

OCRWM  
QUALITY CONCERNS PROGRAM  
FINAL INVESTIGATION REPORT  
Quality Concern No. 93-019

B. C. Scott  
B. C. Scott, Investigator

11/5/93  
Date

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PDR WASTE  
WM-11 PDR

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OCRWM QUALITY CONCERNS PROGRAM  
FINAL INVESTIGATION REPORT  
QCP NO. 93-019

**A. ALLEGED CONCERN:**

"The Chairman  
Nuclear Waste Technical Review Board  
Washington, DC

"The DOE is about to grout the water-making section of the hole UZ-14 at a depth of approximately 1250 feet. This action has the potential of irrevocably compromising the site. The DOE has not made an objective analysis of the consequences of this step and is not capable of doing so in a dispassionate manner. There are instances of grout travelling long distances through fractures. Please recall what happened at hole UZ-1 which is a few tens of feet from UZ-14. In UZ-1 drilled about ten years ago they encountered water at about the same depth. There was conclusive evidence that drilling fluid lost hole USW G-1 two years earlier had travelled updip at least 1000 feet to UZ-1. Thus, the possibility of grout travelling downdip from UZ-14 to the repository block is anything but negligible. The department of energy appears to be deliberately oblivious to that possibility. It is true that without sealing the water-making section it is impossible to ensure the sanctity of the tests to be performed below at the water table at UZ-14. But what is more important - sanctity of the tests or integrity of the site? Why not try other alternatives first?

"Please intervene. You might be preventing a massive waste of public funds."

**B. CONCLUSION:**

The Quality Concerns Program (QCP) could not substantiate the alleged concern as detailed in the Technical Report provided as Attachment 1.

**C. INVESTIGATION:**

On 9/27/93 the investigator met with Raytheon Services Nevada (RSN) Manager/TPO. The purpose of this meeting was to inform RSN management of the quality concern investigation and details of the alleged concern. The Manager requested that the RSN Sr. Project Engineer be contacted for specific details regarding the alleged concern.

On 9/27/93 the investigator met with the RSN Sr. Project Engineer, Surface Based Testing. He informed the investigator that on September 13, 1993, borehole USW UZ-14 had been grouted in order to seal off perched water encountered at a depth of approximately 1250 ft. When asked what authorized the grouting activities, he stated the M&O had issued two (2) documents (1. Test Interference Evaluation for Borehole USW UZ-14 drilling, testing and instrumentation; and 2. Waste Isolation Evaluation, Tracers, Fluids and Materials for the USW UZ-14 Perched Water Grouting Plan) authorizing the grouting activities of Borehole USW UZ-14. He also stated that the DOE/YMPO/RSED authorized RSN to conduct the grouting activities of UZ-14 (RVC:93-077).

Knowing that the Drilling and Testing operations of Borehole USW UZ-14 are classified as quality affecting as required by RSN Work Program No. YMP/WP/93-09 Revision 0; Job Package No. 92-17 and Test Planning Package No. T-92-016, the investigator requested copies of the approved grouting procedure and applicable inspection documentation which verified acceptance of the grouting activities.

On 9/28/93 the Sr. Project Engineer informed the investigator that the grouting activities had not been classified as quality-affecting because the grouting application is considered a scientific prototype experiment using a new type of cement (Micro Matrix) and as such no quality assurance controls had been implemented involving the grouting process. The Sr. Project Engineer could not produce a project document(s) identifying the grouting activities as a non-quality affecting activity.

The determination of importance of this activity had not been made or documented by RSN based on the importance of the item with which the activity is associated and in accordance with the requirements of RSN's approved QA Program (YMP No. AP-6.17Q para. 2.0).

The Sr. Project Engineer did provide procedure "UZ-14 Perched Water Cementing Plan." The procedure is composed of nine pages consisting of a borehole

schematic, the cementing program for UZ-14, cementing information, assumptions and engineering calculations supporting the cementing program. DOE/YMPO/RSED and RSN engineering personnel supervised the cementing operations (RVC:93-077). RSN documentation of the cementing activities and implementation of the cementing plan are contained in RSN's Daily Operations Reports.

The cementing plan was submitted to LANL for Tracers, Fluids, and Materials (TFM) review. LANL requested the M&O to perform a Waste Isolation Evaluation (WIE). The M&O issued Waste Isolation Evaluation, Tracers, Fluids, and Materials for the USW UZ-14 Perched Water Grouting Plan on September 10, 1993 which concluded that the planned activities for borehole sealing will not adversely impact waste isolation if grouting pressures are limited to prevent hydraulic fracturing and the grout seal is checked after completion to demonstrate that perched water will not move down the borehole.

The RSN grouting plan (UZ-14 Perched Water Cementing Plan, RVC:93-077) addresses the maximum bottom hole pressure and checking the grout after completion.

RSN proceeded with the cementing operations as a non-quality affecting activity because the cementing operations had no effect on worker safety or waste isolation. (RSN Report of Cementing Operations at USW UZ-14 Borehole First and Second Cementing Jobs No. YMP:0226:94 dated 10/21/93, page 6.)

On 10/18/93 the QCP obtained the technical services of Mr. Peter Aberle, Grouting Specialist with the Bureau of Reclamation, U. S. Department of the Interior. Mr. Aberle was to determine if controls are in place to preclude the possibility of grout travelling from borehole UZ-14 to the repository. His report is provided as Attachment 1.

**D. CORRECTIVE ACTION:**

No corrective action is required regarding the alleged concern.

**E. DOCUMENTS EXAMINED:**

1. RSN Work Program No. YMP/WP/93-09, Revision 0, USW UZ-14 Borehole Work Program, dated 3/25/93

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2. Test Planning Package No. T-92-16 Revision 0, Borehole USW UZ-14 Drilling and Testing, dated 3/19/93
3. Job Package No. 92-17, Revision 0, UZ-14, Drilling and Testing, dated 4/1/93
4. RSN Field Verification Plan No. FVP-93-037 Revision 0
5. RSN Quality Assurance Grading Reports (QAGR): No. RSN-GR-003, Revision 0; Drill Hole Engineering, Monitoring, and Reporting for YMP Surface Based Programs; No. RSN-GR-035, Revision 0, Borehole Video Surveying for YMP Surfaced Based Testing Programs; No. RSN-GR-037, Revision 0; Geophysical Logging, Surveying or Other Wireline Services for the UZ and SD Boreholes.
6. Waste Isolation Evaluation, Tracers, Fluids, and Materials for the USW UZ-14 Perched Water Grouting Plan No. BAAA00000-01717-2200-0064, Revision 00, dated 9/10/93
7. Test Interference Evaluation for Borehole USW UZ-14 drilling, testing and instrumentation, No. BAAA00000-01717-2200-00067 Revision 1, dated 9/10/93
8. RSN Record of Verbal Communication No. RVC:93-077, UZ-14 Perched Water Cementing Plan, dated 9/27/93
9. RSN Record of Verbal Communication No. RVC:93-078, UZ-14 Perched Water Cementing Plan, dated 10/1/93
10. RSN Report of Cementing Operations at USW UZ-14 Borehole First and Second Cementing Jobs No. YMP:026:94, dated 10/21/93
11. RSN Record of Verbal Communication No. RVC:017:94, UZ-14 Perched Water Cementing Plan, Job #3, dated 10/21/93.

## MEMORANDUM

TO: Ms. Nancy Voltura, OCRWM Quality Concerns Manager

FROM: Peter P. Aberle P.E.   
Construction Liaison Engineer  
U. S. Bureau of Reclamation  
P. O. Box 25007  
Denver, Colorado 80225

DATE: October 28, 1993

SUBJECT: Review of Drilling and Grouting  
Data on Drill Hole No. USW UZ-14  
Performed by the Department of Energy in regard to an alleged concern.

ALLEGED CONCERN:

"The Chairman  
Nuclear Waste Technical Review Board  
Washington, DC

"The DOE is about to grout the water-making section of the hole UZ-14 at a depth of approximately 1250 feet. This action has the potential of irrevocably compromising the site.

"The DOE has not made an objective analysis of the consequences of this step and is not capable of doing so in a dispassionate manner. There are instances of grout travelling long distances through fractures. Please recall what happened at hole UZ-1 which is a few tens of feet from UZ-14. In UZ-1 drilled about ten years ago they encountered water at about the same depth. There was conclusive evidence that drilling fluid lost hole USW G-1 two years earlier had travelled updip at least 1000 feet to UZ-1. Thus, the possibility of grout travelling downdip from UZ-14 to the repository block is anything but negligible. The department of energy appears to be deliberately oblivious to that possibility. It is true that without sealing the water-making section it is impossible to ensure the sanctity of the tests to be performed below at the water table at UZ-14. But what is more important - sanctity of the tests or integrity of the site? Why not try other alternatives first?

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### Introduction

Borehole No. USW UZ-14 is located on a previously constructed drill pad which was used to drill Borehole No. USW UZ-1. The two holes are separated by a distance of 89 feet at the surface. Borehole USW UZ-14 is presently being drilled and USW UZ-1 was drilled in 1983 to a depth of 1270 feet at which depth the hole was abandoned due to drilling problems. The borehole is now sealed between 1180 and 1270 feet. The present depth of Borehole USW UZ-14 is 1282 feet at which depth an infiltration of ground water was detected. Borehole USW UZ-14 is being drilled utilizing a state-of-the-art dry drilling method which requires that a dry hole environment be maintained for the drilling process. In order to maintain the integrity of the hole for scientific research and testing, it was deemed necessary to halt the infiltration of water into the borehole.

During the design of Borehole USW UZ-14 it was recognized that there could not be an exchange of water between any perched zones and the permanent water table. It was anticipated that the unsaturated zones below any perched water table would be protected by low capacity pumping, temporary casing, or borehole grouting. How low capacity pumping or how the installation of temporary casing to seal off the zone would be accomplished was not defined in the plan. It is not believed that these two suggested methods would seem feasible or could be considered as a permanent seal for any perched water zones to be encountered. Another method which was not identified which could be used to seal off the water is to overream the 12.25 inch

diameter borehole to a diameter of about 18 inches with an underreamer, that area of the borehole which is producing water and cement the area which was overreamed. However, this method can be considered very risky in regard to the loss of drill tools in the borehole and jeopardize the integrity of the hole. It should only be used as a last resort alternative.

The grouting method that was originally contemplated and eventually performed is the most viable method from an economic standpoint and also the most effective method to seal off the infiltrating water without hindrance to future drilling, instrumentation installation, compromising the integrity of the surrounding insitu rock formation, or other required future testing or logging in the borehole.

#### GROUTING PLAN

During drilling of borehole USW UZ-14, two water-producing intervals were encountered at depths of 1256 feet and 1265 feet respectively. The interval at 1265 feet was producing the majority of the inflows. It was necessary to seal off these water-producing intervals to prevent the water from entering the hole before drilling could proceed to greater depths.

The method chosen to seal off the water-producing interval was grouting with a cement based grout.

During the design of borehole USW UZ-14, it was contemplated that grouting might be necessary if perched water was encountered, see reference "Test Planning Package T-92-16, page 8, March 26, 1993" and "Work Program by Raytheon Services Nevada, page 8, March 25, 1993." Therefore, when water infiltrated the borehole during drilling, grouting of the borehole was not a spontaneous reaction to the problem of infiltrating water.

During the design stages of the grouting plan, a Test Interference Evaluation Plan was performed (document no. BAAA 00000-01717-2200-000L1 REV 1) whereby existing and future planned boreholes located within 3,000 feet of Borehole USW UZ-14 were identified. Interference of the grouting program with any of these boreholes was not expected except for borehole USW UZ-1 which is located 89 feet from USW UZ-14 at the surface. It was suggested that USW UZ-1 be monitored for evidence of communication; however, no method or type of monitoring to be used was identified in any of the reports reviewed. It was reported (personal conversation with Eddie Wright and Roy Long) that obstructions left in USW UZ-1 at the time of abandonment made any monitoring impossible. (Reference Cementing Operations at UZ-14 Borehole by Eddie Wright, 10/21/93, page 7.)

The distance, 1826 feet, from Borehole UZ-14 to the repository and other underground facilities, proximity to significant geologic features, proximity to the water table, proximity to other surface-based testing studies, were also taken into consideration.

Hydraulic fracturing of the formation in the zone to be grouted due to the static head of the grout column was considered to be a distinct possibility and pressures were therefore to be limited to 85 percent of the minimum anticipated fracture pressures.

A comprehensive grouting plan (UZ-14 Perched Water Cementing Plan, RVC:93-077) was developed which included step-by-step directions as to how the operation was to be performed with emphasis on the amount of cement grout to be injected and measuring of the grout column in the grout tubing so as not to exceed the designed bottom hole pressure and cause the rock to fracture.

#### GROUTING OF BOREHOLE USW UZ-14

Initial grouting of borehole USW UZ-14 was performed on September 13, 1993. A Lynes Production Injection Packer, manufactured by Baker Service Tools, was attached to 2-3/8 in. tubing and placed into the borehole. The Packer was set at a depth of 1265 feet. The hole depth was recorded as 1282 feet with an estimated 9 feet of unconsolidated drill cuttings lying at the bottom of the hole. The actual grouting stage measure 8 feet, depth 1265 to 1273 feet.

The cement used for the grout was a Halliburton Services product called Micro Matrix. This cement has a Blaine fineness ranging from 20,000 to 35,000 square centimeters per gram (personal conversion with Mr. Onan, Halliburton Services) which is approximately 7 times finer than regularly produced cement. This product was chosen

because of the low permeability of the water producing fracture zones and it could therefore be more easily injected into the formation, and sealing off the inflowing water without having to use very high injection pressures and possibly jacking the fractures apart or hydrofracturing the rock thereby causing new fractures.

The diameter of the borehole which was grouted is 12.25 inches. This diameter equates to a hole volume of 6.12 gallons (0.82 cubic feet) per linear foot of hole.

The initial grouting phase consisted of 3 separate cement grout injections of 94.5 gallons, 84 gallons and 52.5 gallons weighing 12.5 lbs. per gallon respectively. The level of the grout column in the grout tubing was measured each time to make assurances that the static level of the grout column would never exceed 85 percent of the computed fracture pressure of the insitu rock.

The residual grout column remaining in the borehole after the packer and grout tubing were retrieved was measured to be 25.24 feet, determined from coring data of the grouted column (depth of 1249.24 to 1272.48). This equates to a volume of 154.47 gallons of in-place grout within the borehole. The volumes of grout remaining in the fractures surrounding the borehole is 76.6 gallons (10.24 cu. ft.).

The differences in the dimensions of the grouted stage of 9 ft. depth 1265 to 1273, and the residual grout column of 25.24 feet depth 1239.24 to 1274.48 can be

explained by the fact that after the Lynes Packer was released, the grout column in the grout tubing became part of the residual column and also after releasing the pressure some of the grout that had traveled into the formation returned back to the borehole.

In the hole interval 1265 to 1273 feet which is the interval subjected to grout under pressure, the core log identifies 12 natural fractures. With an assumption that these 12 natural fractures have an average aperture of .004 inches the void ratio of the rock can be calculated as 0.86 cubic inches per cubic foot of rock (.000497%) which can be considered conservative. Although the grouted stage length was 9 feet, the grout will not only travel away in a lateral direction, but will also travel in the vertical direction, up and down from the stage being grouted. With a void volume of 0.86 cubic inches per cubic foot of rock and an injected volume of 10.24 cu. ft., approximately 20,500 cubic feet of rock could have been affected by the grout which equates that none of the grout most likely traveled farther than 20 feet from the borehole.

### Conclusions

The grouting of USW UZ-14 in stage length 1265 to 1273 feet was accomplished in a very professional manner. A well thought out plan was developed which addressed all pertinent aspects as to how the insitu rock in the vicinity of the hole would or may be affected. In order to halt water inflow into a borehole, it is not necessary to grout large

masses of rock surrounding the borehole, nor is it necessary to force the grout over long distances from the borehole. Only the amount of grout required to seal out the water was injected into the rock formation.

The polymer drilling fluids which were used during the drilling of USW G-1 and were detected in USW UZ-1 are not and cannot be considered a grout. Polymer drilling fluids change to a Newtonian fluid soon after they are injected into the drill hole and resume a viscosity nearly that of water. The cement grout mixture as was designed for USW UZ-14 is a Bingham fluid and the cement and water begin a chemical reaction after mixing and begin to form a jell soon after injection into the rock formation and solidify within 4 to 8 hours. It is inconceivable that cement grouts consisting of mixes as designed can travel great distances through a rock media such as exists in borehole USW UZ-14. The rock fractures have small apertures and as the cement particles travel through the fractures, they tend to quickly bridge or wedge themselves and block off their own path. Assuming a very conservative void ratio for the insitu rock of .0004976, it can be stated that no more than 20,000 cu. ft. of rock was filled with grout and that the grout did not travel more than 20 feet from the borehole. The distance to the repository from the borehole is 1826 feet.

Other alternatives for sealing off inflows into the borehole were considered; however, grouting, utilizing a cement grout was deemed the most feasible method to eliminate

the water inflows and maintain the integrity of the hole and the surrounding rock formation.

The UZ-14 Perched Water Cementing Plan developed to perform the actual field operation for grouting the infiltrating water was a very explicit plan. It detailed the step-by-step operations in a sequential order. It was the most detailed plan that I have ever reviewed and was executed in the field according to plan.

Peter P. Aberle P. E.



#### References

1. USW UZ-1 Seeker Gyro Survey
2. USW UZ-14 Directional Survey
3. USW UZ-14 Structural Log (1230 to 1282 feet)
4. USW UZ-14 Perched Water Cementing Plan (LOG#: RVC: 93-077)
5. USW UZ-14 Cement Operations Report by Eddie Wright, 10/21/93
6. USW UZ-14 Drilling and Testing Job Package 92-17
7. USW UZ-14 Drilling and Testing Test Planning Package T-92-16
8. USW UZ-14 Addendum 2 to the Test  
Interference Evaluation (TTP) T-92-16
9. USW UZ-14 Daily Drill Reports dated Aug. 2, 1993, to Oct. 27, 1993
10. USW UZ-14 Detailed Graphic Structural Log  
depth interval 1230.0 to 1282.0
11. USW UZ-14 USW UZ-14 Borehole Work Program by Raytheon Services  
Nevada