DOE/NV/10845--T3

**FIELD INVESTIGATION AT THE FAULTLESS SITE
CENTRAL NEVADA TEST AREA**

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DE93 005915

by

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November 1992

Received by OST

JAN 19 1993

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Field Investigation at the Faultless Site Central Nevada Test Area

An evaluation of groundwater monitoring at non-Nevada Test Site underground nuclear test sites (Chapman and Hokett, 1991) raised questions about the potential for radionuclide migration from the Faultless event and how to best monitor for such migration. With its long standing interest in the Faultless area and background in Nevada hydrogeology, the Desert Research Institute conducted a field investigation in FY92 to address the following issues:

- the status of chimney infilling (which determines the potential for migration)
- the best level(s) from which to collect samples from the nearby monitoring wells, HTH-1 and HTH-2 (Figure 1)
- the status of hydraulic heads in the monitoring well area following records of sustained elevated post-shot heads.

The field investigation was conducted from July 27 to 31 and August 4 to 7, 1992. Temperature and electrical conductivity logging were performed in HTH-1, HTH-2, and UC-1-P-2SP. Water samples were collected from HTH-1 and HTH-2. Lawrence Livermore National Laboratory (LLNL) also collected samples during the July trip, including samples from UC-1-P-2SR.

This report presents the data gathered during these field excursions and some preliminary conclusions. Full interpretation of the data in light of the issues listed above is planned for FY93.

HTH-1

The depth to water at HTH-1 was measured as 532.2 ft below land surface (bls) on July 28, 1992. This is at an elevation of 5478.8 ft referenced to mean sea level (msl) and is almost 20 feet higher than the pre-event water level elevation of 5459 ft msl. Though the well is cased to 3704 ft (Figure 2), an obstruction was encountered at 2818 ft that prevented deeper penetration. No record of this obstruction could be found, though records of previous water sampling indicate that it may have occurred as a result of the Faultless event. Water samples were collected from HTH-1 in 1967, prior to the Faultless event, and included a sample from the screen at 2950 to 3010 ft. The next recorded sampling, in 1969 (a year after the shot), only included a sample collected at 2887 ft (Thordarson, 1985). It is likely that this sample was collected at the maximum depth at that time. The reason for the apparent additional loss of hole from 2887 in 1969 to 2818 in 1992 is unknown, but could be the collection of loose fill.

Logging was performed on August 5, 1992. Measured downhole temperatures ranged from 17.6 to 44.0°C (Figure 2). Electrical conductivity varied from 507 to 599 $\mu\text{mhos/cm}$ at 25°C (Figure 2). Samples were collected on July 28 and 29 from the middle of the eight accessible screened horizons. Samples could not be collected at the screens located 2950–3010 and 3590–3665 ft bls because the obstruction at 2818 ft prevented lowering the bailer to those depths. Field parameters measured when the samples were drained from the discrete sampler are given in Table 1. The lower temperatures of the deeper samples as compared to the downhole measurements (*e.g.*, for the sample from 2675 ft: 26.5°C measured from the bailer as compared to a logged value of 41.5°C) are attributed to cooling as the bailer was pulled through the water column.

Electrical conductivity measurements at the surface and downhole were comparable, varying between 508 and 542 $\mu\text{mhos/cm}$ at 25°C. pH varied from 8.15 at the bottom screen to 8.44 at 2250 ft. Alkalinity, determined by field titration with sulfuric acid, ranged from 189 mg/L as HCO_3 at 775 ft to 226 mg/L at 2250 ft.

The chemical analyses for the eight samples are contained in the Appendix.

HTH-2

The depth to water at HTH-2 was measured as 553.2 ft bls on July 29, 1992. This water level is at an elevation of 5472 ft msl, and is almost 12 feet higher than the pre-event water level in this hole (5460 ft msl). The bottom of the hole was tagged at 987 ft, slightly more shallow than the 1001 ft of casing recorded as being in the hole (Figure 3). Judging by the appearance of the bottom sample (brown and cloudy), it is likely that loose formation materials have filled in the bottom 14 ft of the casing.

Logging was performed on August 6, 1992. Measured downhole temperatures ranged from 17.9 to 20.7°C (Figure 3). Electrical conductivity was lower in HTH-2 than in HTH-1, ranging from 234 to 393 $\mu\text{mhos/cm}$ at 25°C (Figure 3). Two samples were collected in July 29, 1992 at 750 and 975 ft bls. HTH-2 has slotted casing throughout its saturated interval; the sampling horizons were chosen to match the perforated horizons in HTH-1. Field parameters measured when the water was drained from the discrete sampler are given in Table 2. Logging and surface temperatures are comparable for the sample intervals, though downhole conductivity measurements are higher (approximately 300 $\mu\text{mhos/cm}$ at 25°C for both samples at the surface, compared to 364 and 381 downhole). The lower values are supported by the laboratory measurements, given in the Appendix. Alkalinity was also lower in HTH-2 as compared to HTH-1, with measurements of 161 and 177 mg/L as HCO_3 .

An additional sample was collected on August 6 at a depth of 650 ft because the logging identified a lower salinity zone from the water table to a depth of about 675 ft. This analysis is also in the appendix, though no field parameters were recorded.

UC-1-P-2SR

The depth to water at UC-1-P-2SR was measured as 750.6 ft bls (elevation of 5333.9 ft msl) on August 6, 1992. An obstruction was encountered at 2614.8 ft bls, slightly higher than the obstruction at 2631.9 reported by Thordarson (1985). Measured downhole temperatures ranged from 18.4°C near the water table to 52.8°C at the bottom of the hole (Figure 4). The increase in temperature primarily occurs in the bottom 300 ft of the hole. Electrical conductivity ranges from 277 to 740 $\mu\text{mhos/cm}$ at 25°C (Figure 4) with two depths where sharp increases occur: a jump from approximately 280 to 375 $\mu\text{mhos/cm}$ at 25°C between 975 and 1000 ft bls, and a rise from 450 to 675 $\mu\text{mhos/cm}$ at 25°C at 2150 ft bls. DRI did not collect samples from this hole because of the expected radionuclide concentrations; samples were collected by LLNL on July 28 and 29.

Preliminary Interpretations

The uniformity in pH and EC throughout the water column in HTH-1 and the steady increase in temperature with depth suggest a well-mixed water column rather than discrete horizons at each screen. The water level measurement indicates that head in the hole is still elevated from pre-shot water table measurements, and the chemistry results suggest that the reason for this may be the contribution of water from a deeper, higher pressure horizon, to the overlying units. The candidate for this is the densely welded tuff horizon across from the screen at 2400 to 2460 ft bls.

The contrast between the chemistry in the shallow part of HTH-1 and in HTH-2 is distinct and indicates that HTH-1 is no longer representative of natural conditions in the upper aquifers. Comparing the field parameters from HTH-2 with shallow samples from HTH-1 collected during or shortly after drilling (Dinwiddie and Shroder, 1971) suggests that the shallow horizon penetrated by the two

wells was chemically similar at the time of drilling. The higher salinity, warmer, water moving upward from the welded tuff penetrated by HTH-1 has not migrated laterally through the shallow zone from HTH-1 to HTH-2 (approximately 500 ft). Thus, the two wells currently sample different water masses. Within HTH-2 itself, there are two distinct water types indicated by the electrical conductivity logs, with the lowest salinity water above 700 ft bls. This distinction is not seen in the water samples, but may be a function of sampling too deep to capture the shallower zone (the uppermost sample was collected at 650 ft bls). Though HTH-1 and HTH-2 are sampling different zones of water quality, the head levels in both of these zones have been elevated since the Faultless event, though to differing degrees. Before the shot, the water table elevation in both holes was approximately 5460 ft msl. Now, the water level in HTH-1 is almost 5479 ft and in HTH-2 is almost 5472 ft. There are three possible causes for the increased water levels: pressure buildup from the explosion (a transient effect), seismic compression (gravitational collapse) causing a permeability decrease, or a localized pressure mound caused by the intersection of the higher pressure zone in the welded tuff intersected in HTH-1.

The water level in UC-1-P-2SR is almost 200 ft below the estimated pre-event elevation of 5532.5 ft msl (Thordarson, 1987). The temperature log for the post-shot hole, UC-1-P-2SR, is essentially identical to that in HTH-2 in the upper 1000 ft bls, with both of these being markedly cooler than the water in HTH-1. This suggests that water is infilling the cavity from above or laterally, and is relatively unaffected by cavity conditions below. The temperature and electrical conductivity logs show three distinct zones in UC-1-P-2SR: an upper zone of conductivity below 300 $\mu\text{mhos/cm}$ at 25°C and temperatures below 25°C, a middle zone of very constant conductivity and water temperature (approximately 375 $\mu\text{mhos/cm}$ at 25°C and a water temperature of 26 to 27°C), and a lower zone defined by a very sharp increase in conductivity at 2150 ft bls to around 675 $\mu\text{mhos/cm}$ at 25°C and rapid increases in temperature with depth to the maximum at the bottom of the accessible hole, 52.8°C. Presumably this lower zone is affected by cavity conditions. These zones appear at different levels than those identified by Thordarson (1987) and their characteristics have changed. In particular, the conductivity of the lower zone is much higher now as compared to the data from Thordarson.

Future Work

The preliminary interpretations discussed above will be examined more fully in FY 1993. Historic water level trends will be included with the present data to allow estimation of chimney filling and increase understanding of excess pressures outside the chimney area. This will include an attempt to verify pre-shot heads, particularly in the vicinity of UC-1-P-2SR, through literature review. Simple modeling of the Faultless environment may be necessary to isolate plausible scenarios for the observed hydraulic response to the test. The chemical and isotopic data will be examined to develop a more clear definition of the discrete water quality zones intercepted by each well, from which recommendations of sampling horizons will be made.

Additional field work may also be performed. In particular, a thermal flowmeter could measure the magnitude and direction of water flow in the boreholes (measurements were attempted during this field excursion but were unsuccessful due to problems with the packer). This could reveal if water is indeed entering HTH-1 from the welded tuff, and whether this unit is contributing to UC-1-P-2SR.

References

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Table 1. Field Parameters Measured on Samples From HTH-1

Date (m-d-y)	Time (hr:min)	Depth (ft)	Temp. (°C)	E.C. (μ mhos/ cm@25C)	pH	HCO ₃ (mg/L)
7-28-92	11:00	775	23	536	8.23	189
7-28-92	12:20	1050	26	519	8.35	217
7-28-92	13:15	1450	26	542	8.38	211
7-28-92	14:30	1690	26	516	8.27	220
7-28-92	15:30	1895	25	524	8.34	211
7-28-92	16:45	2250	24	516	8.44	226
7-29-92	12:50	2430	24.5	509	8.25	199
7-29-92	15:00	2675	26.5	508	8.15	205

Table 2. Field Parameters Measured on Samples From HTH-2

Date (m-d-yr)	Time (hr:min)	Depth (ft)	Temp. (°C)	E.C. (μ mhos/ cm@25C)	pH	HCO ₃ (mg/L)
7-29-92	18:30	750	19.5	303	7.84	177
7-29-92	19:15	975	20.5	299	7.94	161

Figure 1. Map showing the location of the Faultless site within Hot Creek Valley and detail of the wells examined in this study.

HTH-1

Figure 2. Completion diagram and temperature and electrical conductivity logs for well HTH-1. An obstruction was encountered at 2818 ft so that the bottom two screens could not be accessed.

ITH-2

Figure 3. Completion diagram and temperature and electrical conductivity logs for well ITH-2.

UC-1-P-2SR

Figure 4. Completion diagram and temperature and electrical conductivity logs for well UC-1-P-2SR. An obstruction was encountered at 2614.8 ft.

Appendix
Chemical Analyses of Faultless Water Samples

WRC Waterlab

Requested by: Chapman, Jenny
Project: DOE Shoal Offsite

Date submitted: 31-Jul-92
File name: 25482DOE.dat

Sample #:	25482		25483		25484		25485	
Sample Date:	28-Jul-92		28-Jul-92		28-Jul-92		28-Jul-92	
Sample Name:	HTH-1 775		HTH-1 1050		HTH-1 1450		HTH-1 1690	
EC	545		539		542		546	
SiO2	55.4		56.0		56.5		57.5	
pH	8.40		8.31		8.30		8.43	
	mg/l	epm	mg/l	epm	mg/l	epm	mg/l	epm
HCO3	238	3.901	243	3.983	244	3.999	238	3.901
CO3	4.1	0.137	0.6	0.020	0.4	0.013	4.7	0.157
Cl	16.7	0.471	16.8	0.474	16.8	0.474	16.8	0.474
SO4	33.5	0.697	33.4	0.695	33.5	0.697	33.4	0.695
NO3	<.04		<.04		<.04		<.04	
F	9.4	0.495	10.4	0.547	10.4	0.547	10.5	0.553
Total Anions		5.701		5.719		5.731		5.779
Na	126	5.481	125	5.438	125	5.438	125	5.438
K	1.52	0.039	1.39	0.036	1.37	0.035	1.37	0.035
Ca	3.28	0.164	3.10	0.155	3.53	0.176	4.51	0.225
Mg	0.10	0.008	0.07	0.006	0.07	0.006	0.09	0.007
Total Cations		5.692		5.634		5.654		5.705
Anions/Cations		1.002		1.015		1.014		1.013

WRC Waterlab

Requested by: Chapman, Jenny
Project: DOE Shoal Offsite

Date submitted: 31-Jul-92
File name: 25482DOE.dat

Sample #:	25486		25487		25488		25489	
Sample Date:	28-Jul-92		28-Jul-92		29-Jul-92		29-Jul-92	
Sample Name:	HTH-1 1895		HTH-1 2250		HTH-1 2430		HTH-1 2675	
EC	540		543		548		561	
SiO2	56.8		57.1		64.3		66.2	
pH	8.32		8.40		8.27		8.24	
	mg/l	epm	mg/l	epm	mg/l	epm	mg/l	epm
HCO3	242	3.966	237	3.884	247	4.048	249	4.081
CO3	0.9	0.030	3.6	0.120				
Cl	16.8	0.474	17.0	0.479	18.2	0.513	19.1	0.539
SO4	33.1	0.689	33.5	0.697	33.4	0.695	34.5	0.718
NO3	<.04		<.04		<.04		<.04	
F	10.5	0.553	10.5	0.553	9.4	0.495	10.4	0.547
Total Anions		5.712		5.734		5.752		5.885
Na	127	5.524	125	5.438	128	5.568	129	5.611
K	1.37	0.035	1.42	0.036	1.55	0.040	1.55	0.040
Ca	3.22	0.161	3.06	0.153	2.95	0.147	2.93	0.146
Mg	0.07	0.006	0.05	0.004	0.06	0.005	0.07	0.006
Total Cations		5.726		5.631		5.760		5.803
Anions/Cations		0.998		1.018		0.999		1.014

WRC Waterlab

Requested by: Chapman, Jenny
Project: DOE Shoal Offsite

Date submitted: 31-Jul-92
File name: 25482DOE.dat

Sample #:	25490		25491					
Sample Date:	29-Jul-92		29-Jul-92					
Sample Name:	HTH-2 750		HTH-2 975					
EC	300		293					
SiO2	29.2		29.5					
pH	8.10		8.13					
	mg/l	epm	mg/l	epm	mg/l	epm	mg/l	epm
HCO3	196	3.212	197	3.229				
CO3								
Cl	2.6	0.073	2.6	0.073				
SO4	4.08	0.085	4.08	0.085				
NO3	2.22	0.036	2.22	0.036				
F	0.08	0.004	0.06	0.003				
Total Anions		3.411		3.426				
Na	19.0	0.826	18.4	0.800				
K	1.47	0.038	1.44	0.037				
Ca	40.8	2.036	40.8	2.036				
Mg	5.52	0.454	5.49	0.451				
Total Cations		3.354		3.325				
Anions/Cations		1.017		1.030				

WRC Waterlab

Requested by: Chapman, Jenny
Project: DOE Shoal Offsite

Date submitted: 11-Aug-92
File name: 25558DOE.dat

Sample #:	25558							
Sample Date:	6-Aug-92							
Sample Name:	HTH-2 650							
EC	304							
SiO2	28.9							
pH	8.27							
	mg/l	epm	mg/l	epm	mg/l	epm	mg/l	epm
HCO3	194	3.180						
CO3								
Cl	2.7	0.076						
SO4	4.11	0.086						
NO3	2.13	0.034						
Total Anions		3.376						
Na	19.0	0.826						
K	1.47	0.038						
Ca	40.7	2.031						
Mg	5.48	0.451						
Total Cations		3.346						
Anions/Cations		1.009						

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