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WBS 1.2.9.3
QA

FEB 08 1991

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OBSERVATIONS 89-03-03 AND 06 RESULTING FROM YUCCA MOUNTAIN QUALITY ASSURANCE DIVISION (YMQAD) AUDIT 89-03 OF SANDIA NATIONAL LABORATORIES (SNL)

The YMQAD staff has evaluated Observations 89-03-03 and 06, generated as a result of YMQAD Audit 89-03 of SNL. It has been determined that the potential weaknesses identified in these observations have been identified as Quality Level 3 activities. The observations have been closed. A copy of the observation is enclosed for your information.

If you have any questions, please contact Catherine E. Hampton at (702) 794-7973 or FTS 544-7973, or Martha J. Mitchell at (702) 794-7852 or FTS 544-7852.


Donald G. Horton, Director
Yucca Mountain Quality Assurance Division

YMQAD:CEH-2059

Enclosures:
Observations 89-03-03 and 06

cc w/encls:
R. R. Richards, SNL, 6319, Albuquerque, NM
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YMP-5

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YUCCA MOUNTAIN PROJECT OFFICE
YMPO OBSERVATION NO. 89-3-03

N-QA-012
4/89

Completed by Originating Organization	2 Noted During: Audit 89-3	3 Identified By: W.R. Sublette	4 Date: 9/26/89		
	5 Organization: SNL	6 Person(s) Contacted: F. Nimick, R. Price, S. Bauer, L. Costin		7 Response Due Date is 20 Days from Date of Transmittal	
	8 Discussion: (See Attached Sheet)				
9 QAE/Lead Auditor <i>S. Dana</i>		Date 10.5.89	10 Branch Manager <i>W.R. Sublette</i>		Date 10-5-89
Completed by Respondee	11 Response: See attached pages for response.				
	12 Signature: <i>L. E. Shipman</i> for T.C. Hunter Date: 11/9/87				
Completed by QA Org.	13 Response Receipt Acceptable <input type="checkbox"/>		<i>S. Dana</i> 2/23/90 QA/Lead Auditor Date		
	Initiator Date <i>Martha Mitchell 3/1/91</i>		<i>SD</i> 2/1/91 Date		
14 Remarks: See attached sheets for reason why response was unacceptable. The work is identified as QA level III 11/11 3/1/91					
				Page 1 of 5	

ENCLOSURE

6. B. Ehgartner, W. Miller

8.

It was observed that there was an inadequate amount of documentation providing traceability from the RIB back through the source documents. This was noted in Work Breakdown Structure Activities that provide rock mechanics information for the RIB, specifically, WBS 1.2.4.2.1.3, Laboratory Properties and WBS 1.2.4.2.1.1, Rock Mass Analysis.

Data from the RIB's "Intact Rock Mechanical Properties" which was developed from the Laboratory Properties WBS (1.2.4.2.1.3), was not adequately traceable through its source documents. Three source documents were checked for the traceability of the mechanical properties: Young's modulus, Poisson's ratio, and unconfined compressive strength. These sources included a data analysis memorandum from Rutherford to Nimick, June 29, 1988 (71/124213/33/Q2), a data report document (SAND83-1646), and a data set from the Data Records Management System (51/L02-02/11/83) Vols. I & II. Various samples were checked but samples GJ3-760.9/2A and G4-749.0/B were checked in detail. The data set sheets and data compilation sheets were lacking adequate documentation in the following areas for sample GJ3-760.9/2A:

- 1) There was no discussion or description that a least squares fitting method was used to determine Modulus of Elasticity and Poisson's Ratio.
- 2) The least squares fitting calculations that are written on the data set sheets are not clearly and completely presented.
- 3) The data compilation sheets do not clearly identify which samples were invalidated. Stickers were placed on invalid data compilation sheets but there is no discussion describing the purpose of the sticker nor the basis for invalidating the data.
- 4) There are no units on any of the raw data plots or raw data tables.

The data analysis memorandum (Rutherford to Nimick, 1988) does not identify which data is invalid in the data list presented in the Appendix. It also does not indicate how the data was averaged for each depth before incorporation into the statistical analyses. This information is presented in the text of the memorandum but could be easily missed by future users of this data. It is therefore recommended that the invalid data should be clearly identified on the data list in the Appendix and another column be added to the Appendix showing exactly what numbers were used when determining the parameters sample average. This additional column will show the average parameter value for each depth when there are multiple samples for a given depth.

Sample G4-749.0/B was invalidated in the data analysis memorandum (Rutherford to Nimick, 1988) because the sample was fractured, however, in the sample description presented in the data report (SAND83-1646) there was no mention of the sample being fractured.

When checking the documentation and traceability for the Mohr-Coulomb strength parameters (cohesion and angle of internal friction) presented in the RIB, the following inadequacies were noted:

- 1) The source document referenced in the RIB for the Mohr-Coulomb strength parameters (cohesion and angle of internal friction) has not been written. This document is entitled "Results of Statistical Analysis of Mechanical Properties Data from Unconfined Compression Tests on Samples of Tuff from Yucca Mountain, Nevada," SAND88-2822, by Rutherford, B.M., F. B. Nimick, and R. H. Price.
- 2) Data compilation sheets that were compiled from Olsson and Jones (1980), Olsson (1982), Price and Jones (1982), Price, Nimick and Zirzow (1982), and Nimick et al (1985), were found to have inadequate documentation in the following instances:
 - * There was no title or description of the purpose and content of the data compilation sheets.
 - * No signature or date on the compilation sheets.
 - * Compilation sheet column headings were not adequately described. This was especially the case for the three porosity columns. One column was apparently a functional porosity and the other two were different interpolated porosities.
 - * The compilation sheets are presently in the Principal Investigators personal files and not in any formal data records management system.
- 3) Data calculation sheets were found to have inadequate documentation and traceability in the following instances:
 - * There was no title or description of the purpose or content of the calculation sheets.
 - * No signature or date on the calculation sheets.
 - * Calculation sheets were not numbered. Very hard to follow when they were out of order.
 - * The calculation sheets were not complete. They did not show all the steps of the calculations or even the final results of the calculations. The purpose of the calculations was to determine the Mohr-Coulomb strength parameters (cohesion and angle of internal friction). These values were not shown on the calculations sheets, however, they were presented in other memorandums or documents that these calculations supported. These memorandums and documents included a Nimick to Blejwas (1985) memorandum summarizing these calculations and also the Nimick and Schwartz, 1987, SAND85-0762 report that is referenced in the RIB.

- * The calculation sheets are presently in the Principal Investigators personal files and not in any formal data records management system.

Inadequate calculation documentation was noted in the source documents referenced in the "Rock Mass Failure" section of the RIB. The source documents that were referenced in the RIB included a memorandum from Ehgartner to Distribution, dated 9/24/87, and entitled "Empirical Rock Mass Strength Criteria", and PDM 75-07, dated 8/31/87, and entitled "Empirical Analyses of Rock Mass Strength". This work was performed under WBS 1.2.4.2.1.1, Rock Mass Analysis.

The documentation problems identified in the calculations of the two source documents are noted as follows:

- 1) The form of the empirical strength equations presented in PDM 75-07 were changed in the results provided in the Ehgartner (1987) memorandum. It is not obvious what the new form of the equations are in the Ehgartner (1987) memorandum since these equations were not rewritten with the same notation that was used in PDM 75-07. Because the jump in calculation steps and equation transformations is so great it is impossible to check the intermediate steps of the calculations and the development of the constants without going back to the initial input and repeating the entire calculations.
- 2) PDM 75-07 indicates that certain constants in the empirical strength equations will be determined from a linear regression analysis of strength data compiled by Nimick (1987). First of all this reference is cited incorrectly on pages 10 through 12 in the PDM and is also incorrectly referenced in the list of references presented on page 15. The reference should be "Nimick, F. B. and Schwartz, B. M., etc.....". But more importantly there is inadequate documentation and traceability when only a source, such as, Nimick and Schwartz (1987) is referenced. The confined strength data for TSw2 is presented in Table 16 in Nimick and Schwartz (1987), however, the unconfined strength data is presented in Tables 16 and B-6 plus a mean value for TSw2 is presented in the text of Nimick and Schwartz (1987) on page 115. The unconfined strength value (q) for TSw2 is identified as 166 MPa on page 11 of the PDM. This value is inconsistent with the unconfined compressive strength presented in Nimick and Schwartz (1987). An average unconfined compressive strength value of 147.9 MPa is presented on page 115 of Nimick and Schwartz (1987). This value was developed from the data in Table B-6 as described in the text on page 115. If the unconfined compressive strength values from table 16 are averaged, the resulting value is 154 MPa. Both the 147.9 MPa and 154 MPa values are noticeably less than the 166 MPa value used in the PDM. It should also be noted that there is no reference as to whether all of the confined strength data in Table 16 was used or a part of it was used. In both the case of the unconfined compressive strengths and the confined compressive strengths, the input data used in statistical analyses or any other types of analyses should be clearly presented in the document in which the analyses are performed.

Based on what was looked at in WBS's 1.2.4.2.1.3. and 1.2.4.2.1.1 it was noted that the necessary documentation required for adequate traceability has improved over the last two years, however, further improvements should still be forthcoming. Previous to the last two years, documentation for adequate traceability was lacking. The concern is that all work, whether it is QA level I, II, or III, be performed with good scientific and engineering documentation workhabits.

Most of the activities described in this observation were performed as QA Level III, and therefore not controlled by QA program requirements. A few of the activities described in this observation were QA Level II, however, there were no procedural deficiencies noted in these instances.

Response to YMPO Observation No. 89-3-03

This observation consists of approximately 3 1/4 pages of text. In order to present a clear response, specific aspects of the observation are addressed sequentially; more general aspects such as "... there was an inadequate amount of documentation..." are addressed at the end of the response.

1. Page 2 of 5, Point 1 The absence of discussion or description of a least-squares fitting method will be avoided in the future because DOP 3-10, "Routine Calculations" applies to these calculations.

2. Page 2 of 5, Point 2 See response (1).

3. Page 2 of 5, Point 3 It was not the purpose of the data compilation sheets to state why samples were invalidated, nor were the stickers on the sheets intended for any purpose other than to identify invalidated data to the Principal Investigator. Discussion of invalid data has belonged, and will continue to belong, in either the appropriate data report (if data are invalid because of invalid testing procedures) or the appropriate analysis report (if data are invalid because of erroneous assumptions about material homogeneity, etc.). Additional notations about data validity may be made in experiment logbooks or on calculation records related to experiments, but ultimately it is the Principal Investigator's responsibility to identify and describe invalid data in one or both of the reports mentioned above.

4. Page 2 of 5, Point 4
The absence of units will not occur in the future because DOP's 5-2 and 11-1 both contain requirements for specification of units for every parameter of interest. A requirement to specify units has been added to DOP 11-2.
5. Page 2 of 5, Paragraph 3
This paragraph is an individual opinion on how data is best presented. The comment will be considered in writing future reports, but no action is required to either correct the memorandum or to prevent a future recurrence.
6. Page 2 of 5, Paragraph 4
This point is valid, except that the data report is misidentified (SAND84-1101 is the correct document). The statistical analyses will be repeated when the SNL Software QA Plan is approved, and the subject sample will be included in the analysis.
7. Page 3 of 5, Point 1
True. The report will be written after the related data report is available in draft.
8. Page 3 of 5, Point 2
Use of DOP 3-10 will prevent recurrence of these problems.
9. Page 3 of 5, Point 3
Use of DOP 3-10 will prevent recurrence of this problem.
10. Page 4 of 5, Point 1
The work audited was performed at QA Level 3. As such, it was not necessary to control the work by QA procedures. Nonetheless, the work was controlled by analysis procedures (here DOP 3-3) "The DOP provides a means for an analysis or calculational task to be

performed in sufficient detail as to purpose, method, assumptions, input, reference, and units such that a technically qualified person may review, understand, and verify the analysis without recourse to the originator" (DOP 3-3, Rev. C, Section 1.0). In other words, the problem definition memo, and ensuing documentation, should be such that a competent individual could repeat the work, or in this case, fill in the blanks. During the audit, SNL personnel started with the PDM, worked out the detailed analysis steps, and shared this information with the auditor. It is therefore unclear why the auditor found it "impossible to check the intermediate steps..." Clearly, the information was presented. Further, the spirit and letter of DOP 3-3 was met by PDM 75-07 because a competent individual from SNL was able to reproduce the work, starting from the PDM. The level of detail in the PDM and ensuing documentation is consistent with the QA level assigned.

In reviewing PDM 75-07, we feel that the data used in the analysis, when presented by reference only, was sufficiently detailed for a competent individual to repeat the work. Further, the auditor is confused in the nature of the operations called for in the PDM. A mean value of the unconfined compressive strengths was not called for. Rather, the unconfined compressive strength (q) for TSw2 was calculated by performing a least-squares linear regression to the data

Page 4 of 5, Point 2 (cont'd.) in Nimick and Schwartz. Thus, neither the mean value the auditor calculated nor that reported in Nimick and Schwartz has any bearing or relation to the q value calculated in PDM 75-07, because these values were derived in different ways.

Again, it is felt that the level of detail in the PDM and ensuing documentation is consistent with the QA level assigned.

In summary, the responsible SNL personnel disagree with the auditor that documentation was inadequate, because all conclusions could be reproduced by the SNL PI (and, in the case of PDM 75-07, by a different SNL individual) using only the available documentation. In addition, as pointed out in the observation by the auditor, no procedural deficiencies were identified.

SNL personnel will continue to make every effort to maintain adequate documentation at every step of the process of data collection and analysis. In return, it is recommended that YMP discontinue auditing records which were obtained before procedural controls were established against requirements which have subsequently been developed.

RESPONSE REJECTION

Observation No. 89-3-03

Page 1 of 3

14. Remarks: (cont.)

Each of the ten parts of the SNL responses will be addressed in sequential order, plus the additional two summarizing paragraphs at the end of the response:

1.) SNL response is not acceptable.

SNL suggested that the implementation of DOP 3-10 will resolve this documentation problem. However, DOP 3-10 does not apply to QA Level-III work, although, it can be used for QA Level-III work. Since the work referenced in this observation is QA Level-III work, DOP 3-10 does not necessarily apply.

Suggested SNL response:

Future QA Level-III data analysis or compilation will be documented sufficiently to provide adequate traceability and clarity. Future QA Level-I & II work will be controlled by DOP 3-10, "Routine Calculations". The appropriate documentation will be added to the data sheets and data compilation sheets for sample GU3-760.9/2A and any other samples lacking adequate documentation which will be used to support any future QA Level-I or II activities.

2.) SNL response is not acceptable. See part (1) for suggested response.

3.) SNL response is acceptable.

4.) SNL response is acceptable, however, it is suggested that the following be added to the response: "Units will be added to the raw data plots and data tables for sample GU3-760.9/2A and any other samples lacking adequate unit documentation."

5.) SNL response is acceptable.

6.) SNL response is acceptable.

7.) SNL response is acceptable.

8.) SNL response is not acceptable.

SNL suggested that the implementation of DOP 3-10 will resolve this SNL documentation problem. However, DOP 3-10 does not apply to QA Level-III work, although, it can be used for QA Level-III work. Since the work referenced in this observation is QA Level-III work DOP 3-10 does not necessarily apply.

Suggested SNL response:

Future QA Level-III data compilations and calculations will be documented in a manner that will satisfy the documentation concerns addressed in this part of the Observation. The appropriate documentation will be added to the data compilation and calculation sheets referenced in this Observation and filed in the SNL NWRT Records Management System (RMS) if it is determined that this data will support future QA Level-I or II work.

9.) SNL response is not acceptable. See part (8) for suggested response.

10.) SNL response is not acceptable.

Irrespective of the QA-Level assignment, there is an inadequate amount of documentation and intermediate steps presented in the analysis to satisfactorily check the analysis. The auditor, who has the appropriate background, could not duplicate the results of the linear regression analyses using the linear forms of the Yudbir-Bieniawski or Hoek and Brown empirical equations and the documentation provided in PDM 75-07 and the Eghartner (1987) memorandum. Other SAIC individuals were requested to check the analyses and they also could not reproduce the results. During the course of the audit SNL personnel checked the results of the analysis, however, it was determined later that the SNL personnel did not check the linear regression analysis by redoing it using the linear forms of the empirical strength relationships. Instead they plotted the data and then plotted the strength curve based on the parameters presented in the analysis (fixing the curve at the unconfined compressive strength of 166 MPa), and then visually checked it. The linear regression analysis was not actually redone, therefore the work was not reproduced by the SNL personnel during the audit. It also appears to the auditor that there is an error in the analysis and this problem will be addressed at a later date. One of the areas of concern is that the linear regression analysis using the Hoek & Brown empirical strength relationship was not performed on the linear form of the equation.

Two Possible SNL responses are suggested:

- a) The material in the "Rock Mass Failure" section of the RIB will be removed and not used in future design or performance assessment activities. The analysis presented in PDM 75-07 will be rechecked. If an error is found, the PDM will either be corrected or a memorandum will be added to the PDM file indicating that the analysis is in error and should not be used in the future unless corrected.
- b) The appropriate documentation will be added to PDM 75-07 and its supporting memorandum to make the analysis clear and easily traceable. This includes clearly defining which strength data in the Nimick and Schwartz (1987) document was used in the analysis. The transformed equations presented in the supporting memorandum will be written with the same notation as used in PDM 75-07. The analysis will be rechecked and corrections made to the PDM, supporting memorandum, and the RIB if errors are found.

11.) SNL response is not acceptable. See number (10) for suggested response.

To put this documentation concern or problem in proper perspective, it should be noted that the SNL response to this part of the Observation incorrectly stated how the unconfined compressive strength was determined. The SNL response indicated that the "unconfined compressive strength (q) for TSw2 was calculated by performing a least-squares linear regression to the data in Nimick and Schwartz." Apparently this is not how "q" was determined from my conversation with other SNL personnel. Based on these conversations it was determined that "q" was taken from the RIB. The point here is that if the documentation was sufficient to provide adequate traceability through the analysis, the SNL response would not have been in error in its description of how "q" was determined.

The auditor would also like to reiterate as to why this QA Level III work was audited. All of this work either feeds directly or indirectly into the RIB. Since this rock mechanic RIB data was used or available for use in the previous ESF design efforts and will probably be the only rock mechanic RIB data available for the next ESF design effort, it is therefore considered very important data and should have documentation commensurate with the importance of activities such as ESF design.

YUCCA MOUNTAIN PROJECT OFFICE
1 YMPO OBSERVATION NO. 89-3-06

N-QA-012
4/89

Completed by Originating Organization	2 Noted During: Audit 89-3	3 Identified By: W.R. Sublette	4 Date: 9/28/89				
	5 Organization: SNL	6 Person(s) Contacted: S. Bauer, L. Costin, W. Miller, B. Ehgartner	7 Response Due Date is 20 Days from Date of Transmittal				
	8 Discussion: (See Attached Sheet)						
	9 QAE/Lead Auditor <i>S. Davis</i>	Date 10/5/89	10 Branch Manager <i>W. R. Sublette</i>				
			Date 10-5-89				
Completed by Respondee	11 Response: See attached page for response.						
	12 Signature: <i>L. E. Shipkord</i> for: T. O. Hester Date: 11/9/89						
Completed by QA Org.	13 Response Receipt Acceptable <input checked="" type="checkbox"/>	<table style="width:100%; border: none;"> <tr> <td style="width: 50%; padding: 5px;">Initiator <i>Mastra/Mitchell</i></td> <td style="width: 50%; padding: 5px;">Date 31 Jan 91</td> </tr> <tr> <td style="padding: 5px;">QA/Lead Auditor <i>S. Davis</i></td> <td style="padding: 5px;">Date 2/23/90</td> </tr> </table>		Initiator <i>Mastra/Mitchell</i>	Date 31 Jan 91	QA/Lead Auditor <i>S. Davis</i>	Date 2/23/90
	Initiator <i>Mastra/Mitchell</i>	Date 31 Jan 91					
QA/Lead Auditor <i>S. Davis</i>	Date 2/23/90						
14 Remarks: See attached sheet for reason why the response was unacceptable. The work is QA level III + so identified 31 Jan 91							

8. It was noted during the checking of the traceability of the RIB's "Rock Mass Failure" section, that there was a very questionable selection of unconfined and confined intact rock strength data used in the development of the rock mass strength criterion for TSw2. The development of the rock mass strength criterion is presented in the following source documents: PDM 75-07, dated 8/31/87, and entitled "Empirical Analyses of Rock Mass Strength", and a memorandum from Ehgartner to Distribution, dated 9/24/87, and entitled "Empirical Rock Mass Strength Criteria".

PDM 75-07 identified the Nimick and Schwartz (1987) document as the source for the intact rock strength data relating σ_1 to σ_3 . The author of PDM 75-07 stated that the intact rock strength data was taken from table 16 in Nimick and Schwartz (1987). This table provides a very limited amount of intact rock strength data which includes 16 unconfined compression test results and 24 confined compression test results. Unfortunately the variability of compressive strength (σ_1) is very large for each confinement stress (σ_3). Apparently this is a result of the high variability of porosity for the samples tested, in addition to different testing conditions, such as, strain rate, degrees of saturation, and drained or undrained testing. Nimick and Schwartz (1987) noted that these factors are the probable cause for the high variability of the strength data presented in Table 16. Because of these factors (especially the dependence of strength on porosity), another strength relationship was developed and presented in Appendix E of the Nimick and Schwartz (1987) document that relates compressive strength to confinement stress and porosity (Equation 10 in Appendix E of Nimick and Schwartz (1987) document). This equation should be more representative of the intact rock strength since it was developed on a much larger sample of data and considers both the effects of porosity and confinement stress on rock strength. However, the author of PDM 75-07 did not use the strength relationship in Appendix E and instead used the highly variable and limited data presented in Table 16. It should also be noted that this author did not consult with the principal author of the Nimick and Schwartz (1987) document before using the data in Table 16. In addition, the unconfined compressive strengths referenced in PDM 75-07 are inconsistent with the unconfined compressive strengths in Table 16 or any other section of the Nimick and Schwartz (1987) document. This discrepancy is described in more detail in Observation 3.

Activities described in this observation were performed as QA Level III, and therefore not controlled by QA program requirements.

11 Response

Response to Observation 89-3-06

The primary point of this observation seems to be the use of actual data from samples of unit TSw2 for estimates of rock mass strength with confining pressure. The auditor suggests that relationships of sample strength as functions of confining pressure and porosity be used instead. This choice is not clear cut but is a matter of professional judgement. Clearly, the high variability of porosity is a primary contributor to the high variability in strength in unit TSw2. The author of PDM 75-07 chose to deal with this variability directly and provide recommendations for rock mass strength that are based on linear fits of strengths from TSw2 samples. If the relationship with porosity had been used instead, users of the information would have to concern themselves with the porosity variability in order to determine values of rock mass strength. In our opinion, the former better meets the needs of users of the Reference Information Base.

The auditor's observation that "... the unconfined compressive strengths referenced in PDM 75-07 are inconsistent with the unconfined compressive strengths in Table 16..." cannot be confirmed. PDM 75-07 does not list the values used, but the document associated with the PDM confirms that the values were correct.

RESPONSE REJECTION

Observation No. 89-3-06

14. Remarks (cont.)

The second to the last sentence of the first paragraph in the SNL response is questionable, "If the relationship with porosity had been used instead, users of the information would have to concern themselves with the porosity variability in order to determine values of rock mass strength." This is not a reasonable response since it would be better for SNL to concern themselves with porosity variability since there is a significant amount of data showing porosity variability. Because of the variability of the porosity data the analyst could also develop a more reliable expected range of strength values.

The last paragraph of the SNL response is not correct. The unconfined compressive strength was taken from the RIB and not from Table 16 as the auditor was told. In addition, the document associated with the PDM does not confirm that the unconfined compression values are correct.