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Consulting Hydrogeologist

P.G. 4634
C.E.G. 1454
C.Hg 145

April 5, 2021

Seaside Basin Watermaster
PO Box 51502
Pacific Grove, CA
93950

Attention: Bob Jaques, PE

Subject: Geophysical Investigation Fort Ord Monitoring Wells FO-9 and FO-10 – Preliminary Findings

Dear Bob:

Two monitoring wells in the Seaside Basin monitoring program, FO-9 Shallow and FO-10 Shallow, have recently displayed increasing concentrations of chloride ions; raising the possibility that these data are indicative of advancement of seawater into the basin. However, these data are difficult to reconcile with other data from the more seaward Sentinel Wells that have seen no changes. The ad-hoc advisory team discussed this and generally believed that the data from the monitoring wells would benefit from further confirmation. It was suggested that the monitoring wells be induction logged and the data from the induction logs be compared to the original electric logs to assist in evaluating if there have been conductivity changes in the formation since the time of the well installations. This work has been completed and I'm pleased to provide the initial data and preliminary interpretations.

Background.
Monitoring Wells Clusters FO-9 and FO-10 were drilled in 1994 and 1996, respectively. The wells are nested completions with multiple casings of varying lengths in the same borehole. FO-9 has two completions - a shallow completion in the Paso Robles Formation and a deeper completion in the Santa Margarita Sandstone. FO-10 has 3 completions - one in the Paso Robles Formation, one in the Santa Margarita Sandstone and a third completion in an intermediate depth. The details of well construction are shown on Figures 1 and 2.

Findings

Prior to the recent field work, the original elogs from both of the borings were digitized so the original elogs could be easily compared to the inverse of the induction logs (elog measures resistivity, induction log measures the inverse, i.e., conductivity). After acquiring digital versions of the elogs, the wells were geophysically logged on March 23, 2021. Both induction logs and temperature/fluid resistivity logs were performed. The induction logging measures the bulk conductivity of a sphere of earth materials (including the borehole contents - gravel envelope and casings) of approximately 6 feet in diameter. The temperature/fluid resistivity measures temperature/resistivity of the fluid in the casing. The temperature data allows for the resistivity data to be corrected for temperature. At each location, the deepest accessible well was induction logged while the shallow well was temperature/fluid resistivity logged. The data from the logging and the well construction are attached as Figure 1 and 2.

FO-09

- Both of the completions (shallow and deep) at this site have debris (airlift pipe, suction pipe?) in the bottom of the wells so we were not able to get to bottom or even into perforations.

- As can be seen in the Fluid Resistivity log for this well, FO-09 Shallow is leaking poor quality water into the well at about 185 feet bgs (about -40 ft msl). The data suggest the well has a structural flaw (crack, open joint?) at this depth.

- Below this depth, water quality is impacted but as the log approaches the perforations, the quality improves.

- The induction logging matches the original elog reasonably well. Although the magnitude of the recent trace appears higher than the original, no area looks more conductive than it was in 1994. The higher magnitude of the recent trace is likely a function relating to the legacy elog to which it is compared, which reflects the higher conductivity fluid in the borehole at the time of original logging. The drilling mud had a conductivity (EC) of about 625 µS at time of drilling whereas now the water (where not impacted by the leak) in the well (and formation) is closer to 400 µS.

- The elevated chloride values in the water quality samples from this well are the result of the entry of water from higher in the casing, not recently advancing SWI.

FO-10

- The induction tool was not able descend in the deep well as the upper section has a bend in the casing that is too tight for passage. The intermediate and shallow wells were successfully logged to bottom.

- The induction log is severely muted when compared with the original elog. At first glance it looks like seawater intrusion, but on further reflection the shift is along the entire profile, which is considered unlikely. The reason for the muted response is unclear. Discussions with the geophysical contractor suggest that all the intermediate well seals are leaking and allowing poor quality water from above. Whereas that theory would explain the data, it again is consider highly unlikely because water level data from these wells consistently show significant differences between shallow and deep completions.

- The fluid resistivity logs show elevated EC in the screen section relative to the standing water in the casing, suggesting the quality in the screen section may be changing and the water quality samples from this well maybe valid.

The two shallow wells were displaying elevated chloride values. The new data confirms that the water quality samples from FO-09 Shallow are impacted by a structural flaw in the casing that is allowing poor quality water to enter the casing and contaminate the perforated area from which samples are taken. The recent samples are not representative of the in-situ aquifer water from the screened interval at this location. It is recommended that this well be video surveyed to assess the nature of the flaw. After confirmation of the nature of the structural flaw, the well should be repaired or destroyed to prevent continued contamination of the Paso Robles Formation at this location.

The data also confirms that the recent increase in chlorides in FO-10 Shallow is representative of the water in the perforations. The reason for the increase is not known. Ongoing routine sampling may assist in better determining water quality trends and any additional well investigative recommendations at this location.

The opportunity to perform this work is appreciated. Please call if you have any questions.

Sincerely,

Figure 1

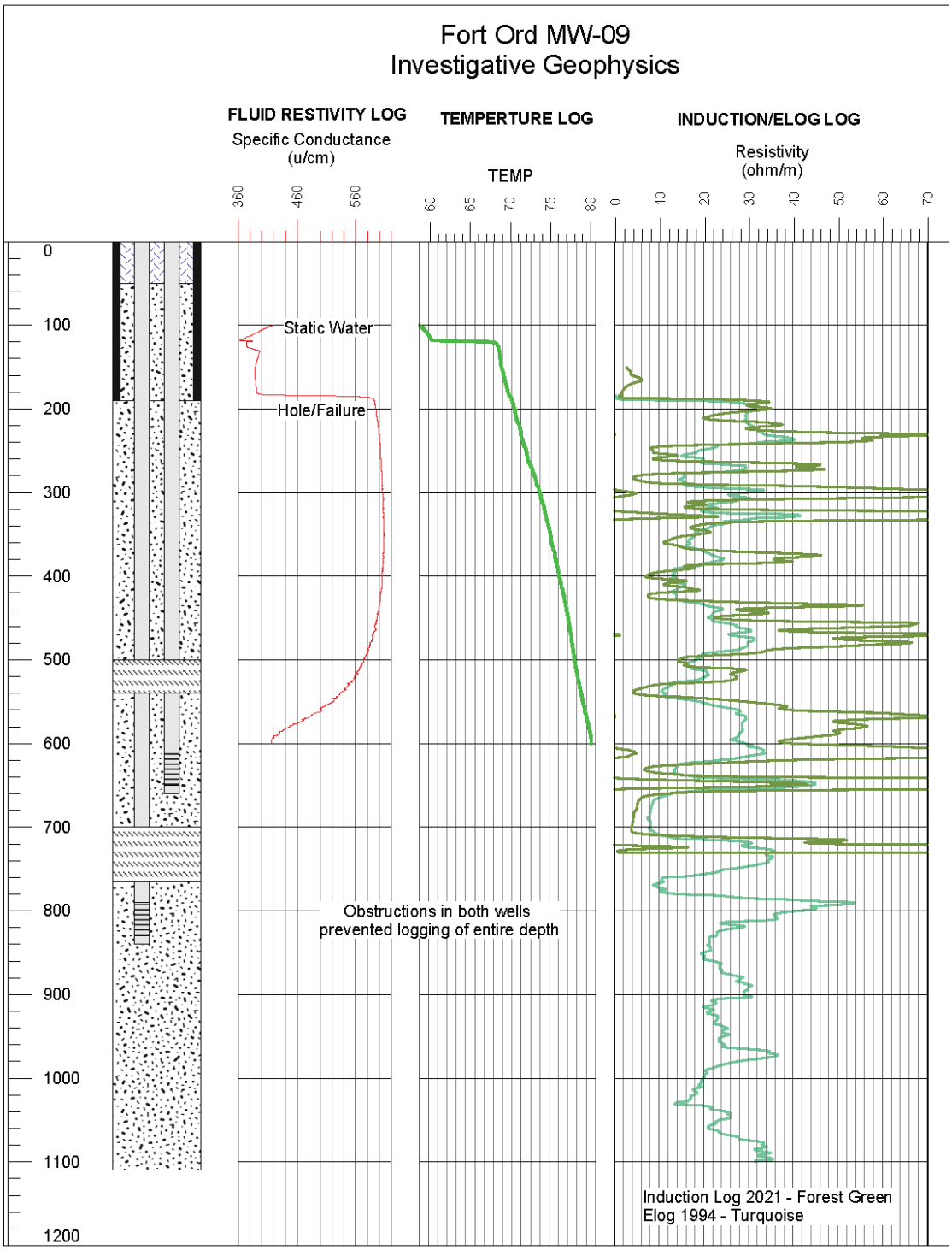
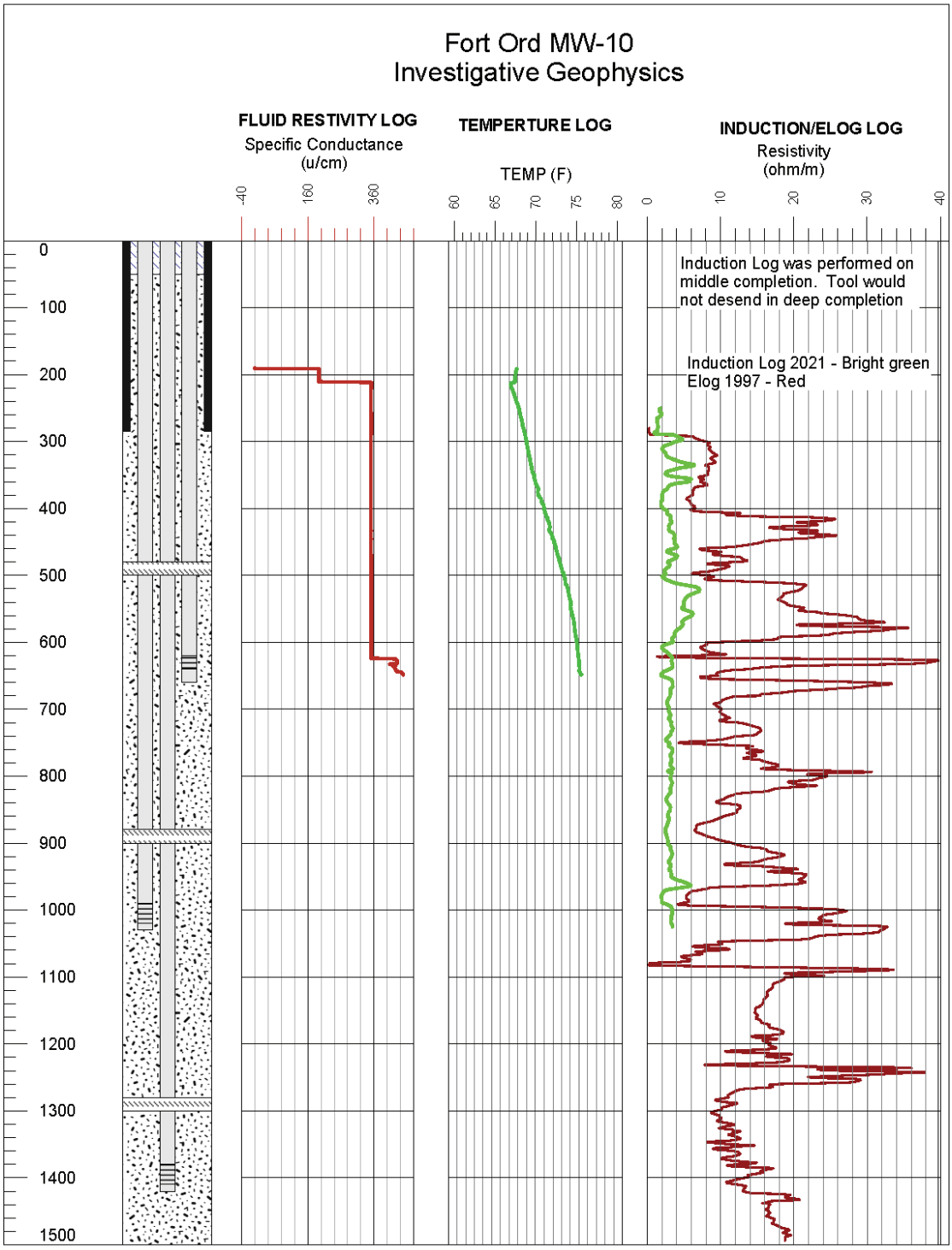

Fort Ord MW-09
Investigative Geophysics
FLUID RESTIVITY LOG
Specific Conductance (u/cm)
360
460
560
TEMPERTURE LOG
TEMP
60
65
70
75
80
INDUCTION/ELOG LOG
Resistivity (ohm/m)
0
10
20
30
40
50
60
70
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Static Water
Hole/Failure
Obstructions in both wells
prevented logging of entire depth
Induction Log 2021 - Forest Green
Elog 1994 - Turquoise

Figure 2


Fort Ord MW-10
Investigative Geophysics
FLUID RESTIVITY LOG
Specific Conductance
(u/cm)
-40
160
360
TEMPERTURE LOG
TEMP (F)
60
65
70
75
80
INDUCTION/ELOG LOG
Resistivity
(ohm/m)
0
10
20
30
40
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Induction Log was performed on middle completion. Tool would not desend in deep completion
Induction Log 2021 - Bright green
Elog 1997 - Red

Sent by email by Martin 2-28-22

Colleagues:

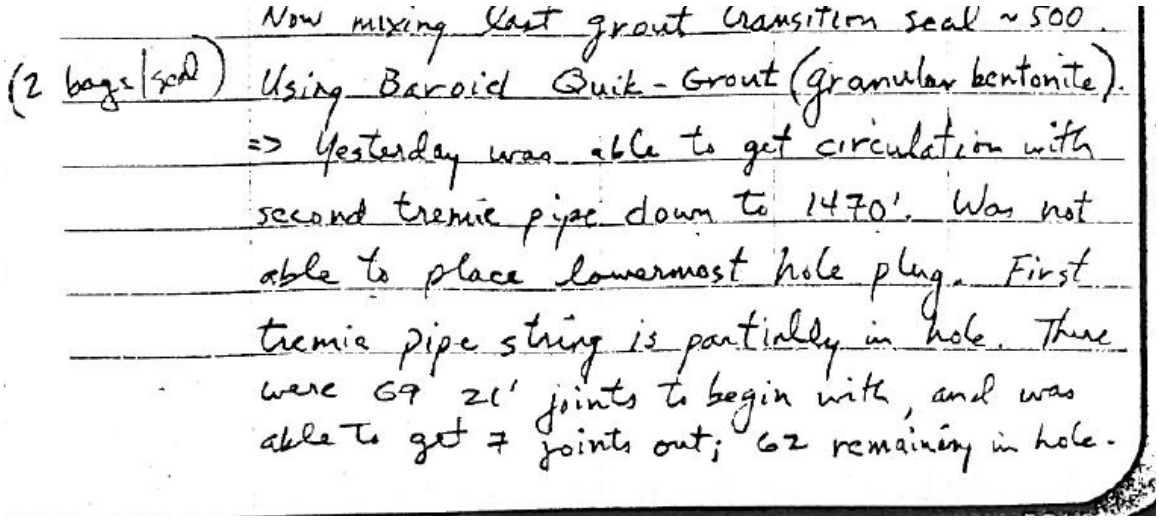
Last spring chloride levels were increasing in two monitoring wells on the former Fort Ord; Wells FO-9S and FO-10S. In response to these rising levels an investigation was conducted to confirm and better understand the rising chloride levels. This work included digitizing the original elogs and induction logging the deepest well at each location. EC/Temp logging was also performed at the shallowest well at each location.

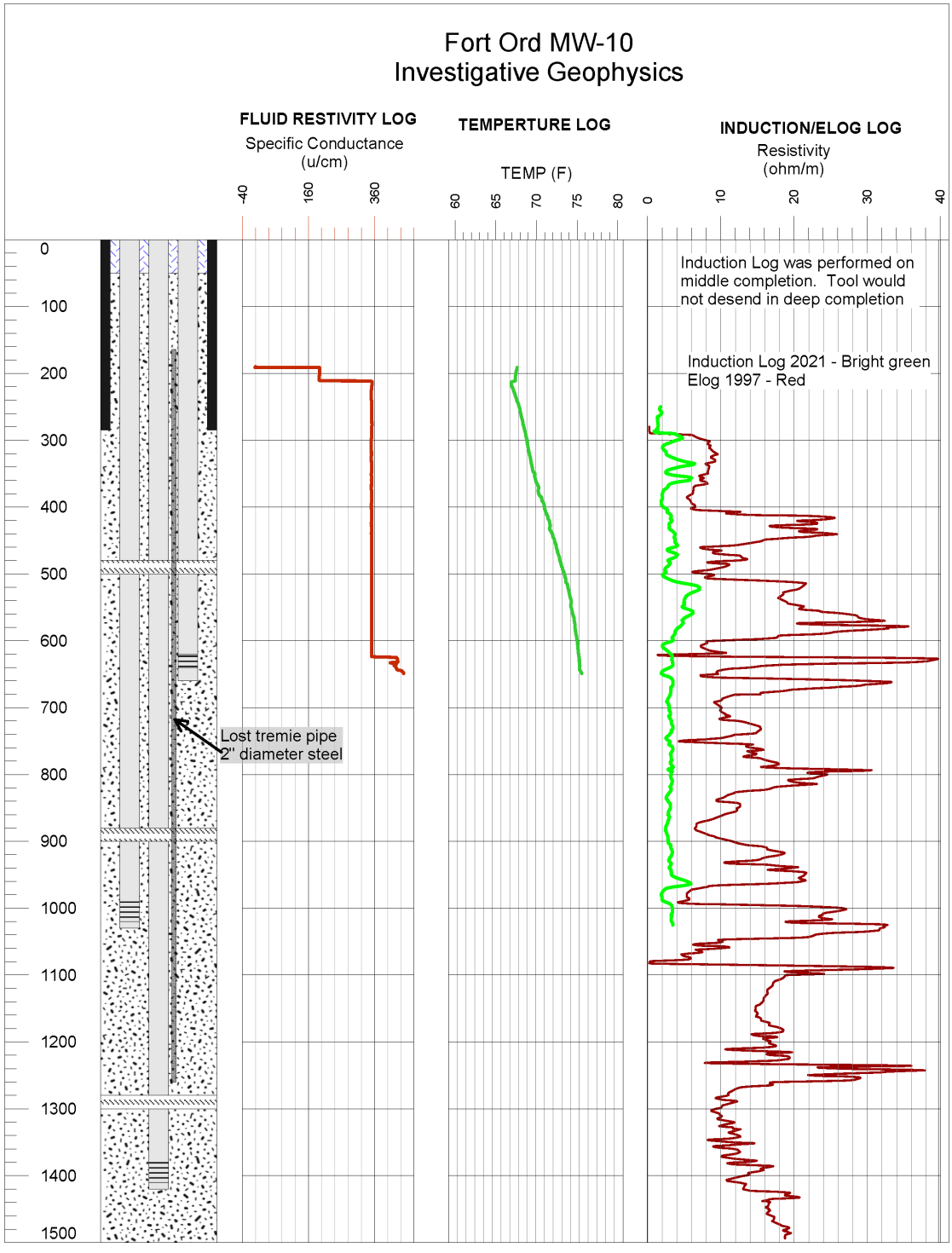
From this work, it was determined that there was a leak in the casing of FO-9S that was allowing poorer quality water from the shallow zone to enter the casing, changing the water quality within the perforations. The induction log of FO-9D matched the original elog, confirming that there had been no changes in formation conductivity. FO-9S is being destroyed this week.

The data collected from FO-10 were more confusing. The EC/Temp showed water similar to that in the perforations throughout the water column. The induction log data were quite confusing. Like FO-9 the original elog was digitized, but the induction log data showed a quite muted signal compared to the original elog. The reason for this response was unknown at the time.

Recently, in discussions with Joe Oliver and review of the field notes that are included in the summary report of the construction of FO-10 (MPWMD TM 97-04), it has been discovered that approximately 1300 feet of 2-inch diameter steel tremie pipe became stuck and had to be abandoned in the hole during construction of this well (see diagram). The presence of this steel pipe now explains the previously unexplained muted response of the induction log. This also could explain the rising chlorides in the FO-10S well. It has been close to 30 years since construction, and the tremie pipe may be corroded and, similar to FO-9S, allowing poorer quality water to move from zone to zone.

From Joe Oliver's field notes.


Now mixing Kast grout transition seal ~500.
(2 bags/sack) Using Baroid Quik-Grout (granular bentonite).
=> Yesterday was able to get circulation with
second tremie pipe down to 1470'. Was not
able to place lowermost hole plug. First
tremie pipe string is partially in hole. There
were 69 21' joints to begin with, and was
able to get 7 joints out; 62 remaining in hole.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1200
1300
1400
1500
Induction Log was performed on middle completion. Tool would not desend in deep completion
Induction Log 2021 - Bright green
Elog 1997 - Red
Lost tremie pipe
2" diameter steel