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Civilian Radioactive Waste Management System
Bechtel SAIC, LLC

Data Qualification Report: Flow Meter Survey Data from Borehole UE-25c#3 for Use on the Yucca Mountain Project

TDR-NBS-HS-000009 REV 00

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EXECUTIVE SUMMARY

This Data Qualification Report uses corroborating data methods according to Attachment 2 of AP-SIII.2Q, Rev. 00, ICN 3, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*, to qualify flowing interval data from a borehole spinner log. This report was prepared in accordance with Data Qualification Plan DQP-NBS-GS-000005, Rev. 00. These data were collected under the Yucca Mountain Site Characterization Project (YMP) Quality Assurance Requirements and Description (QARD) document but are unqualified because unqualified software was used in data reduction.

The unqualified flow log was run in Borehole UE-25c#3 in 1995. Corroborative evidence is available from independent flow logs run in the same borehole in 1984 by an earlier investigator. This corroborative support is unusually strong because it represents a second measurement of the same data. The corroborating data agree well with the data being qualified and support the adequacy of the data. The unqualified software, the TERRASTATION code by TerraSciences Inc., is widely used and accepted by the technical community for non-project applications. The widespread acceptance of the software further supports the adequacy of the data.

In view of the evidence provided by the corroborating data and general acceptance of the software, the Data Qualification Team has concluded that the flowing interval data considered in this report are adequate for generalized use. These data are qualified for use by the YMP and can be appropriately used in a wide variety of applications, so long as consideration is given to accuracy, precision, and representativeness of the data for an intended use in a technical product.

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ACRONYMS AND ABBREVIATIONS

AMOPE	Assistant Manager, Office of Project Execution
AMR	Analysis Model Report
DOE	U.S. Department of Energy
DTN	Data Tracking Number
QAPP	Quality Assurance Program Plan
QARD	Quality Assurance Requirements and Description
TDMS	Technical Data Management System
USGS	U.S. Geological Survey
YMP	Yucca Mountain Site Characterization Project

1.0 INTRODUCTION

1.1 PURPOSE

The data addressed in this qualification report have been cited in an Analysis Model Report (AMR) to support the Site Recommendation in determining the suitability of Yucca Mountain as a repository for high-level nuclear waste. Within the context of this report, a flowing interval is a zone of detectable groundwater flow into or out of a borehole. The spacing of flowing intervals within the volcanic rocks at Yucca Mountain may be used as input in developing saturated zone flow and transport models for the Yucca Mountain Site Characterization Project (YMP) total system performance assessment. This report evaluates the unqualified data within the context of supporting such kinds of studies by the YMP. The unqualified data considered in this report were directly used in AMR S0030, *Probability Distribution of Flowing Interval Spacing,* ANL-NBS-MD-000003 (CRWMS M&O 1999). The AMR presents an analysis of the spacing of flowing intervals in the saturated volcanic rocks beneath Yucca Mountain using as direct inputs the locations of flowing intervals and the dips of fractures encountered in test boreholes at the site.

The purpose of this report is to recommend data that can be cited as qualified for use in technical products to support the Site Recommendation and that may also be used to support the License Application. The qualified data may either be retained in the original Data Tracking Number (DTN) or placed in new DTNs generated as a result of the evaluation. The appropriateness and limitations (if any) of the data with respect to intended use are addressed in this report. References to tables, figures, and sections from CRWMS M&O (1999) are based on Rev. 00 of that document.

In accordance with Attachment 1 of Administrative Procedure (AP)-3.15Q, Rev. 02, *Managing Technical Product Inputs*, it has been determined that the unqualified flowing interval data are used in the direct calculation of Principal Factors for postclosure safety or disruptive events. Specifically, the spacing of flowing intervals directly affects calculation of the retardation of radionuclide migration in the saturated zone.

1.2 SCOPE

This report evaluates the data identified in Data Qualification Plan DQP-NBS-GS-000005, Rev. 00. This plan replaces and is the same as Data Qualification Plan TDP-NBS-GS-000035, Rev. 02, which received concurrence by the U.S. Department of Energy (DOE) Assistant Manager, Office of Project Execution (AMOPE). The Data Qualification Plan identifies nine DTNs containing acquired and developed flowing interval locations and fracture dips. Most of these data were collected by the U.S. Geological Survey (USGS) and are cited in USGS literature. The flowing interval locations directly used by CRWMS M&O (1999) were identified from tracejector and spinner logs, and the fracture dips were identified from acoustic televiewer logs. The data considered in this plan are presented in the DTNs listed in Table 1. Additional DTNs identified in the course of this work may be included in this evaluation.

Table 1. DTNs Considered in this Report

DTN	Short Title
GS900908312211.001	Data for Test Well USW H-1
GS900908312312.001	Data for Test Well USW H-3
GS900908312314.001	Data for Test Well USW H-4
GS920408312314.006	Geohydrologic Data for Test Well USW G-4
GS920408312314.009	Geohydrologic Data for Test Well UE-25p#1
GS930283117461.002	Geology of Drill Hole UE-25p#1
GS931008312313.016	Data for Test Wells UE-25c#1, UE-25c#2, and UE-25c#3
SN9907T0571599.001	Probability Distribution of Flowing Interval Spacing
MO0002C3FLOWRT.001	Production Data for UE-25c#3 from Spinner Survey

One DTN included in this report, SN9907T0571599.001, contains detailed, tabular data and statistical analysis files that support the CRWMS M&O (1999) analysis. These files are Attachment III to the CRWMS M&O (1999) report and were part of the work scope of that report (CRWMS M&O 1999, p. 12). DTN SN9907T0571599.001 was not an input data source and does not require qualification.

The seven USGS DTNs included in this report (those with the 'GS' prefix), were qualified in *Data Qualification Report: Flowing Interval Data for Use on the Yucca Mountain Project,* TDR-NBS-GS-000017. That report was prepared pursuant to Rev. 01 of Data Qualification Plan TDP-NBS-GS-000035 and concurrence with its recommendations was received from DOE AMOPE. The current plan DQP-NBS-GS-000005, Rev. 00 added the remaining DTN, MO0002C3FLOWRT.001, which has become unqualified since the earlier Data Qualification Report was prepared.

The data in the foregoing USGS DTNs were unqualified because they were collected in the early 1980s prior to implementation of the YMP-approved USGS Quality Assurance Program Plan (QAPP). The USGS QAPP was approved by the YMP Office on May 3, 1989. The data in DTN MO0002C3FLOWRT.001 were collected under the YMP Quality Assurance Requirements and Description (QARD) document but became unqualified because of quality assurance issues recently identified with data reduction software. This DTN contains flowing interval location data for Borehole UE-25c#3 and was used in the earlier Data Qualification Report to corroborate unqualified data from that same borehole. The same corroborative evidence will be used in this report to evaluate this additional DTN for qualification.

The additional DTN includes specific data sets in the Technical Data Management System (TDMS). In addition to the data used in AMR S0030, these data sets contain other information that was not directly used by CRWMS M&O (1999) and is not within the scope of this qualification activity This qualification report focuses on the specific data points selected to support CRWMS M&O (1999) flowing interval studies. To the extent that only subsets of data within a specific DTN were used by CRWMS M&O (1999), only those data are evaluated for qualification.

1.3 DATA QUALIFICATION TEAM

The **Responsible Manager** for this Data Qualification Task is Robert F. Wemheuer.

Chairperson

The Chairperson for the Data Qualification Team is Charles R. Wilson. Dr. Wilson has a Ph.D. (1970) in civil engineering with an emphasis in groundwater hydrology. He has 20 years of experience in site characterization for nuclear facilities and served on the data qualification independent Peer Review Panel for the DOE's Waste Isolation Pilot Project license application. Dr. Wilson has had no involvement with the collection or processing of YMP data.

Technical Representative

William Zelinski is a Technical Representative on the Data Qualification Team. Mr. Zelinski has an M.S. Degree in Geology from New Mexico Institute of Mining and Technology. He has 22 years experience in a variety of geoscience activities including five years on the YMP primarily creating computer models of geology and rock properties. Mr. Zelinski has had no involvement with the collection or processing of geophysical data on the YMP.

1.4 BACKGROUND

The data in DTN MO0002C3FLOWRT.001 were collected in 1995 under a YMP-approved quality assurance program. They became unqualified in August, 2000 when the TerraSciences Inc. software code TERRASTATION V5.4 was found to have not been qualified for use on the YMP (LV.ART.DSQD.GFC.08/00-299). This software was used to reformat, manipulate, and display the geophysical log data. The source geophysical logs are presented in DTN TMUE25C3000095.001 and remain qualified. The data analysis is presented in DTN MO00002C3FLWRT.000 and became unqualified because of the software issue. The DTN considered in this report, MO0002C3FLOWRT.001, contains the data directly used in AMR S0030. It became unqualified when its source DTN, MO00002C3FLWRT.000, became unqualified. As previously mentioned, the data qualification effort documented in this report addresses the data in DTN MO0002C3FLOWRT.001 that were directly used in AMR S0030 (CRWMS M&O 1999). The field activities associated with these data are qualified and not at issue.

2. QUALIFICATION APPROACH

2.1 QUALIFICATION METHODS

Qualification methods of corroboration are used in making cross comparisons to evaluate the consistency of the unqualified data with independently acquired data. Procedure AP-SIII.2Q, Attachment 2, states that the corroborating data approach may include comparisons of unqualified to unqualified data as well as unqualified to qualified data. A strong corroboration was obtained because the two sets of data are from the same borehole and rely on different and

independent geophysical techniques to measure the same parameters. Although these data sets are based on different measurement techniques, they can be shown to be mutually corroborative in that they support similar conclusions.

2.2 EVALUATION CRITERIA

The criteria identified in Data Qualification Plan DQP-NBS-GS-000005, Rev. 00, for evaluating the qualification status of the flowing interval data are listed below. These criteria were selected to incorporate the considerations in procedure AP-SIII.2Q, Attachment 2 and the applicable qualification process attributes listed in procedure AP-SIII.2Q, Attachment 3.

1. Are the data collection and analytical methods reasonable in view of standard measurement and instrumentation practice at the time the data were collected?

2. Are the data the best available?

3. Are these data or similarly collected data generally accepted by the technical community for use in non-project applications?

4. Does analysis of comparable qualified and unqualified data sets suggest the same conclusions regarding flowing intervals?

5. Are the conclusions reached regarding flowing intervals beneath Yucca Mountain consistent with conclusions reached based on independent, hydrological data sources?

Although these criteria were considered in determining whether the status of the data should be changed to qualified, the final recommendations of the data qualification team were based on a preponderance of evidence, and not all of the qualification criteria were necessarily applied.

2.3 DATA QUALIFICATION FOR GENERALIZED USES

Because of the inherent variability in earth sciences data, particularly in data remotely acquired such as in borehole logging, the data qualification team has concluded that a finding that the data are qualified means that the data are adequate for generalized uses. Such data can be appropriately used in a wide variety of applications, so long as consideration is given to accuracy, precision, and representativeness of the data for an intended use in a technical product.

Although precise definition of the accuracy and precision of a data point is often not possible, particularly with older data, the team recognizes that even qualified borehole logging data have an inherent variability. This variability can result from natural fluctuations in the field as well as from minor changes in measurement techniques and should be expected. A generalized use of data is therefore a use wherein conclusions are not based on the precise value of a single data point or on minor differences among a small number of data points but are rather based on the cumulative evidence of many corroborating data points. Such use tends to be self-correcting, it simplifies identification of significant errors and outliers, and it focuses on general trends and ranges of values. A generalized use of data is therefore most appropriate for data points with mixed origin and pedigree.

3. EVALUATION RESULTS

3.1 FLOWING INTERVAL LOCATIONS

The unqualified flowing interval data directly used by CRWMS M&O (1999) from DTN MO0002C3FLOWRT.001 were taken from spinner logs performed in June and July, 1995 during production-rate pumping in Borehole UE-25c#3. Two sets of flow logs were available for this borehole, one taken in 1995 and qualified at the time AMR S0030 was written (CRWMS M&O 1997), and the other taken in 1984 and unqualified (Geldon 1996). CRWMS M&O (1999) chose to use the flowing interval data from the then-qualified source (CRWMS M&O 1997, Table B-3).

As previously mentioned, data in DTN MO0002C3FLOWRT.001 are unqualified because the TerraSciences' software code TERRASTATION V5.4 used to create the log plots and crossplots is unqualified (LV.ART.DSQD.GFC.08/00-299). TERRASTATION is a set of codes for manipulating and interpreting geophysical logs and other data that has been widely accepted by the technical community for non-project applications. Better-known users include the USGS, Mobil Oil, and Stanford University. The Data Qualification Team considers TERRASTATION software to be appropriate for the CRWMS M&O (1997) applications.

CRWMS M&O (1997, p. 1) identified flowing intervals in test borehole UE-25c#3 using a full-bore flowmeter survey (spinner log) and water flow logs. The spinner log determines wellbore flow rate by measuring the rate of rotation of a calibrated propeller on the logging tool. The water flow log uses an impulse activation method. A burst of high energy neutrons from a neutron generator activates the oxygen in the flowing water in the wellbore and scintillation detectors spaced along the tool detect the radiation as the activated slug flows past (CRWMS M&O 1997, p. 9). Geldon's earlier survey was based primarily on tracejector and heat flow logs (Geldon 1996, p 9). In tracejector logging, a tracer is injected into the column of water in a borehole and its movement to a detector is timed.

The flow logging measurements are repeated at many elevations in the wellbore, usually under the influence of a steady, artificial gradient imposed by pumping or injection. The results are interpreted in terms of the rate of flow in the wellbore and changes in that flow rate are used to indicate zones where water is entering from the formation or exits the wellbore laterally into the formation. Such zones were interpreted by CRWMS M&O (1999) as flowing intervals supported by conductive fractures (CRWMS M&O 1999, p. 12). Iodine-131 is commonly used as a tracer in tracejector surveys because it has a low (8-day) half-life, it is water soluble, and it is detectable at minute concentrations. Iodine-131 was used as a tracer in the tracejector surveys addressed in this report. A detailed discussion of the use of radioactive tracers in tracejector surveys is presented by Edwards and Holter (1962). Flow logging techniques are described in the USGS Techniques of Water Resources Investigations publication *Application of Borehole Geophysics to Water-Resources Investigations* (Keys and MacCary 1971, p 109-118).

CRWMS M&O (1997) spinner survey and water flow log measurements in Borehole UE-25c#3 are shown along with the results of other geophysical logs in CRWMS M&O Logplot 1

(CRWMS M&O 1997, p 26). Also shown on the logplot for comparison are Geldon's 1984 tracejector results. CRWMS M&O (1997) 1995 spinner and water flow logs and Geldon's 1984 tracejector log are in good agreement. Each of the three logs clearly identifies strong producing zones at about 2440 and 2830-foot depths. According to CRWMS M&O (1997) spinner log production rate data, these two producing zones accounted for 83 percent of the total flow from the well (CRWMS M&O 1997, Table B-3). Remaining measurable inflows were from three minor zones, the greatest of which provided less than 7 percent of the total production.

CRWMS M&O (1997) compared results with those of Geldon to provide corroborative support for the measurements. CRWMS M&O (1997) conclusions were similar to those of the Data Qualification Team. CRWMS M&O (1997) found that "Close agreement between the Full-Bore Flowmeter [spinner] and Water Flow Log provide confidence in the accuracy of the calculation of water flow rates. The radioactive tracer [tracejector] survey which was run 10 years earlier also indicates close agreement with the Full-Bore Flowmeter and Water Flow Log, though the absolute flow rates are slightly greater" (CRWMS M&O 1997, p. 5). CRWMS M&O (1997) also states that "The temperature survey conducted on May 7, 1984 is in excellent agreement with the flow profile obtained in June 1995." (CRWMS M&O 1997, p. 10). In summary, it states "Comparison of flow measurements taken 10 years earlier indicated flow from the same zones in the borehole, and resulted in comparable flow rates and percentage of contribution." (CRWMS M&O 1997, p. 1). The comparison of CRWMS M&O (1997) data with Geldon's earlier data strongly corroborates his results and supports the adequacy of these data for use by the YMP.

Flowing interval locations were calculated by CRWMS M&O (1999) from the depths at which the slopes of the survey logs changed (CRWMS M&O 1999, p. 12). In a comparison of the logs run in 1995 in Borehole UE-25c#3 with the earlier unqualified logs run in 1984, CRWMS M&O (1997, p. A-2) states, "Category I [1995 data] log depths correlated to the density log run 4/27/84 at the top of the logged interval, but the density log runs one foot deeper at the bottom portion of the logged interval. This is considered negligible for the purposes of this analysis and future flow rate calculations." Based on this information, the overall error in depth measurement in UE-25c#3 is expected to be on the order of +/- 1 foot. Because of the generalized nature of CRWMS M&O (1999) results and the use of the differences in depths rather than the absolute magnitude of the depth, this error is considered negligible.

3.2 FRACTURE DIPS

The dips of fractures in and near the flowing intervals were used by CRWMS M&O (1999) to correct the effect of the angle of intersection between the plane of the fracture and the borehole (CRWMS M&O 1999, p. 12). Dip data for Borehole UE-25c#3 were not provided by CRWMS M&O (1997) and were instead taken from Geldon (1996, Table 12). The dip data were addressed in the earlier Data Qualification Report TDR-NBS-GS-000017 and have been qualified.

3.3 SUMMARY OF EVALUATION RESULTS

Corroborative methods of data evaluation were emphasized by the Data Qualification Team. Corroboration was straightforward because similar measurements had been made in the same

well by another investigator 10 years earlier. Although the two sets of measurements were made using different techniques, the results were in good agreement. The Data Qualification Team found that the flowing interval data considered in this report are suitable for use by the YMP. The data collection and analysis methodologies are documented in a report (CRWMS M&O 1997), providing information to help prospective data users determine the appropriateness of the data for specific applications. These data may be appropriately used in a wide range of applications so long as consideration is given to the accuracy, precision, and representativeness of the data for an intended use in a technical product.

4. EVALUATION CONCLUSIONS

The conclusions of the Data Qualification Team's review of flowing interval data are presented below in terms of the five evaluation criteria presented in the controlling flowing interval Data Qualification Plan (DQP-NBS-GS-000005, Rev. 00).

1. Are the data collection and analytical methods reasonable in view of standard measurement and instrumentation practice at the time the data were collected?

The data considered in this report are unqualified because of quality assurance issues with the TerraSciences' software code TERRASTATION V5.4 used in data analysis. TERRASTATION has been widely used and accepted by the technical community and its use is considered reasonable in view of standard measurement and instrumentation practice at the time the data were collected.

2. Are the data the best available?

The data considered in this report were likely selected for use because they were Qualified at the time AMR S0030 was prepared and the alternative data set for the same borehole was Unqualified. At the time the AMR was prepared, these data were the best available from a quality assurance standpoint. The information reviewed in this report indicates that the two data sets are corroborative and use of either set would produce similar results.

3. Are these data or similarly collected data generally accepted by the technical community for use in non-project applications?

Spinner log data and TerraSciences software are widely used and accepted within the technical community as standard components of borehole logging suites for hydrologic site characterization. These data and analysis methods would be acceptable for use in non-project applications.

4. Does analysis of comparable qualified and unqualified data sets suggest the same conclusions regarding flowing intervals?

Comparable data from tracejector and temperature logs have been shown to identify flowing interval locations in Borehole UE-25c#3 that are consistent with those defined by the spinner log results addressed in this report.

5. Are the conclusions reached regarding flowing intervals beneath Yucca Mountain consistent with conclusions reached based on independent, hydrological data sources?

There is close agreement between the major flowing intervals identified by the spinner logs and those identified using independent tracejector logs. Because the results of these logs are essentially the same, either log could be used with essentially the same results.

5. RECOMMENDATIONS

Based on a preponderance of evidence, the spinner log data used by CRWMS M&O (1999) are qualified for generalized uses as defined in Section 2.2 of this report. These data may be appropriately used in a wide range of applications so long as consideration is given to accuracy, precision, and representativeness of the data for an intended use in a technical product. Because these data are a subset of a larger data set presented in an unqualified source DTN, they have been separately identified and assigned a new DTN as identified in the Table 2.

Table 2. Assigned Replacement DTN

Original DTN	New DTN	Comments
MO0002C3FLOWRT.001 SEP Table S00128_001	MO0012FLOW25C3.001	Replace the old DTN with the new, qualified DTN. The old DTN will remain unqualified.

The newly created DTN listed above may be used in place of the associated unqualified DTN provided that the data used in the AMR are the same as those contained in the newly created DTN. The old DTN will remain unqualified.

6. REFERENCES

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1997. *Analysis of Flow Rate Logs from Borehole UE-25c#3 in Support of Characterization of the Site Saturated-Zone Groundwater Flow System at Yucca Mountain, Nevada.* BAA000000-01717-0200-00002, REV 00. Las Vegas, Nevada: CRWMS M&O. DTN: TMUE25C3000095.001, ACC: MOL.19971031.0053.

(CRWMS M&O 1997)

CRWMS M&O 1999. *Probability Distribution of Flowing Interval Spacing,* ANL-NBS-MD-000003, REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000602.0052.

(CRWMS M&O 1999)

Edwards, J.M. and Holter, E.L. 1962. Applications of a subsurface solid-state isotope injector to nuclear-tracer survey methods. *Jour. Petroleum Technology,* v. 14, February, p. 121-124. TIC: 248040.

(Edwards and Holter 1962)

Geldon, A.L. 1996. *Results and Interpretation of Preliminary Aquifer Tests in Boreholes UE-25c#1, UE-25c#2, and UE-25c#3, Yucca Mountain, Nye County, Nevada.* WRI 94-4177. USGS Denver, Colorado. DTN: GS931008312313.016. ACC: MOL.19980724.0389.

(Geldon 1996)

Keys, W.S. and MacCary, L.M. 1971. Application of Borehole Geophysics to Water-Resources Investigations. *USGS Techniques of Water Resources Investigations Book 2 Chapter E1.* Washington, D.C. ACC: NNA.19900103.0187.

(Keys and MacCary 1971)