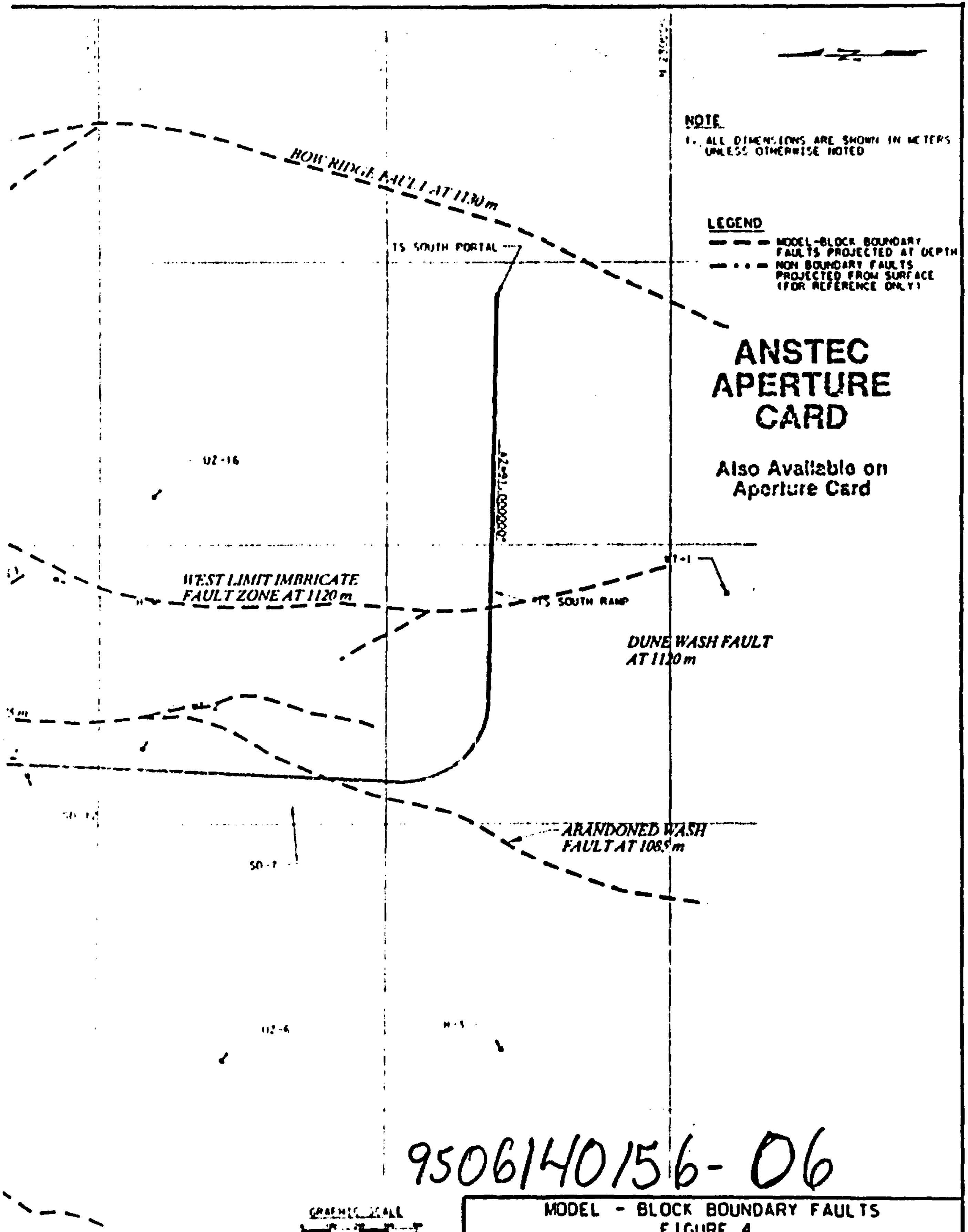
The Drill Hole Wash fault was first recognized by Scott and Bonk (Reference 5.35) as a right-lateral fault structure defined by the prominent topographic expression of Drill Hole Wash (Figure 3a). The fault has an apparent vertical offset of approximately 3 m (Reference 5.56).

Most of the interpretations of the Drill Hole Wash fault are inferred from investigations of the boreholes in the area. It appears that the Drill Hole Wash fault is actually associated with a complex system of interfingering faults with complex geometry and movement history. Boreholes UE25A-4, -5, and -7, which were drilled within the wash, appear to lie within a block bounded by two faults. Projected vertical offsets range from 6 to 23 m, but offsets appear to be different for each of the major lithostratigraphic units, suggesting a complex motion and history to the system (Reference 5.9). Recent vertical seismic profile surveys in USW NRG-6 (Daley and Majer, 1994) (Reference 5.6), which is on the southern edge of Drill Hole Wash, imply multiple fracture sets oriented in a north-northwest to north direction. This suggests that there may be many fault planes and brecciated zones encountered when excavating through the Drill Hole Wash fault system. Based on projections, the system may be as wide as 180 m, but since the TS North Ramp is crossing the structure at an acute angle, the structure may be encountered over a distance of up to 700 m from Station 17+00 to 24+00 m (Reference 5.9).

Ghost Dance Fault

Although the Ghost Dance fault is not anticipated to be encountered during ESF excavation it is a major fault in the area and warrants further discussion. The fault will, however, be investigated through two currently planned exploration drifts. The Ghost Dance fault is actually a system of numerous north-trending,


TS NORTH PORTAL
NRG-1
NRG-2B
NRG-2C
NRG-2
NRG-2D
NRG-3
RF#8
NRG-2A
WT-4
AZ=209.974722°
TS NORTH RAMP
B#1
NRG-4
(SURFACE PROJECTION)
UZ-4
UZ-5
A#1
A#2
NRG-5
WT-18
A#6
A#5
A#4
NRG-6
NRG-7/7A
G-4
SUNDANCE FAULT
(SURFACE PROJECT
H-1
GHOST DANCE FAULT A
DRILL HOLE WASH
FAULT AT 1085 m
AZ=183.0
SD-9
TS MAIN DRIFT
G-1
UZ-1
UZ-14
H-5
(SURFACE PROJECTION)
SOLITARIO CANYON
FAULT AT 1085 m



NOTE
1. ALL DIMENSIONS ARE SHOWN IN METERS UNLESS OTHERWISE NOTED

LEGEND
▬ ▬ ▬ MODEL-BLOCK BOUNDARY FAULTS PROJECTED AT DEPTH
▬ • • ▬ NON BOUNDARY FAULTS PROJECTED FROM SURFACE (FOR REFERENCE ONLY)

9506140156-06

GRAPHIC SCALE
1:8000

MODEL - BLOCK BOUNDARY FAULTS
FIGURE 4

through-going structures which attains a width of at least 213 m (Reference 5.38) and may extend to a width of nearly 366 m (Reference 5.39). The dominant structural feature for which the system is named maintains a position near the middle of the system. Near the southern edge of the repository area the Ghost Dance offsets the volcanic strata by about 30 m with this displacement decreasing towards the north (Reference 5.38). The fault system appears to terminate to the north on the south flank of Diabolus Ridge, just south of Drill Hole Wash (Reference 5.35). Good outcrops on the north flank of the ridge indicate that the Ghost Dance fault does not extend northwards to Drill Hole Wash (Reference 5.38). To the south, the Ghost Dance fault trends toward a complex zone of north- to northwest-trending faults and fault segments, primary of which is the Abandoned Wash fault (Reference 5.19).

Sundance Fault

Spengler, et al., (Reference 5.39) reported a newly recognized shear zone at Yucca Mountain consisting of nearly vertical N30°-40°W-trending strike-slip faults (Figure 3b). The zone is considered to be at least 274 m wide and was revealed during detailed mapping (1:240 scale) within the potential repository. The shear zone has been named the Sundance fault system and the dominant structure occurring near the middle of the zone the Sundance fault. The primary structure should intersect the TS Main Drift near Station 36+35 (Figure 3b) at an acute angle of approximately 30° (Figure 2). Since this structure is anticipated to intersect the ESF at an angle, minor faults associated with the system may occur as much as 240 m or more to either side of this station.

Abandoned Wash Fault

The Abandoned Wash fault is actually a system of many north-northwest striking, steeply west-dipping fractures and faults (Figure 3b) (Reference 5.42). Dips of beds steepen progressively eastward towards the Abandoned Wash fault system and are commonly between 20° and 40° E. Locally dips of beds may reach as much as 70° E. The system trends to the north toward the Ghost Dance fault (Reference 5.42). The USGS geology model, YMP.R2.0, indicates that the Abandoned Wash fault should be encountered by the excavation towards the south end of the TS Main Drift (near Station 57+08), however, smaller associated faults of the system may be encountered before this.

Dune Wash Fault

The Dune Wash fault, the next major structure anticipated to be encountered by the ESF (Figure 3c), is largely concealed on the surface. The structure was originally identified by Scott and Bonk (Reference 5.35) from a series of small north trending faults. Examination of available data, including aerial photography, indicates that the structure extends from the west side of Dune Wash in the south along the west side of Boundary Ridge, and then cuts across the low mountain spurs directly north of Boundary Ridge (Reference 5.19). The Dune Wash fault is a steeply dipping, westward plunging fault with an anticipated vertical offset along the TS South Ramp alignment between 7.6 to 27.4 m (Reference 5.56). The ESF should intersect the fault near station 67+58.

7.4 ESF GEOLOGIC MODEL AND CROSS SECTIONS

The USGS LYNX preliminary geology model YMP.R2.0 was used for this design analysis (Reference 5.5). YMP.R2.0 is the latest release in the USGS LYNX model series for the Yucca Mountain Project. The model has been updated from the previous release to include data from drill holes NRG-7/7A, SD-9, and SD-12 and is considered at the present to be the most complete model available.

The model was constructed based upon the revised lithostratigraphic nomenclature developed by the USGS (Reference 5.4 and Reference 5.18). Thirteen units were modeled and represent either individual lithostratigraphic units or combinations of two or more lithostratigraphic units (Table 2). For example, the unit described as "Tiva Canyon Tuff; undifferentiated, devitrified" includes the crystal-rich Tiva Canyon Tuff, Tuff Unit "X", and the Timber Mountain Tuff (T/M units TCw and UO). For modeling purposes the USGS LYNX geology model, YMP.R2.0, was constructed in a series of several blocks separated by major faults. These model-block boundary faults are presented in Figure 4 (Reference 5.56). It should be noted that the modeling effort is an ongoing process with updates undertaken as warranted by the availability of pertinent data.

The model is constructed based upon both surface and subsurface investigations. Subsurface control is provided by borings drilled in the ESF vicinity, as shown in Figures 1 and 2. The area with the highest density of subsurface control is the TS North Ramp, where the majority of the borings have been drilled. The TS Main Drift is controlled in the model by three borings, USW WT-2, SD-9 and SD-12. Geologic data from SD-7 was not available for the current model release. The nearest boring providing subsurface geologic control to the TS South is USW WT-1, which is approximately 830 m south of the ramp.

7.4.1 Model Cross Sections

Cross sections along the ESF centerline (including the north ramp, main drift and south ramp) were cut through the USGS LYNX model. The TS North and South Ramp curves were approximated by a series of smaller cross sections. YMP.R2.0 was constructed using English units of measurement. To convert the ESF cross sections to metric a conversion factor of 0.30480061 meter/foot was applied to all coordinates (northings, eastings, and elevations). The converted cross sections were imported and stored in a separate LYNX project (YMP.R2.M). These cross sections were then modeled to form a three-dimensional LYNX volume model extending 25 m (82 feet) on either side of the centerline. The cross sections are presented in Figures 3a, 3b, and 3c. A subsurface engineering model of the ESF was developed and intersected with the geology model. The engineering model of the ESF was developed in accordance with the TS Main Drift Layout Calculation (Reference 5.15). In addition to producing the cross sections along the ESF alignment, the model was further used to estimate distances to the expected intersection of the ESF with T/M unit contacts (Table 3).

Within LYNX, the metric version of the USGS geology model along the ESF alignment is identified as G.ESF and the engineering model as M.ESF. Both are stored in LYNX project YMP.R2.M.

7.4.2 Model Analysis

Using the LYNX volume model, YMP.R2.M, distances were estimated for the various T/M units and geologic structures encountered by the ESF. The station distances are summarized in Table 3 and shown in Figures 3a through 3c. Distances were measured directly from the model along the ESF centerline using interactive LYNX capabilities.

The planned ESF excavation begins in the TCw, with the TBM excavation beginning at Station 00+60. The Bow Ridge fault, near Station 02+00, was the first major geologic structure to be encountered by the ESF excavation. The ESF will remain in the TCw until the PTn contact unit near Station 08+65. While still in the TCw, west of the Bow Ridge fault, the first faults associated with the Imbricate fault system should be encountered. These faults will continue in the PTn until approximately Station 11+15. The ESF should stay in the PTn over the next 275 m until the TSw1 near Station 11+40. The TSw1 will be present over a distance of about 1,560 m. It is projected that the Drill Hole Wash system will be encountered by the ESF within this unit between Stations 17+00 to 24+00. The primary structure should be encountered near Station 21+50. Near Station 27+00 the ESF should enter TSw2. The ESF is designed to remain within TSw2 throughout the TS Main Drift and not reenter TSw1 until near TS South Ramp Station 63+20. While in TSw2 the Sundance fault will be encountered by the TS Main Drift near Station 36+35 and the Abandoned Wash fault near Station 57+08. Since the Sundance fault system has been estimated to be at least 274 m wide, faults of the system may be encountered much sooner, as is similarly possible with faults associated with the Abandoned Wash fault system. The ESF will reenter TSw1 near Station 63+20 and will remain for approximately 330 m until again encountering the PTn (Station 66+50). The ESF should remain in the PTn for approximately 110 m until again entering TSw1 on the up-faulted side of the Dune Wash fault (Station 67+60). The ESF will remain in TSw1 for approximately 615 m until again reentering the PTn near Station 73+75. Faults of the Imbricate fault system should first be encountered near Station 69+80 and continue to be encountered throughout the TSw1 and subsequent units until approximately Station 77+35. The final material excavated in the ESF will be TCw (Station 75+45) over an estimated distance of 310 m until the South Portal.

Table 3. Projected ESF Station Coordinates for Stratigraphic Contacts and Faults

Projected ESF Station Coordinates for Stratigraphic Contacts and Faults

T/M Unit Contacts and Major Faults	Station Number	T/M Units	T/M Unit Interval (m)
North Portal	0+00		
Bow Ridge Fault	02+00	UO/TCw	865
East Limit Imbricate Fault System (TS North Ramp)	04+70		
TCw with/ PTn Contact	08+65	PTn	275
West Limit Imbricate Fault System (TS North Ramp)	11+15		
PTn / TSw1 Contact	11+40	TSw1	1,560
Drill Hole Wash Fault	21+50		
TSw1 / TSw2 Contact	27+00	TSw2	3,620
Sundance Fault	36+35		
Abandoned Wash Fault	57+10		
TSw2 / TSw1 Contact	63+20	TSw1	330
TSw1 / PTn Contact	66+50	PTn	110
Dune Wash Fault	67+60		
PTn / TSw1 Contact	67+60	TSw1	615
West Limit Imbricate Fault System (TS South Ramp)	69+80		
TSw1 / PTn Contact	73+75	PTn	170
PTn / TCw Contact	75+45	TCw/UO	310
East Limit Imbricate Fault System (TS South Ramp)	77+35		
South Portal	78+56.257		

Notes: Station Numbers and T/M unit Intervals are approximations based upon LYNX project YMP.R2.M (Reference 5.56). The projected ESF intersect with the Bow Ridge fault agrees with field observation taken in the ESF.

7.5 ROCK MECHANICAL PROPERTIES

The following section summarizes site geotechnical data acquired from samples collected from NRG-series geology boreholes. Laboratory testing of samples and subsequent data reduction of analytical results was performed by SNL. Additional information and reference can be found in Brechtel, et al. (Reference 5.3).

The data was used to determine the rock mass rating (RMR) used in opening stability and ground support analysis. RMRs are derived from the intact properties determined by the analysis of samples collected from NRG-series geology boreholes. Samples for these analysis were collected from NRG-2, -2A, -3, -4, -5, -6, -7/7A.

Rock mechanics laboratory test data from NRG borehole samples compiled in this summary report include:

- Unconfined compressive strength (UCS) in MPa
- Elastic modulus in GPa
- Poisson's ratio
- Ultimate tensile strength (UTS) in MPa
- Dry bulk density (DBD) in g/cc.

A summary of sample intact property test results is presented in Table 4 (Reference 5.22), while a complete listing of sample intact property test results is given in Attachments I through III.

Data for porosity and average grain density are also available, but were not used in this analysis and are therefore not included in this report. The laboratory test data were combined and analyzed according to T/M units. Samples were selected throughout the length of the NRG boreholes where available and not limited by either core condition or core loss. Uniaxial compression and Brazilian tensile tests of core strength were preformed on intact 50.8 mm diameter samples, while confined compression tests were preformed on intact 25.4 mm samples. All strength test samples were first saturated at 10 MPa for a one hour minimum, followed by two vacuum saturation cycles. All samples were tested at 100% saturation to avoid variability associated with partial saturation.

Table 4. Summary of Intact Sample Test Results

Summary of Intact Sample Test Results

T/M Units		UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio	UTS (MPa)	DBD (g/cc)
TCw	Mean:	156.9	28.4	0.20	8.9	2.150
	Stan. Dev.:	120.7	10.4	0.03	3.6	0.226
PTn	Mean	8.3	2.3	0.20	0.8	1.299
	Stan. Dev.:	11.7	3.0	0.10	1.4	0.225
TSw1	Mean:	73.9	20.1	0.24	[illegible]	2.162
	Stan. Dev.:	43.6	6.6	0.08	2.3	0.077
TSw2	Mean	184.7	32.4	0.21	8.7	2.274
	Stan. Dev.:	76.7	6.5	0.05	3.5	0.053

Unconfined Compressive Strength - Examination of the calculated mean for unconfined compressive strength shows TSw2 with the highest mean unconfined compressive strength of 184.7 MPa and a standard deviation of 76.7 MPa. PTn has the lowest unconfined compressive strength of 8.3 MPa and a standard deviation of 11.7 MPa.

Elastic Modulus and Poisson's Ratios - Examination of the calculated mean for the elastic modulus yields a similar trend as for the unconfined compressive strength. TSw2 has the highest mean elastic modulus of 32.4 GPa (standard deviation = 6.5), while PTn has the lowest of 2.3 GPa (standard deviation = 3.0 GPa). The mean Poisson's ratio is between 0.20 (TCw and PTn) and 0.24 (TSw1), with 0.21 for TSw2, and standard deviations ranging from 0.03 (TCw) to 0.10 (PTn).

Indirect Tensile Strength - Indirect tensile strengths were measured by conducting Brazilian tensile tests. The highest means were in TCw (8.9 MPa) and TSw2 (8.7 MPa) with standard deviations respectively of 3.6 MPa and 3.5 MPa. PTn had the lowest mean tensile strength of 0.8 MPa (standard deviation 1.4 MPa).

Dry Bulk Density - Dry bulk densities were measured on samples being analyzed for both the confined compression and Brazilian tensile tests. TSw2 has the highest mean dry bulk density of 2.274 g/cc (standard deviation = 0.053 g/cc), while PTn has the lowest of 1.299 g/cc (standard deviation = 0.225 g/cc).

7.6 ROCK MASS MECHANICAL PROPERTIES

The numerical analysis used to support ESF rock mechanics design requires site-specific design input data. These analyses are required to address the impact of seismic and thermomechanical loading on the ESF design. The analyses require mechanical properties at the rock mass scale which are known to be very different from laboratory analysis on intact rock samples. These differences are the result of scale-effects and are attributed to the influences of size of the affected rock mass and the presence of discontinuous surfaces such as joints, bedding planes, and fault planes in the rock mass. A methodology to estimate rock mass mechanical properties based on empirical correlations with the rock mass rating (RMR) has been proposed by Hardy and Bauer (Reference 5.13).

To estimate rock mass mechanical properties, appropriate rock mass strength criteria and mechanical models for representing the mechanical rock mass response of the Yucca Mountain Tuffs were utilized as recommended in the Drift Design Methodology by Hardy and Bauer (Reference 5.13). The rock mass strength criteria include RMRs, intact rock uniaxial compressive strengths, and triaxial compressive strength data. Empirical relationships based on RMRs, calculated using the approach described by Bieniawski (Reference 5.2), were used in conjunction with data from rock structure summary logs and rock mechanical properties. Rock mass strengths in a form of power law relationship were derived based on Hoek and Brown (Reference 5.14) and Yudhbir, et al., (Reference 5.58) criteria. Design parameters for rock mass elastic modulus (Reference 5.36), Poisson's ratios, and Mohr-Coulomb strength were developed for each mechanical unit. Rock mass strength criteria are generated for the five classes of rock mass quality based upon frequency of occurrence. The rock mass mechanical properties for Boreholes NRG-1, -2, -2A, -3, -4, -5, -6, and -7/7A are presented in Table 5 (Reference 5.22).

Table 5. Summary of Rock Mass Properties (continued on next page)

T/Mu Unit	Rock Mass Mechanical Properties		Rock Mass Quality Categories				
			1	2	3	4	5
Tuff Unit "X"	Q		2.23	7.5	10.98	14.49	24.29
	Average RMR		51	58	61	64	66
	Estimated Rock Mass Elastic Modulus (GPa)		4.3	4.3	4.3	4.3	4.3
	Estimated Rock Mass Poisson's Ratio		0.14	0.14	0.14	0.14	0.14
	Mohr-Coulomb	cohesion (MPa)	0.2	0.3	0.3	0.3	0.4
	Strength	friction angle (degrees)	15	15	15	16	16
	Parameters	dilation angle (degrees)	7	8	8	8	8
TCw	Q		0.38	0.68	2.08	5.66	9.14
	Average RMR		43	48	55	63	68
	Estimated Rock Mass Elastic Modulus (GPa)		6.7	8.92	13.33	21.2	27.71
	Estimated Rock Mass Poisson's Ratio		0.2	0.2	0.2	0.2	0.2
	Mohr-Coulomb	cohesion (MPa)	1.2	1.3	1.7	2.4	3
	Strength	friction angle (degrees)	53	53	54	55	55
	Parameters	dilation angle (degrees)	26	27	27	27	27
PTn	Q		0.15	0.28	0.66	1.62	3.74
	Average RMR		36	42	47	56	63
	Estimated Rock Mass Elastic Modulus (GPa)		2.5	2.5	2.5	2.5	2.5
	Estimated Rock Mass Poisson's Ratio		0.2	0.2	0.2	0.2	0.2
	Mohr-Coulomb	cohesion (MPa)	0.1	0.2	0.2	0.3	0.4
	Strength	friction angle (degrees)	14	15	15	16	16
	Parameters	dilation angle (degrees)	7	7	8	8	8

T/Mu Unit	Rock Mass Mechanical Properties		Rock Mass Quality Categories				
			1	2	3	4	5
TSw1	Q		0.24	0.87	1.73	5.09	12
	Average RMR		40	48	53	60	68
	Estimated Rock Mass Elastic Modulus (GPa)		5.66	8.78	11.71	17.86	18.9
	Estimated Rock Mass Poisson's Ratio		0.3	0.3	0.3	0.3	0.3
	Mohr-Coulomb Strength Parameters	cohesion (MPa)	0.7	0.9	1	1.3	1.9
		friction angle (degrees)	41	42	42	43	43
		dilation angle (degrees)	20	21	21	21	22
TSw2	Q		0.3	0.65	1.91	3.75	8.44
	Average RMR		42	48	54	59	65
	Estimated Rock Mass Elastic Modulus (GPa)		6.37	8.95	12.55	17.11	23.51
	Estimated Rock Mass Poisson's Ratio		0.21	0.21	0.21	0.21	0.21
	Mohr-Coulomb Strength Parameters	cohesion (MPa)	1.3	1.6	2.2	2.8	3.8
		friction angle (degrees)	49	49	50	50	50
		dilation angle (degrees)	25	25	25	25	25

7.7 GROUND WATER AND DRILLING FLUIDS

The ESF is entirely within the unsaturated zone above the water table. Ground water was encountered in the ESF location during drilling of the NRG-series geology boreholes. In NRG-7/7A, a small amount of water was encountered at the TSw3 vitrophyre layer, or about 240 m below the TS North Ramp excavation (Reference 5.21).

The NRG-series geology boreholes were drilled using air as the drilling fluid. Previous borehole G-1 (Reference 5.11), located in Drill Hole Wash about 750 m northwest of NRG-7/7A, was drilled with water and polymers as the drilling fluid. Throughout most of the coring operation, circulation of the drilling fluid was poor to nonexistent. Although, fluid losses totaled approximately 9,000 m^3 during the coring operation, there was no sign of drilling fluids when USW NRG-7/7A was drilled (Reference 5.21).

Other boreholes in the immediate area of the TS North Ramp were drilled with water and bentonite mud as the drilling fluid. One previous borehole, UE25A-4, drilled to a depth of 152 m, is located approximately 90 m west of NRG-5. The drilling records indicated a loss of circulation, resulting in mud being pumped into the hole with no return (Reference 5.10). Borehole NRG-5 was drilled to a depth of 411 m with no sign of the lost drilling fluids from UE25A-4.

Based on these observations, it is considered to be very unlikely that drilling fluids of any sizeable volume will be encountered within the excavated ESF alignment.

8. CONCLUSIONS

The geologic interpretation presented in this analysis is based on the present knowledge of the ESF geology as presented in the USGS geology model, YMP.R2.0 (Reference 5.56). The accuracy of this model is naturally dependent upon the amount of both surface and subsurface data controlling the model. Currently, the best controlled area in the subsurface is along the TS North Ramp. As more information is developed and data becomes available the current interpretation may be subject to change or refinement.

The projected ESF intersection with the Bow Ridge fault at Station 02+00, as predicted by the geologic interpretation presented in the USGS geology model, is in agreement with the observed intersection, measured along the right wall center line of the ESF. The Bow Ridge fault, having been investigated both on the surface by mapping and trenching and in the subsurface by boreholes NRG-2 and NRG-2B, is the best understood geologic structure along the ESF alignment. Although, this initial field observation supports the geologic interpretation presented in the USGS model, further surface and subsurface investigation is needed to increase the confidence of the geology model especially along the TS Main Drift and TS South Ramp.

The geologic information presently available appears sufficient to support the TS North Ramp design, while the TS Main Drift and especially the TS South Ramp may require further investigation to increase the confidence of the geologic interpretation presented in this design analysis. Understandably, as ESF excavation continues unanticipated geologic conditions may be encountered. This design analysis will be updated as warranted by the availability of additional data.

9. ATTACHMENTS

ATTACHMENT	TITLE	PAGE
I	Confined Compression Test on Intact Samples	10
II	Tensile Strength Test Results on Intact Samples	9
III	Dry Bulk Densities	17

CONFINED COMPRESSION TEST ON INTACT SAMPLES

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TCw	NRG-2	170.4 A	117.5	40.1	0.19
TCw	NRG-2	174.0 A	141.8	38.7	0.20
TCw	NRG-2	178.0 A	142.7	39.8	0.20
TCw	NRG-2	179.5 A	215.8	40.1	0.22
TCw	NRG-2	180.0 A	149.1	37.1	0.20
TCw	NRG-2	188.3 A	209.2	39.8	0.20
TCw	NRG-2	196.2 A	185.6	36.5	0.22
TCw	NRG-2	200.0 A	145.3	38.7	0.23
TCw	NRG-2A	172.1 A	110.6	38.2	0.23
TCw	NRG-2A	199.4 A	17.5	8.9	0.20
TCw	NRG-2A	203.9 A	31.1	13.8	0.17
TCw	NRG-2A	209.3 A	22.2	11.5	0.19
TCw	NRG-2A	213.0 A	23.6	11.4	0.19
TCw	NRG-2A	218.8 A	25.5	13.8	0.21
TCw	NRG-2A	223.1 A	19.9	9.7	0.24
TCw	NRG-2A	226.4 A	24.5	11.5	0.24
TCw	NRG-2A	234.9 A	10.4	6.5	0.16
TCw	NRG-2A	238.4 A	20.2	10.3	0.29
TCw	NRG-2A	254.5 A	53.2	17.5	0.22
TCw	NRG-3	21.4 A	18.8	N/A	N/A
TCw	NRG-3	32.1 A	13.1	9.7	0.21
TCw	NRG-3	38.9 A	39.7	17.6	0.20
TCw	NRG-3	42.6 A	27.1	12.6	0.15
TCw	NRG-3	48.0 A	36.6	15.0	0.19

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TCw	NRG-3	55.7 A	21.5	16.4	0.17
TCw	NRG-3	93.8 A	132.9	33.4	0.22
TCw	NRG-3	123.2 A	83.4	29.6	0.20
TCw	NRG-3	142.3 A	34.3	14.8	0.18
TCw	NRG-3	154.4 A	32.5	17.9	0.15
TCw	NRG-3	187.1 A	75.0	29.3	0.20
TCw	NRG-3	195.7 A	85.5	27.0	0.20
TCw	NRG-3	208.9 A	71.9	20.0	0.17
TCw	NRG-3	218.0 A	105.2	36.3	0.20
TCw	NRG-3	226.7 A	108.9	30.1	1.13*
TCw	NRG-3	256.0 A	230.9	41.4	0.21
TCw	NRG-3	257.6 A	174.3	38.4	0.20
TCw	NRG-3	257.6 B	192.8	39.5	0.19
TCw	NRG-3	263.3 A	244.0	39.6	0.22
TCw	NRG-3	289.2 A	121.1	33.5	0.23
TCw	NRG-3	292.4 A	119.9	30.3	0.32
TCw	NRG-3	297.1 A	75.4	24.6	0.22
TCw	NRG-6	5.7 A	120.3	24.4	0.07
TCw	NRG-6	22.2 A	313.6	36.7	0.22
TCw	NRG-6	22.2 B	429.7	36.9	0.23
TCw	NRG-6	22.2 C	424.6	38.1	0.20
TCw	NRG-6	22.2 D	333.4	35.6	0.21
TCw	NRG-6	22.2 E	407.3	38.3	0.21
TCw	NRG-6	22.2 F	390.5	36.4	0.22
TCw	NRG-6	22.2 G	386.2	37.4	0.22

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TCw	NRG-6	22.2 H	391.8	36.8	0.21
TCw	NRG-6	22.2 I	302.1	36.3	0.20
TCw	NRG-6	22.2 J	315.8	37.2	0.21
TCw	NRG-6	22.2 K	284.2	37.4	0.20
TCw	NRG-6	22.2 L	313.8	36.4	0.22
TCw	NRG-6	22.2 M	332.4	36.7	0.22
TCw	NRG-6	23.4 A	303.7	39.0	0.22
TCw	NRG-6	46.4 A	147.9	22.3	0.10
TCw	NRG-6	98.1 A	245.6	30.0	0.24
TCw	NRG-6	98.1 B	242.2	29.2	0.25
TCw	NRG-6	111.0 A	78.2	23.1	0.21
TCw	NRG-6	111.0 B	114.1	26.5	0.21
TCw	NRG-6	122.7 A	173.1	18.8	0.17
TCw	NRG-7/7A	18.0 A	84.6	28.7	0.18
TCw	NRG-7/7A	33.5 A	160.4	35.0	0.21
TCw	NRG-7/7A	41.4 A	135.0	31.5	0.18
TCw	NRG-7/7A	47.4 A	228.1	28.1	0.20
TCw	NRG-7/7A	55.4 A	143.3	21.4	0.20
Mean: Standard Deviation			156.9 120.7	28.4 10.4	0.20 0.03
PTn	NRG-4	416.6 A	4.9	1.9	0.28
PTn	NRG-4	422.3 A	1.8	0.7	0.53
PTn	NRG-4	428.4 A	3.5	1.2	0.18
PTn	NRG-4	433.2 A	3.3	0.8	0.36

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
PTn	NRG-4	456.0 A	9.4	2.1	0.09
PTn	NRG-4	458.7 A	5.2	0.8	0.15
PTn	NRG-4	466.8 A	6.4	1.7	0.14
PTn	NRG-4	469.0 A	2.0	0.2	0.19
PTn	NRG-6	143.5 A	61.8	14.8	0.13
PTn	NRG-6	151.2 A	11.3	5.9	0.13
PTn	NRG-6	161.4 A	3.5	2.9	0.16
PTn	NRG-6	169.5 A	5.9	2.4	0.12
PTn	NRG-6	174.0 A	4.3	1.2	0.21
PTn	NRG-6	182.2 A	3.3	0.8	0.23
PTn	NRG-6	187.0 A	4.1	1.3	0.34
PTn	NRG-6	222.0 A	4.8	1.5	0.23
PTn	NRG-6	227.9 A	2.7	0.7	0.23
PTn	NRG-6	241.5 A	2.1	0.5	0.29
PTn	NRG-7/7A	73.7 A	27.4	7.7	0.09
PTn	NRG-7/7A	77.7 A	12.2	2.1	0.06
PTn	NRG-7/7A	84.4 A	6.9	3.7	0.10
PTn	NRG-7/7A	91.0 A	5.4	3.9	0.06
PTn	NRG-7/7A	97.9 A	3.9	0.3	0.21
PTn	NRG-7/7A	105.0 A	1.2	0.2	0.17
PTn	NRG-7/7A	119.4 A	22.8	9.2	0.15
PTn	NRG-7/7A	130.0 A	21.0	2.3	0.17
PTn	NRG-7/7A	135.3 A	26.2	4.9	0.16
PTn	NRG-7/7A	169.1 A	0.8	0.2	0.28
PTn	NRG-7/7A	174.1 A	1.8	0.3	0.19

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
PTn	NRG-7/7A	213.6 A	1.5	0.3	0.25
PTn	NRG-7/7A	249.7 A	2.3	0.6	0.31
PTn	NRG-7/7A	254.0 A	2.1	0.4	0.26
PTn	NRG-7/7A	268.6 A	0.8	0.1	0.13
PTn	NRG-7/7A	292.4 A	5.8	1.9	0.30
Mean: Standard Deviation:			8.3 11.7	2.3 3.0	0.20 0.10
TSw1	NRG-4	508.4 A	102.6	32.3	0.22
TSw1	NRG-4	515.5 A	98.5	31.6	0.22
TSw1	NRG-4	525.0 A	97.9	27.3	0.21
TSw1	NRG-4	530.4 A	67.1	21.6	0.20
TSw1	NRG-4	535.3 A	55.4	22.3	0.22
TSw1	NRG-4	541.0 A	33.2	14.6	0.34
TSw1	NRG-4	546.0 A	56.8	19.2	0.26
TSw1	NRG-4	550.0 A	61.9	20.8	0.26
TSw1	NRG-4	582.4 A	26.2	13.2	0.28
TSw1	NRG-4	591.7 A	31.8	9.2	0.26
TSw1	NRG-4	597.0 A	33.3	15.6	0.29
TSw1	NRG-4	602.9 A	34.1	13.6	0.27
TSw1	NRG-4	607.6 A	43.7	11.4	0.27
TSw1	NRG-4	612.5 A	47.9	17.2	0.32
TSw1	NRG-4	623.8 A	43.4	14.9	0.27
TSw1	NRG-4	627.7 A	32.0	11.2	0.20
TSw1	NRG-4	655.8 A	31.1	14.5	0.41

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TSw1	NRG-4	664.4 A	26.9	10.7	0.60
TSw1	NRG-4	667.8 A	17.4	6.4	0.31
TSw1	NRG-4	695.8 A	35.9	10.3	0.28
TSw1	NRG-6	276.2 A	118.6	33.2	0.21
TSw1	NRG-6	290.5 A	218.5	28.4	0.21
TSw1	NRG-6	304.4 A	102.2	28.1	0.21
TSw1	NRG-6	316.3 A	79.2	22.0	0.26
TSw1	NRG-6	318.2 A	77.2	22.4	0.27
TSw1	NRG-6	326.0 A	111.1	25.4	0.22
TSw1	NRG-6	328.7 A	73.2	21.5	0.29
TSw1	NRG-6	328.7 B	72.8	23.8	0.24
TSw1	NRG-6	354.4 A	32.4	17.0	0.15
TSw1	NRG-6	362.0 A	83.6	17.5	0.19
TSw1	NRG-6	372.6 A	33.3	15.1	0.16
TSw1	NRG-6	373.1 A	68.8	21.2	0.25
TSw1	NRG-6	391.6 A	58.3	20.6	0.22
TSw1	NRG-6	394.6 A	94.3	20.0	0.20
TSw1	NRG-6	395.2 A	48.4	21.8	0.21
TSw1	NRG-6	397.0 A	60.4	20.6	0.29
TSw1	NRG-6	407.2 A	56.8	20.1	0.27
TSw1	NRG-6	420.8 A	36.2	12.2	0.33
TSw1	NRG-6	427.0 A	43.4	14.2	0.19
TSw1	NRG-6	488.0 A	149.4	33.3	0.21
TSw1	NRG-6	662.2 A	50.4	29.2	0.38
TSw1	NRG-6	687.5 A	95.8	24.6	0.12

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TSw1	NRG-7/7A	334.5 A	63.3	22.4	0.19
TSw1	NRG-7/7A	344.4 A	175.0	27.3	0.21
TSw1	NRG-7/7A	344.4 B	129.1	25.2	0.15
TSw1	NRG-7/7A	344.4 D	198.3	29.4	0.15
TSw1	NRG-7/7A	344.4 E	51.5	24.7	0.17
TSw1	NRG-7/7A	344.4 F	158.9	28.7	0.23
TSw1	NRG-7/7A	344.4 G	70.9	22.5	0.20
TSw1	NRG-7/7A	344.4 H	105.2	20.6	0.21
TSw1	NRG-7/7A	344.4 I	106.2	26.3	0.17
TSw1	NRG-7/7A	344.4 J	89.5	19.1	0.15
TSw1	NRG-7/7A	344.4 K	97.3	27.7	0.18
TSw1	NRG-7/7A	344.4 L	88.7	27.2	0.15
TSw1	NRG-7/7A	345.0 A	99.5	29.0	0.24
TSw1	NRG-7/7A	350.3 A	148.4	34.3	0.17
TSw1	NRG-7/7A	369.5 A	45.2	22.9	0.19
TSw1	NRG-7/7A	380.8 A	61.0	19.9	0.22
TSw1	NRG-7/7A	396.6 A	33.9	13.1	0.26
TSw1	NRG-7/7A	411.4 A	78.4	17.8	0.20
TSw1	NRG-7/7A	417.9 A	27.9	9.8	0.16
TSw1	NRG-7/7A	422.0 A	60.8	19.0	0.18
TSw1	NRG-7/7A	427.6 A	68.1	16.1	0.14
TSw1	NRG-7/7A	428.7 A	55.5	21.8	0.20
TSw1	NRG-7/7A	441.0 A	93.3	20.3	0.22
TSw1	NRG-7/7A	443.2 A	66.3	17.9	0.31
TSw1	NRG-7/7A	450.1 A	25.7	17.2	0.28

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TSw1	NRG-7/7A	454.6 A	65.5	14.0	0.24
TSw1	NRG-7/7A	461.0 A	52.6	13.7	0.36
TSw1	NRG-7/7A	469.4 A	53.9	18.4	0.43
TSw1	NRG-7/7A	470.2 A	129.3	19.8	0.33
TSw1	NRG-7/7A	472.9 A	54.2	15.5	0.23
TSw1	NRG-7/7A	483.3 A	62.1	14.4	0.28
TSw1	NRG-7/7A	525.9 A	21.1	13.0	0.35
TSw1	NRG-7/7A	546.2 A	15.7	6.0	0.46
TSw1	NRG-7/7A	649.6 A	36.1	13.4	0.20
TSw1	NRG-7/7A	671.4 A	106.9	32.4	0.19
TSw1	NRG-7/7A	672.0 A	217.9	22.3	0.11
TSw1	NRG-7/7A	692.5 A	81.8	19.7	0.09
TSw1	NRG-7/7A	717.7 A	71.9	17.8	0.42
Mean: Standard Deviation:			73.9 43.6	20.1 6.6	0.24 0.08
TSw2	NRG-5	847.2 A	84.2	35.2	0.21
TSw2	NRG-5	849.4 A	240.8	37.0	0.19
TSw2	NRG-5	861.2 A	55.3	17.1	0.23
TSw2	NRG-5	873.4 A	38.4	13.4	0.30
TSw2	NRG-5	887.2 A	240.9	40.5	0.20
TSw2	NRG-5	888.8 A	288.9	39.4	0.19
TSw2	NRG-5	891.9 A	253.5	38.3	0.15
TSw2	NRG-5	896.5 A	184.7	39.1	0.10
TSw2	NRG-6	720.7 A	235.5	37.1	0.19

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TSw2	NRG-6	742.3 A	162.3	30.6	0.20
TSw2	NRG-6	742.9 A	212.8	32.4	0.22
TSw2	NRG-6	762.9 A	112.1	29.2	0.18
TSw2	NRG-6	773.5 A	117.4	36.2	0.23
TSw2	NRG-6	784.8 A	223.0	29.7	0.17
TSw2	NRG-6	785.6 A	218.6	30.1	0.16
TSw2	NRG-6	806.8 A	261.9	31.7	0.16
TSw2	NRG-6	848.0 A	175.5	34.6	0.19
TSw2	NRG-6	953.2 A	31.6	16.9	0.11
TSw2	NRG-6	963.3 A	56.3	19.3	0.31
TSw2	NRG-6	971.4 A	97.3	27.4	0.19
TSw2	NRG-6	985.7 A	177.3	37.6	0.25
TSw2	NRG-6	1017.8 A	84.9	27.4	0.23
TSw2	NRG-7/7A	777.0 A	143.8	32.9	0.22
TSw2	NRG-7/7A	800.2 A	179.2	N/A	N/A
TSw2	NRG-7/7A	805.6 A	137.1	21.4	0.27
TSw2	NRG-7/7A	806.3 A	225.4	36.7	0.19
TSw2	NRG-7/7A	818.5 A	126.3	33.1	0.20
TSw2	NRG-7/7A	827.4 A	125.3	23.4	0.33
TSw2	NRG-7/7A	859.2 A	118.8	38.8	0.20
TSw2	NRG-7/7A	861.7 A	245.8	33.9	0.21
TSw2	NRG-7/7A	865.4 A	315.2	32.3	0.19
TSw2	NRG-7/7A	865.4 B	344.0	34.0	0.21
TSw2	NRG-7/7A	865.4 C	254.8	35.0	0.20
TSw2	NRG-7/7A	865.4 D	225.5	32.0	0.25

T/M Unit	HOLE ID	Sample ID	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio
TSw2	NRG-7/7A	865.4 E	306.7	34.1	0.22
TSw2	NRG-7/7A	865.4 F	317.3	34.5	0.21
TSw2	NRG-7/7A	865.4 G	250.1	34.0	0.18
TSw2	NRG-7/7A	865.4 H	226.6	36.8	0.21
TSw2	NRG-7/7A	865.4 I	215.8	34.3	0.20
TSw2	NRG-7/7A	865.4 J	232.0	33.5	0.19
TSw2	NRG-7/7A	865.4 K	239.1	34.9	0.22
TSw2	NRG-7/7A	865.4 L	248.5	35.7	0.21
TSw2	NRG-7/7A	977.8 A	206.9	29.6	0.20
TSw2	NRG-7/7A	1230.2 A	117.2	29.8	0.23
TSw2	NRG-7/7A	1236.7 A	61.0	21.8	0.40
TSw2	NRG-7/7A	1252.3 A	82.9	30.4	0.14
TSw2	NRG-7/7A	1257.8 A	169.3	41.8	0.20
TSw2	NRG-7/7A	1259.1 A	172.5	40.6	0.21
TSw2	NRG-7/7A	1265.2 A	192.9	40.7	0.21
TSw2	NRG-7/7A	1314.8 A	173.4	37.7	0.21
TSw2	NRG-7/7A	1399.1 A	147.6	30.8	0.22
TSw2	NRG-7/7A	1400.5 B	251.8	39.6	0.26
Mean: Standard Deviation:			184.7 76.7	32.4 6.5	0.21 0.05
* Not used					

TENSILE STRENGTH TEST RESULTS ON INTACT SAMPLES

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TCw	NRG-2	171.0 A	10.9
TCw	NRG-2	171.7 A	13.3
TCw	NRG-2	172.0 A	8.2
TCw	NRG-2	176.1 A	12.4
TCw	NRG-2	178.5 A	12.0
TCw	NRG-2	180.5 A	12.6
TCw	NRG-2	188.8 A	9.3
TCw	NRG-2	196.9 A	8.4
TCw	NRG-2	199.0 A	9.6
TCw	NRG-2A	172.1 B	8.7
TCw	NRG-2A	177.0 A	3.8
TCw	NRG-2A	177.0 B	3.8
TCw	NRG-2A	209.3 B	3.8
TCw	NRG-2A	218.8 B	5.8
TCw	NRG-2A	223.1 B	5.6
TCw	NRG-2A	234.9 B	5.6
TCw	NRG-2A	238.4 B	2.7
TCw	NRG-3	15.4 A	3.0
TCw	NRG-3	32.1 B	2.6
TCw	NRG-3	42.6 B	3.3
TCw	NRG-3	48.0 B	3.9
TCw	NRG-3	55.7 B	4.0
TCw	NRG-3	87.3 B	10.1
TCw	NRG-3	93.8 B	11.7
TCw	NRG-3	119.6 A	9.1

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TCw	NRG-3	136.1 A	8.9
TCw	NRG-3	136.1 B	10.3
TCw	NRG-3	195.7 B	10.2
TCw	NRG-3	218.0 B	10.2
TCw	NRG-3	226.7 B	5.3
TCw	NRG-3	256.0 B	14.8
TCw	NRG-3	292.4 B	7.4
TCw	NRG-6	23.4 B	16.0
TCw	NRG-6	23.4 C	13.2
TCw	NRG-6	98.1 C	10.6
TCw	NRG-6	98.1 D	11.3
TCw	NRG-6	111.0 C	8.2
TCw	NRG-6	111.0 D	12.1
TCw	NRG-7/7A	18.0 B	10.6
TCw	NRG-7/7A	24.4 A	9.4
TCw	NRG-7/7A	24.4 B	9.9
TCw	NRG-7/7A	41.4 B	13.0
TCw	NRG-7/7A	47.4 B	13.4
TCw	NRG-7/7A	55.4 B	11.8
Mean: Standard Deviation:			8.9 3.6
PTn	NRG-4	382.9 A	0.1
PTn	NRG-4	428.4 B	0.2
PTn	NRG-4	433.2 B	0.2
PTn	NRG-4	439.4 B	0.2
PTn	NRG-4	456.0 B	0.7

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
PTn	NRG-4	458.7 B	0.8
PTn	NRG-4	469.0 B	0.1
PTn	NRG-6	145.7 A	4.5
PTn	NRG-6	151.2 B	1.9
PTn	NRG-6	174.0 B	0.3
PTn	NRG-6	182.2 B	0.4
PTn	NRG-6	222.0 B	0.3
PTn	NRG-6	241.5 B	0.2
PTn	NRG-7/7A	73.7 B	5.1
PTn	NRG-7/7A	77.7 B	1.2
PTn	NRG-7/7A	91.0 B	0.5
PTn	NRG-7/7A	135.3 B	3.0
PTn	NRG-7/7A	174.1 B	0.1
PTn	NRG-7/7A	182.5 A	0.1
PTn	NRG-7/7A	182.5 B	0.03
PTn	NRG-7/7A	182.5 C	0.02
PTn	NRG-7/7A	224.4 A	0.02
PTn	NRG-7/7A	244.7 A	0.2
PTn	NRG-7/7A	244.7 B	0.1
PTn	NRG-7/7A	268.6 B	0.1
Mean			0.8
Standard Deviation			1.4
TSw1	NRG-4	489.4 A	7.7
TSw1	NRG-4	504.5 A	9.0
TSw1	NRG-4	504.6 B	9.3
TSw1	NRG-4	515.5 B	6.7

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TSw1	NRG-4	525.0 B	8.6
TSw1	NRG-4	530.4 B	8.2
TSw1	NRG-4	535.3 B	7.5
TSw1	NRG-4	541.0 B	2.8
TSw1	NRG-4	546.0 B	4.8
TSw1	NRG-4	550.0 B	5.8
TSw1	NRG-4	587.4 A	3.0
TSw1	NRG-4	587.4 B	4.2
TSw1	NRG-4	591.7 B	2.3
TSw1	NRG-4	597.0 B	2.7
TSw1	NRG-4	602.9 B	3.4
TSw1	NRG-4	607.6 B	2.8
TSw1	NRG-4	612.5 B	4.3
TSw1	NRG-4	617.4 A	3.6
TSw1	NRG-4	617.4 B	4.0
TSw1	NRG-4	617.4 C	3.6
TSw1	NRG-4	691.8 A	3.7
TSw1	NRG-4	691.8 B	3.7
TSw1	NRG-5	788.6 A	4.3
TSw1	NRG-5	832.9 A	7.7
TSw1	NRG-6	276.2 B	8.4
TSw1	NRG-6	304.4 B	9.3
TSw1	NRG-6	318.2 B	7.6
TSw1	NRG-6	355.4 A	5.3
TSw1	NRG-6	373.6 B	6.6
TSw1	NRG-6	392.6 B	6.5

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TSw1	NRG-6	395.0 B	6.8
TSw1	NRG-6	397.5 B	4.7
TSw1	NRG-6	407.0 B	5.1
TSw1	NRG-6	421.5 B	4.1
TSw1	NRG-6	427.0 B	4.0
TSw1	NRG-6	462.3 A	5.2
TSw1	NRG-6	640.0 A	5.1
TSw1	NRG-6	687.5 B	8.7
TSw1	NRG-7/7A	322.9 A	9.3
TSw1	NRG-7/7A	334.5 B	6.3
TSw1	NRG-7/7A	350.3 B	10.5
TSw1	NRG-7/7A	362.8 A	6.8
TSw1	NRG-7/7A	388.6 A	1.6
TSw1	NRG-7/7A	388.6 B	2.3
TSw1	NRG-7/7A	407.3 A	6.1
TSw1	NRG-7/7A	407.3 B	4.9
TSw1	NRG-7/7A	409.9 A	5.9
TSw1	NRG-7/7A	409.9 B	6.2
TSw1	NRG-7/7A	417.9 B	4.7
TSw1	NRG-7/7A	422.0 B	3.9
TSw1	NRG-7/7A	428.7 B	7.0
TSw1	NRG-7/7A	436.4 A	4.9
TSw1	NRG-7/7A	436.4 B	5.4
TSw1	NRG-7/7A	443.2 B	4.7
TSw1	NRG-7/7A	450.1 B	5.3
TSw1	NRG-7/7A	461.0 B	4.8

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TSw1	NRG-7/7A	465.7 A	4.0
TSw1	NRG-7/7A	465.7 B	5.1
TSw1	NRG-7/7A	469.4 B	4.4
TSw1	NRG-7/7A	472.9 B	4.2
TSw1	NRG-7/7A	479.4 A	5.3
TSw1	NRG-7/7A	488.4 A	3.4
TSw1	NRG-7/7A	490.6 A	5.1
TSw1	NRG-7/7A	507.4 A	7.3
TSw1	NRG-7/7A	520.0 A	3.6
TSw1	NRG-7/7A	533.4 A	5.7
TSw1	NRG-7/7A	566.9 A	2.1
TSw1	NRG-7/7A	595.2 A	3.9
TSw1	NRG-7/7A	605.5 A	3.5
TSw1	NRG-7/7A	625.2 A	4.0
TSw1	NRG-7/7A	640.4 A	6.4
TSw1	NRG-7/7A	653.5 A	4.3
TSw1	NRG-7/7A	653.5 B	4.8
TSw1	NRG-7/7A	665.3 A	11.2
TSw1	NRG-7/7A	680.1 A	9.0
TSw1	NRG-7/7A	680.1 B	2.7
TSw1	NRG-7/7A	698.4 A	12.9
TSw1	NRG-7/7A	698.4 B	3.6
TSw1	NRG-7/7A	708.4 A	1.9
TSw1	NRG-7/7A	716.4 A	8.5
TSw1	NRG-7/7A	716.4 B	3.9
TSw1	NRG-7/7A	762.1 A	9.3

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
Mean: Standard Deviation:			5.5 2.3
TSw2	NRG-5	847.2 B	5.7
TSw2	NRG-5	887.2 B	16.8
TSw2	NRG-5	888.8 B	15.9
TSw2	NRG-5	891.9 B	12.9
TSw2	NRG-6	742.3 B	14.5
TSw2	NRG-6	742.9 B	13.0
TSw2	NRG-6	773.5 B	7.9
TSw2	NRG-6	784.8 B	12.5
TSw2	NRG-6	785.6 B	14.1
TSw2	NRG-6	848.0 B	7.9
TSw2	NRG-6	908.2 A	8.8
TSw2	NRG-6	934.0 A	10.8
TSw2	NRG-6	934.0 B	4.0
TSw2	NRG-6	956.8 A	5.3
TSw2	NRG-6	963.3 B	3.2
TSw2	NRG-6	969.3 A	7.5
TSw2	NRG-6	971.4 B	11.7
TSw2	NRG-7/7A	828.4 A	6.1
TSw2	NRG-7/7A	855.0 A	11.6
TSw2	NRG-7/7A	879.2 A	14.3
TSw2	NRG-7/7A	879.2 B	11.0
TSw2	NRG-7/7A	881.0 A	12.1
TSw2	NRG-7/7A	958.7 A	11.2
TSw2	NRG-7/7A	958.7 B	11.5

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TSw2	NRG-7/7A	976.4 A	5.5
TSw2	NRG-7/7A	976.4 B	6.3
TSw2	NRG-7/7A	979.6 A	5.2
TSw2	NRG-7/7A	1046.8 A	6.2
TSw2	NRG-7/7A	1090.3 A	10.4
TSw2	NRG-7/7A	1090.3 B	10.2
TSw2	NRG-7/7A	1098.3 A	6.6
TSw2	NRG-7/7A	1129.3 A	7.0
TSw2	NRG-7/7A	1180.0 A	5.3
TSw2	NRG-7/7A	1188.7 A	8.6
TSw2	NRG-7/7A	1230.2 B	9.2
TSw2	NRG-7/7A	1263.7 A	13.7
TSw2	NRG-7/7A	1263.7 B	9.9
TSw2	NRG-7/7A	1263.7 C	9.0
TSw2	NRG-7/7A	1307.0 A	10.9
TSw2	NRG-7/7A	1307.0 B	8.8
TSw2	NRG-7/7A	1348.8 A	4.8
TSw2	NRG-7/7A	1348.8 B	5.9
TSw2	NRG-7/7A	1353.7 A	7.6
TSw2	NRG-7/7A	1363.5 A	7.6
TSw2	NRG-7/7A	1385.0 A	6.1
TSw2	NRG-7/7A	1385.0 B	6.3
TSw2	NRG-7/7A	1402.7 A	4.8
TSw2	NRG-7/7A	1409.0 A	7.6
TSw2	NRG-7/7A	1437.8 A	4.1
TSw2	NRG-7/7A	1448.5 A	4.2

T/M Unit	HOLE ID	SAMPLE ID	UTS (MPa)
TSw2	NRG-7/7A	1448.5 B	3.6
Mean:			8.7
Standard Deviation:			3.5

DRY BULK DENSITIES

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TCw	NRG-2	170.4 A	2.335
TCw	NRG-2	171.0 A	2.340
TCw	NRG-2	171.7 A	2.342
TCw	NRG-2	172.0 A	2.303
TCw	NRG-2	174.0 A	2.342
TCw	NRG-2	176.1 A	2.354
TCw	NRG-2	178.0 A	2.319
TCw	NRG-2	178.5 A	2.338
TCw	NRG-2	179.5 A	2.360
TCw	NRG-2	180.0 A	2.334
TCw	NRG-2	180.5 A	2.322
TCw	NRG-2	188.3 A	2.345
TCw	NRG-2	188.8 A	2.352
TCw	NRG-2	196.2 A	2.350
TCw	NRG-2	196.9 A	2.355
TCw	NRG-2	199.0 A	2.344
TCw	NRG-2	200.0 A	2.347
TCw	NRG-2A	172.1 A	2.260
TCw	NRG-2A	172.1 B	2.266
TCw	NRG-2A	177.0 A	1.461
TCw	NRG-2A	177.0 B	1.448
TCw	NRG-2A	199.4 A	1.512
TCw	NRG-2A	203.9 A	1.862
TCw	NRG-2A	209.3 A	1.825
TCw	NRG-2A	209.3 B	1.805

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TCw	NRG-2A	213.0 A	1.834
TCw	NRG-2A	218.8 A	1.907
TCw	NRG-2A	218.8 B	1.891
TCw	NRG-2A	223.1 A	1.871
TCw	NRG-2A	223.1 B	1.934
TCw	NRG-2A	226.4 A	1.900
TCw	NRG-2A	234.9 A	1.803
TCw	NRG-2A	234.9 B	1.927
TCw	NRG-2A	238.4 A	1.843
TCw	NRG-2A	238.4 B	1.833
TCw	NRG-2A	254.5 A	2.075
TCw	NRG-3	15.4 A	1.587
TCw	NRG-3	21.4 A	1.902
TCw	NRG-3	32.1 A	1.746
TCw	NRG-3	32.1 B	1.725
TCw	NRG-3	38.9 A	1.955
TCw	NRG-3	42.6 A	1.925
TCw	NRG-3	42.6 B	1.932
TCw	NRG-3	48.0 A	1.939
TCw	NRG-3	48.0 B	1.940
TCw	NRG-3	55.7 A	1.904
TCw	NRG-3	55.7 B	1.925
TCw	NRG-3	87.3 B	2.178
TCw	NRG-3	93.8 A	2.202
TCw	NRG-3	93.8 B	2.179
TCw	NRG-3	119.6 A	2.166
TCw	NRG-3	123.2 A	2.155

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TCw	NRG-3	136.1 A	2.098
TCw	NRG-3	136.1 B	2.130
TCw	NRG-3	142.3 A	1.995
TCw	NRG-3	154.4 A	1.946
TCw	NRG-3	187.1 A	2.154
TCw	NRG-3	195.7 A	2.136
TCw	NRG-3	195.7 B	2.127
TCw	NRG-3	208.9 A	2.159
TCw	NRG-3	218.0 A	2.200
TCw	NRG-3	218.0 B	2.205
TCw	NRG-3	226.7 A	2.259
TCw	NRG-3	226.7 B	2.166
TCw	NRG-3	256.0 A	2.310
TCw	NRG-3	256.0 B	2.297
TCw	NRG-3	257.6 A	2.300
TCw	NRG-3	257.6 B	2.295
TCw	NRG-3	263.3 A	2.325
TCw	NRG-3	289.2 A	2.295
TCw	NRG-3	292.4 A	2.282
TCw	NRG-3	292.4 B	2.090
TCw	NRG-3	297.1 A	2.251
TCw	NRG-6	5.7 A	2.239
TCw	NRG-6	22.2 A	2.354
TCw	NRG-6	22.2 B	2.357
TCw	NRG-6	22.2 C	2.351
TCw	NRG-6	22.2 D	2.329
TCw	NRG-6	22.2 E	2.363

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TCw	NRG-6	22.2 F	2.368
TCw	NRG-6	22.2 G	2.367
TCw	NRG-6	22.2 H	2.354
TCw	NRG-6	22.2 I	2.360
TCw	NRG-6	22.2 J	2.358
TCw	NRG-6	22.2 K	2.363
TCw	NRG-6	22.2 L	2.367
TCw	NRG-6	22.2 M	2.363
TCw	NRG-6	23.4 A	2.356
TCw	NRG-6	23.4 B	2.352
TCw	NRG-6	23.4 C	2.355
TCw	NRG-6	46.4 A	2.287
TCw	NRG-6	98.1 A	2.309
TCw	NRG-6	98.1 B	2.305
TCw	NRG-6	98.1 C	2.311
TCw	NRG-6	98.1 D	2.308
TCw	NRG-6	111.0 A	2.219
TCw	NRG-6	111.0 B	2.236
TCw	NRG-6	111.0 C	2.238
TCw	NRG-6	111.0 D	2.219
TCw	NRG-6	122.7 A	2.096
TCw	NRG-7/7A	18.0 A	2.318
TCw	NRG-7/7A	18.0 B	2.286
TCw	NRG-7/7A	24.4 A	2.345
TCw	NRG-7/7A	24.4 B	2.338
TCw	NRG-7/7A	33.5 A	2.361
TCw	NRG-7/7A	41.4 A	2.266

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TCw	NRG-7/7A	41.4 B	2.273
TCw	NRG-7/7A	47.4 A	2.173
TCw	NRG-7/7A	47.4 B	2.152
TCw	NRG-7/7A	55.4 A	2.085
TCw	NRG-7/7A	55.4 B	2.080
Mean: Standard Deviation:			2.150 0.226
PTn	NRG-4	382.9 A	1.132
PTn	NRG-4	416.6 A	1.175
PTn	NRG-4	422.3 A	1.066
PTn	NRG-4	428.4 A	1.114
PTn	NRG-4	428.4 B	1.053
PTn	NRG-4	433.2 A	1.179
PTn	NRG-4	433.2 B	1.155
PTn	NRG-4	439.4 B	1.084
PTn	NRG-4	456.0 A	1.390
PTn	NRG-4	456.0 B	1.322
PTn	NRG-4	458.7 A	1.488
PTn	NRG-4	458.7 B	1.558
PTn	NRG-4	466.8 A	1.485
PTn	NRG-4	469.0 A	1.278
PTn	NRG-4	469.0 B	1.363
PTn	NRG-6	143.5 A	1.897
PTn	NRG-6	145.7 A	1.717
PTn	NRG-6	151.2 A	1.431
PTn	NRG-6	151.2 B	1.430
PTn	NRG-6	161.4 A	1.490

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
PTn	NRG-6	169.5 A	1.501
PTn	NRG-6	174.0 A	1.10
PTn	NRG-6	174.0 B	1.070
PTn	NRG-6	182.2 A	1.039
PTn	NRG-6	182.2 B	1.062
PTn	NRG-6	187.0 A	1.113
PTn	NRG-6	222.0 A	1.396
PTn	NRG-6	222.0 B	1.331
PTn	NRG-6	227.9 A	1.027
PTn	NRG-6	241.5 A	1.027
PTn	NRG-6	241.5 B	0.997
PTn	NRG-7/7A	73.7 A	1.757
PTn	NRG-7/7A	73.7 B	1.779
PTn	NRG-7/7A	77.7 A	1.602
PTn	NRG-7/7A	77.7 B	1.559
PTn	NRG-7/7A	84.4 A	1.438
PTn	NRG-7/7A	91.0 A	1.414
PTn	NRG-7/7A	91.0 B	1.341
PTn	NRG-7/7A	97.9 A	1.442
PTn	NRG-7/7A	105.0 A	1.004
PTn	NRG-7/7A	119.4 A	1.457
PTn	NRG-7/7A	130.0 A	1.643
PTn	NRG-7/7A	135.3 A	1.642
PTn	NRG-7/7A	135.3 B	1.624
PTn	NRG-7/7A	169.1 A	1.494
PTn	NRG-7/7A	174.1 A	1.097
PTn	NRG-7/7A	174.1 B	1.150

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
PTn	NRG-7/7A	182.5 A	1.104
PTn	NRG-7/7A	182.5 B	1.055
PTn	NRG-7/7A	182.5 C	1.065
PTn	NRG-7/7A	213.6 A	1.202
PTn	NRG-7/7A	224.4 A	1.178
PTn	NRG-7/7A	244.7 A	1.077
PTn	NRG-7/7A	244.7 B	1.164
PTn	NRG-7/7A	249.7 A	1.146
PTn	NRG-7/7A	254.0 A	1.172
PTn	NRG-7/7A	268.6 A	1.113
PTn	NRG-7/7A	268.6 B	1.102
PTn	NRG-7/1A	292.4 A	1.349
Mean: Standard Deviation:			1.299 0.225
TSw1	NRG-4	489.4 A	2.401
TSw1	NRG-4	504.5 A	2.208
TSw1	NRG-4	504.6 B	2.228
TSw1	NRG-4	508.4 A	2.266
TSw1	NRG-4	515.5 A	2.262
TSw1	NRG-4	515.5 B	2.235
TSw1	NRG-4	525.0 A	2.151
TSw1	NRG-4	525.0 B	2.159
TSw1	NRG-4	530.4 A	2.082
TSw1	NRG-4	530.4 B	2.113
TSw1	NRG-4	535.3 A	2.072
TSw1	NRG-4	535.3 B	2.079
TSw1	NRG-4	541.0 A	2.017

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw1	NRG-4	541.0 A	2.109
TSw1	NRG-4	541.0 B	1.998
TSw1	NRG-4	546.0 B	2.099
TSw1	NRG-4	550.0 A	2.115
TSw1	NRG-4	550.0 B	2.086
TSw1	NRG-4	582.4 A	2.151
TSw1	NRG-4	587.4 A	2.128
TSw1	NRG-4	587.4 B	2.155
TSw1	NRG-4	591.7 A	2.111
TSw1	NRG-4	591.7 B	2.072
TSw1	NRG-4	597.0 A	2.133
TSw1	NRG-4	597.0 B	2.147
TSw1	NRG-4	602.9 A	2.152
TSw1	NRG-4	602.9 B	2.172
TSw1	NRG-4	607.6 A	2.114
TSw1	NRG-4	607.6 B	2.109
TSw1	NRG-4	612.5 A	2.158
TSw1	NRG-4	612.5 B	2.180
TSw1	NRG-4	617.4 A	2.177
TSw1	NRG-4	617.4 B	2.184
TSw1	NRG-4	617.4 C	2.222
TSw1	NRG-4	623.8 A	2.201
TSw1	NRG-4	627.7 A	2.198
TSw1	NRG-4	655.8 A	2.185
TSw1	NRG-4	664.4 A	2.099
TSw1	NRG-4	667.8 A	2.066
TSw1	NRG-4	691.8 A	2.030

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw1	NRG-4	691.8 B	1.978
TSw1	NRG-4	695.8 A	2.008
TSw1	NRG-5	788.6 A	2.042
TSw1	NRG-5	832.9 A	2.253
TSw1	NRG-6	276.2 A	2.304
TSw1	NRG-6	276.2 B	2.307
TSw1	NRG-6	290.5 A	2.218
TSw1	NRG-6	304.4 A	2.270
TSw1	NRG-6	304.4 B	2.288
TSw1	NRG-6	316.3 A	2.192
TSw1	NRG-6	318.2 A	2.194
TSw1	NRG-6	318.2 B	2.220
TSw1	NRG-6	326.0 A	2.188
TSw1	NRG-6	328.7 A	2.166
TSw1	NRG-6	328.7 B	2.182
TSw1	NRG-6	354.4 A	2.163
TSw1	NRG-6	355.4 A	2.171
TSw1	NRG-6	362.0 A	2.147
TSw1	NRG-6	372.6 A	2.173
TSw1	NRG-6	373.1 A	2.145
TSw1	NRG-6	373.6 B	2.197
TSw1	NRG-6	391.6 A	2.223
TSw1	NRG-6	392.6 B	2.230
TSw1	NRG-6	394.6 A	2.244
TSw1	NRG-6	395.0 B	2.261
TSw1	NRG-6	395.2 A	2.229
TSw1	NRG-6	397.0 A	2.246

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw1	NRG-6	397.5 B	2.252
TSw1	NRG-6	407.0 B	2.237
TSw1	NRG-6	407.2 A	2.228
TSw1	NRG-6	420.8 A	2.201
TSw1	NRG-6	421.5 B	2.170
TSw1	NRG-6	427.0 A	2.172
TSw1	NRG-6	427.0 B	2.209
TSw1	NRG-6	462.3 A	2.171
TSw1	NRG-6	488.0 A	2.219
TSw1	NRG-6	640.0 A	2.185
TSw1	NRG-6	662.2 A	2.146
TSw1	NRG-6	687.5 A	2.222
TSw1	NRG-6	687.5 B	2.233
TSw1	NRG-7/7A	322.9 A	2.300
TSw1	NRG-7/7A	334.5 A	2.027
TSw1	NRG-7/7A	334.5 B	1.980
TSw1	NRG-7/7A	344.4 A	2.154
TSw1	NRG-7/7A	344.4 B	2.148
TSw1	NRG-7/7A	344.4 D	2.174
TSw1	NRG-7/7A	344.4 E	2.114
TSw1	NRG-7/7A	344.4 F	2.157
TSw1	NRG-7/7A	344.4 G	2.082
TSw1	NRG-7/7A	344.4 H	2.114
TSw1	NRG-7/7A	344.4 I	2.158
TSw1	NRG-7/7A	344.4 J	2.141
TSw1	NRG-7/7A	344.4 K	2.135
TSw1	NRG-7/7A	344.4 L	2.132

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw1	NRG-7/7A	345.0 A	2.142
TSw1	NRG-7/7A	350.3 A	2.289
TSw1	NRG-7/7A	350.3 B	2.243
TSw1	NRG-7/7A	362.8 A	2.135
TSw1	NRG-7/7A	369.5 A	2.126
TSw1	NRG-7/7A	380.8 A	2.155
TSw1	NRG-7/7A	388.6 A	2.091
TSw1	NRG-7/7A	388.6 B	2.140
TSw1	NRG-7/7A	396.6 A	2.117
TSw1	NRG-7/7A	407.3 A	2.149
TSw1	NRG-7/7A	407.3 B	2.153
TSw1	NRG-7/7A	409.9 A	2.142
TSw1	NRG-7/7A	409.9 B	2.133
TSw1	NRG-7/7A	411.4 A	2.151
TSw1	NRG-7/7A	417.9 A	2.126
TSw1	NRG-7/7A	417.9 B	2.197
TSw1	NRG-7/7A	422.0 A	2.201
TSw1	NRG-7/7A	422.0 B	2.244
TSw1	NRG-7/7A	427.6 A	2.209
TSw1	NRG-7/7A	428.7 A	2.199
TSw1	NRG-7/7A	428.7 B	2.190
TSw1	NRG-7/7A	436.4 A	2.162
TSw1	NRG-7/7A	436.4 B	2.209
TSw1	NRG-7/7A	441.0 A	2.199
TSw1	NRG-7/7A	443.2 A	2.208
TSw1	NRG-7/7A	443.2 B	2.179
TSw1	NRG-7/7A	450.1 A	2.194

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw1	NRG-7/7A	450.1 B	2.194
TSw1	NRG-7/7A	454.6 A	2.197
TSw1	NRG-7/7A	461.0 A	2.217
TSw1	NRG-7/7A	461.0 B	2.278
TSw1	NRG-7/7A	465.7 A	2.236
TSw1	NRG-7/7A	465.7 B	2.234
TSw1	NRG-7/7A	469.4 A	2.257
TSw1	NRG-7/7A	469.4 B	2.254
TSw1	NRG-7/7A	470.2 A	2.268
TSw1	NRG-7/7A	472.9 A	2.257
TSw1	NRG-7/7A	472.9 B	2.237
TSw1	NRG-7/7A	479.4 A	2.222
TSw1	NRG-7/7A	483.3 A	2.166
TSw1	NRG-7/7A	488.4 A	2.012
TSw1	NRG-7/7A	490.6 A	2.256
TSw1	NRG-7/7A	507.4 A	2.103
TSw1	NRG-7/7A	520.0 A	2.050
TSw1	NRG-7/7A	525.9 A	1.940
TSw1	NRG-7/7A	533.4 A	1.965
TSw1	NRG-7/7A	546.2 A	2.101
TSw1	NRG-7/7A	566.9 A	2.105
TSw1	NRG-7/7A	595.2 A	1.997
TSw1	NRG-7/7A	605.5 A	2.051
TSw1	NRG-7/7A	625.2 A	1.971
TSw1	NRG-7/7A	640.4 A	2.117
TSw1	NRG-7/7A	649.6 A	2.092
TSw1	NRG-7/7A	653.5 A	2.127

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw1	NRG-7/7A	653.5 B	2.077
TSw1	NRG-7/7A	665.3 A	2.192
TSw1	NRG-7/7A	671.4 A	2.176
TSw1	NRG-7/7A	672.0 A	2.217
TSw1	NRG-7/7A	680.1 A	2.215
TSw1	NRG-7/7A	680.1 B	2.108
TSw1	NRG-7/7A	692.5 A	2.217
TSw1	NRG-7/7A	698.4 A	2.252
TSw1	NRG-7/7A	698.4 B	2.153
TSw1	NRG-7/7A	708.4 A	2.192
TSw1	NRG-7/7A	716.4 A	2.161
TSw1	NRG-7/7A	716.4 B	2.068
TSw1	NRG-7/7A	717.7 A	2.130
TSw1	NRG-7/7A	762.1 A	2.181
Mean: Standard Deviation:			2.162 0.077
TSw2	NRG-5	847.2 A	2.294
TSw2	NRG-5	847.2 B	2.210
TSw2	NRG-5	849.4 A	2.310
TSw2	NRG-5	861.2 A	2.177
TSw2	NRG-5	873.4 A	2.181
TSw2	NRG-5	887.2 A	2.280
TSw2	NRG-5	887.2 B	2.286
TSw2	NRG-5	888.8 A	2.287
TSw2	NRG-5	888.8 B	2.293
TSw2	NRG-5	891.9 A	2.282
TSw2	NRG-5	891.9 B	2.267

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw2	NRG-5	896.5 A	2.284
TSw2	NRG-6	720.7 A	2.292
TSw2	NRG-6	742.3 A	2.249
TSw2	NRG-6	742.3 B	2.281
TSw2	NRG-6	742.9 A	2.275
TSw2	NRG-6	742.9 B	2.268
TSw2	NRG-6	762.9 A	2.309
TSw2	NRG-6	773.5 A	2.264
TSw2	NRG-6	773.5 B	2.223
TSw2	NRG-6	784.8 A	2.270
TSw2	NRG-6	784.8 B	2.270
TSw2	NRG-6	785.6 A	2.274
TSw2	NRG-6	785.6 B	2.274
TSw2	NRG-6	806.8 A	2.309
TSw2	NRG-6	848.0 A	2.322
TSw2	NRG-6	848.0 B	2.344
TSw2	NRG-6	908.2 A	2.310
TSw2	NRG-6	934.0 A	2.251
TSw2	NRG-6	934.0 B	2.258
TSw2	NRG-6	953.2 A	2.099
TSw2	NRG-6	956.8 A	2.124
TSw2	NRG-6	963.3 A	2.165
TSw2	NRG-6	963.3 B	2.184
TSw2	NRG-6	969.3 A	2.208
TSw2	NRG-6	971.4 A	2.227
TSw2	NRG-6	971.4 B	2.277
TSw2	NRG-6	985.7 A	2.301

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw2	NRG-6	1017.8 A	2.246
TSw2	NRG-7/7A	777.0 A	2.267
TSw2	NRG-7/7A	800.2 A	2.265
TSw2	NRG-7/7A	805.6 A	2.212
TSw2	NRG-7/7A	806.3 A	2.279
TSw2	NRG-7/7A	818.5 A	2.269
TSw2	NRG-7/7A	827.4 A	2.178
TSw2	NRG-7/7A	828.4 A	2.161
TSw2	NRG-7/7A	855.0 A	2.253
TSw2	NRG-7/7A	859.2 A	2.276
TSw2	NRG-7/7A	861.7 A	2.284
TSw2	NRG-7/7A	865.4 A	2.270
TSw2	NRG-7/7A	865.4 B	2.267
TSw2	NRG-7/7A	865.4 C	2.267
TSw2	NRG-7/7A	865.4 D	2.234
TSw2	NRG-7/7A	865.4 E	2.277
TSw2	NRG-7/7A	865.4 F	2.267
TSw2	NRG-7/7A	865.4 G	2.248
TSw2	NRG-7/7A	865.4 H	2.250
TSw2	NRG-7/7A	865.4 I	2.260
TSw2	NRG-7/7A	865.4 J	2.266
TSw2	NRG-7/7A	865.4 K	2.271
TSw2	NRG-7/7A	865.4 L	2.263
TSw2	NRG-7/7A	879.2 A	2.295
TSw2	NRG-7/7A	879.2 B	2.241
TSw2	NRG-7/7A	881.0 A	2.294
TSw2	NRG-7/7A	958.7 A	2.228

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw2	NRG-7/7A	958.7 B	2.249
TSw2	NRG-7/7A	976.4 A	2.277
TSw2	NRG-7/7A	976.4 B	2.234
TSw2	NRG-7/7A	977.8 A	2.251
TSw2	NRG-7/7A	979.6 A	2.282
TSw2	NRG-7/7A	1046.8 A	2.217
TSw2	NRG-7/7A	1090.3 A	2.306
TSw2	NRG-7/7A	1090.3 B	2.293
TSw2	NRG-7/7A	1098.3 A	2.196
TSw2	NRG-7/7A	1129.3 A	2.267
TSw2	NRG-7/7A	1180.0 A	2.252
TSw2	NRG-7/7A	1188.7 A	2.286
TSw2	NRG-7/7A	1230.2 A	2.291
TSw2	NRG-7/7A	1230.2 B	2.206
TSw2	NRG-7/7A	1236.7 A	2.286
TSw2	NRG-7/7A	1252.3 A	2.248
TSw2	NRG-7/7A	1257.8 A	2.334
TSw2	NRG-7/7A	1259.1 A	2.338
TSw2	NRG-7/7A	1263.7 A	2.322
TSw2	NRG-7/7A	1263.7 B	2.296
TSw2	NRG-7/7A	1263.7 C	2.343
TSw2	NRG-7/7A	1265.2 A	2.342
TSw2	NRG-7/7A	1307.0 A	2.335
TSw2	NRG-7/7A	1307.0 B	2.333
TSw2	NRG-7/7A	1314.8 A	2.325
TSw2	NRG-7/7A	1348.8 A	2.353
TSw2	NRG-7/7A	1348.8 B	2.335

T/M Unit	HOLE ID	Sample ID	DBD (g/cc)
TSw2	NRG-7/7A	1353.7 A	2.287
TSw2	NRG-7/7A	1363.5 A	2.368
TSw2	NRG-7/7A	1385.0 A	2.348
TSw2	NRG-7/7A	1385.0 B	2.347
TSw2	NRG-7/7A	1399.1 A	2.337
TSw2	NRG-7/7A	1400.5 B	2.371
TSw2	NRG-7/7A	1402.7 A	2.265
TSw2	NRG-7/7A	1409.0 A	2.423
TSw2	NRG-7/7A	1437.8 A	2.350
TSw2	NRG-7/7A	1448.5 A	2.346
TSw2	NRG-7/7A	1448.5 B	2.341
Mean:			2.274
Standard Deviation:			0.053

Proposed Schedule

ESF Design Analysis	External Review Package Availability
Geology of the ESF TS Loop	05/23/95
ESF Layout Calculation	06/12/95
Subsurface Determination of Importance Evaluation	06/30/95
Test, Inspection & Material Dedication: Shotcrete, Rockbolts & Accessories	
ESF Ground Support - Structural Steel Material Dedication Analysis	
Subsurface General Construction Methods	07/07/95
ESF Ground Support - Structural Steel Analysis	
Location & Sizing Analysis of ESF Alcoves	
TBM Tunnel Precast Concrete Invert Segment	
ESF Ground Support Design Analysis	07/14/95
Alcove Turnout Frame Analysis	08/18/95
Alcove/Drifts Steel Sets Analysis	

• This schedule reflects current plans and may be changed.

ENCLOSURE 2