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June 20, 1994

Mr. Gene McLoughlin, P.E.
MDWASA
P.O. Box 330316
Miami, Florida 33233-0316

Dear Mr. McLoughlin,

The purpose of this letter report is to describe the procedures used and the results obtained from quantitative hydraulic analysis of a potential monitoring zone within the Floridan Aquifer system penetrated by Injection well I-16. The straddle packer test and subsequent hydraulic analysis were conducted in the zone of the aquifer between 1560 and 1590 feet below land surface (BLS).

METHOD

A straddle packer was used to isolate the test zone for drawdown and recovery tests. The formation tested is under artesian pressure, and was pumped at a rate of 122.5 gpm during the drawdown portion of the test. Water level changes were measured in the drill stem with a pressure transducer and recorded on a Hermit 1000-C data logger. Prior to testing, the well was developed by pumping the formation fluid until the specific conductance stabilized. Specific conductance readings taken during the test are included in Appendix I. The well was then allowed to recover from development before performing the test.

BACKGROUND

A 17 inch pilot hole was drilled below casing to a depth of 1900 feet below land surface. A suite of geophysical logs were run and, together with the borehole cutting samples, the test zone was selected by the WASA project hydrogeologist. The zone was selected between 1560-1590 feet below land surface. The zone was isolated with an inflatable 30 foot straddle packer with 10 feet of perforated pipe, open to the formation, between the two packer elements.

The packer assembly was lowered on the drill stem into the original pilot hole to the tested interval of 1560-1590 feet B.L.S. The packer elements were then inflated. After more than 9 hours of pumping, a constant specific conductance of 11,000 umhos was reached. The well was allowed to recover to its initial antecedent conditions and pumped for 1 hour while drawdown data was recorded. Recovery data were recorded until formation water level had again reached antecedent conditions. Background, drawdown and recovery water level data is graphed on Figure 1. The test was run at a flow rate of 122.5 gpm, and is analyzed as follows. Raw data are presented in Appendix II.
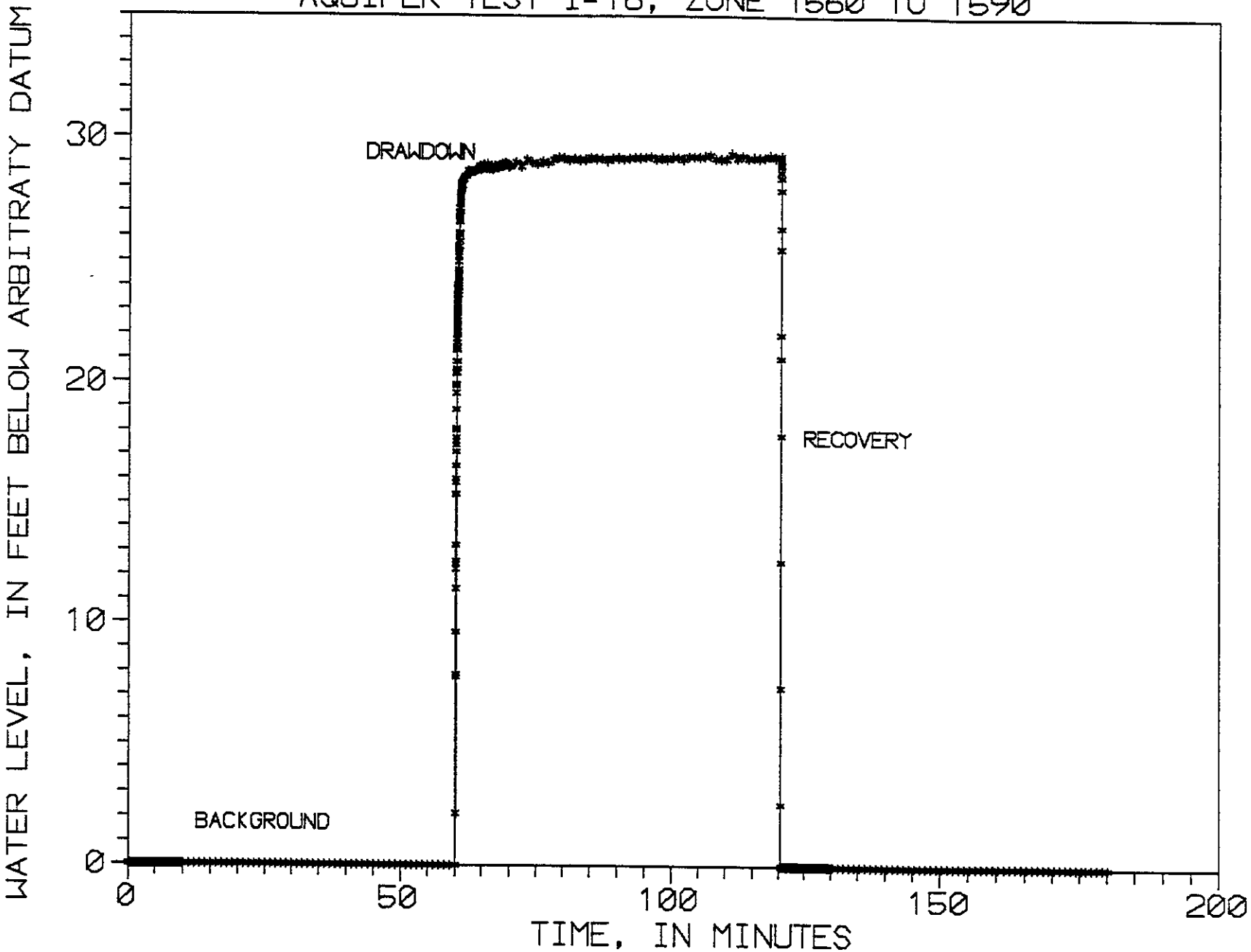
Figure 1.— Background, drawdown and recovery data from I-16, from 1560 to 1590 zone, arbitrary datum.

DATA ANALYSIS

Three methods of data analysis were tested for this zone.

    1. Cooper-Jacob Analysis

    2. Theis Analysis (Leaky)

    3. Theis recovery analysis

1. Cooper-Jacob Analysis

The Cooper-Jacob method (figure 2) (Todd, 1980 p. 129) was used to compute a transmissivity value. The equation is as follows:

$$T = \frac{(2.3)\ (Q)}{(4)\ (\pi)\ (\Delta s_t)}$$

where

Q =   discharge in cubic feet per day

s_t =   drawdown over one log cycle of time

The data were plotted on semi-log paper (s verses log t) and a straight line is fitted to the data, (Figure 2).

Using the observed drawdown over a single log cycle, (s), the transmissivity can be determined from the equation given by Todd (1980, p. 130) as:

$$T = \frac{2.3\ (23599\ ft^3/day)}{(4)\ (3.1416)\ (9.8ft)}$$
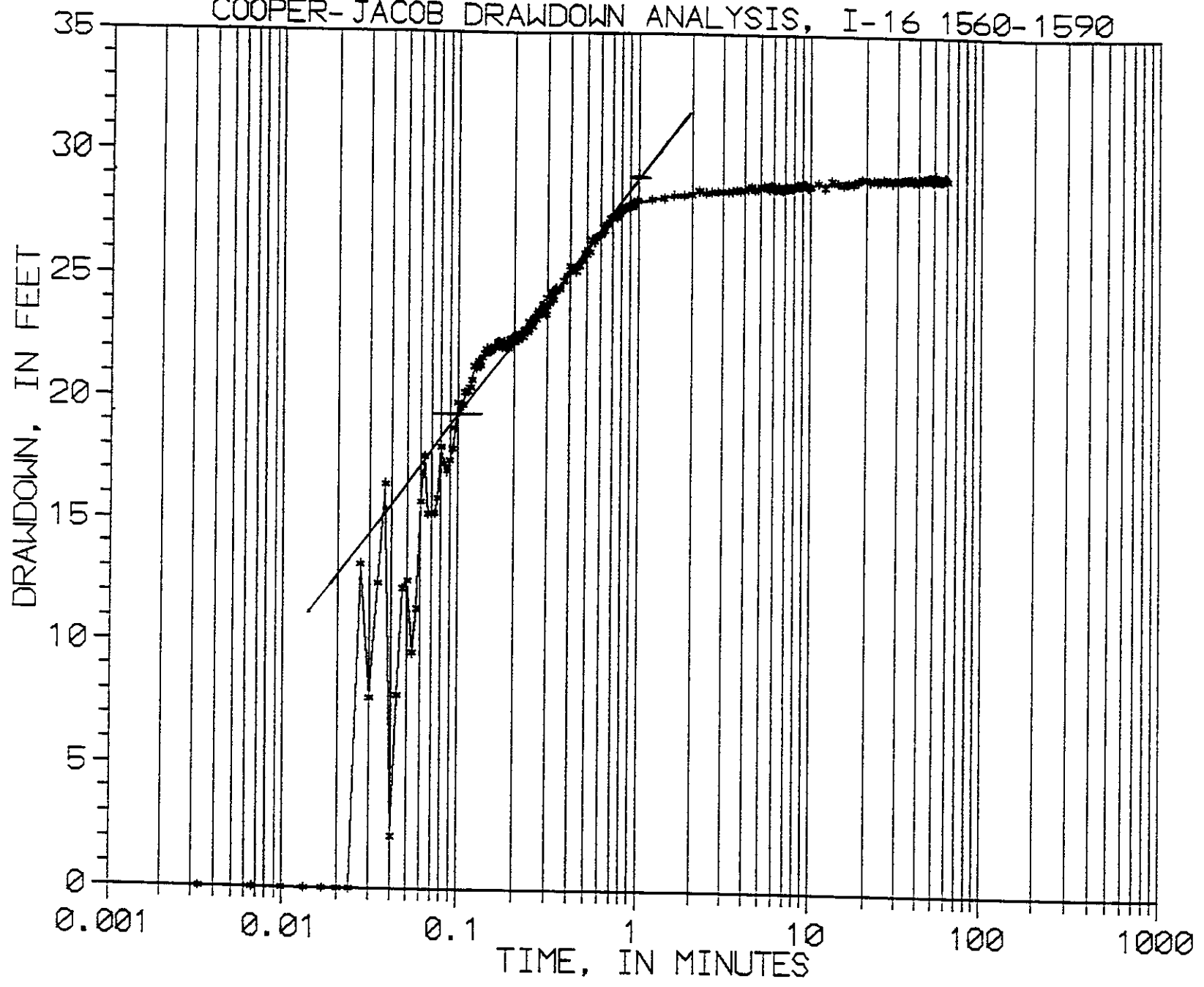
$$T =\ \ 441\ ft^2/D$$

Figure 2.-- Cooper-Jacob Drawdown Analysis I-16, zone 1560 to 1590

Using a unit thickness of 30 ft., the horizontal hydraulic conductivity is:

$$K = 14.7 \text{ ft/D or } 109.9 \text{ gal/day/ft}^2$$

$$K = 5.2 \times 10^{-3} \text{ cm/sec.}$$

2. Theis Analysis

The time-drawdown data for the packer test was analyzed using the Theis nonequilibrium equation given by (Todd, 1980, 123) as:

$$s = \frac{(Q)\ (W(u))}{(4)\ (\pi)\ (T)}$$

Where s is the drawdown, Q is the pumping rate and T is the transmissivity. W (u) is the well function and (u is the exponential integral function) where

$$u = \frac{(r^2) \cdot (S)}{(4)\ (\pi)\ (T)\ (t)}$$

Where r is the distance to the observation well (r = well radius for a single well test).

S = Storage coefficient

t = Time since the start of pumping

Transmissivity and storage coefficient values were determined from the drawdown data by type - curve matching techniques as described in Todd (P125-128) by using the computer package GWAP (Graphical Well Analysis Package). Figure 3 shows the type curve superimposed on the drawdown data plot and the resulting computed values for transmissivity, hydraulic conductivity and storativity (Storage coefficient divided by unit thickness). Values for horizontal hydraulic conductivity expressed in standard units are:

K = 54.97 gal/day/sq.ft. $= 7.4 \ ft/d$ ✓

K = 2.6 X 10^{-3} cm/sec

I-16 ZONE 1560 — 1590
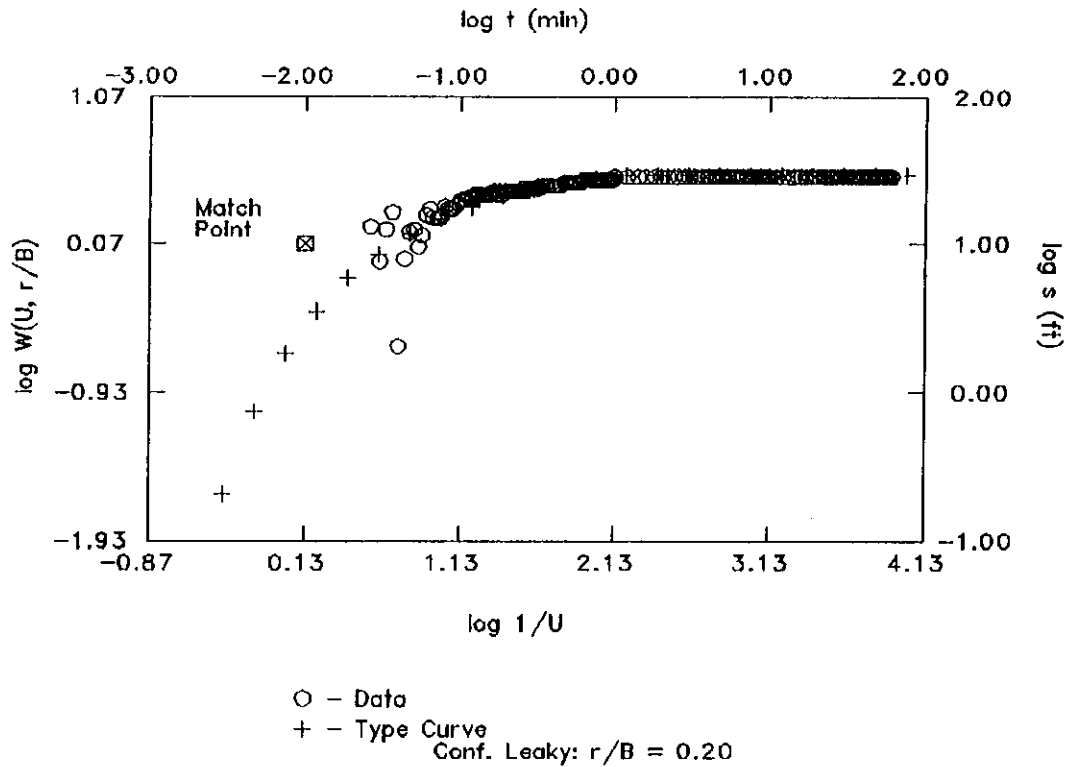
MATCH POINT		SOLUTION		
t	= 1.000E−0002	Transmissivity (T)	= 1.649E+0003	gpd/ft
s	= 1.000E+0001	Hydraulic Conductivity (K)	= 5.497E+0001	gpd/sq ft
1/U	= 1.349E+0000	Storativity (S)	= 1.816E−0002	
W(U, r/B)	= 1.175E+0000	Leakage Factor (B)	= 2.500E+0000	ft
WELL INFORMATION				
WELL IDENTIFICATION		: I−16		
DATE OF AQUIFER TEST		: 06/11/94		
AQUIFER THICKNESS (b)		: 3.000E+0001 ft		
DISCHARGE RATE (Q)		: 1.225E+0002 gpm		
PUMPING WELL RADIUS (r)		: 1.400E+0000 ft		
DISTANCE OF OBSERVATION WELL FROM PUMPING WELL (d)		: 5.000E−0001 ft		

Figure 3.--Theis Leaky Curve Analysis I-16, zone 1560 to 1590

3. Theis Recovery Analysis

The Theis Recovery Method was reviewed to analyze recovery in the well after the pump was shut down, using the method as described in Todd (1980 p. 133). Residual drawdown, s´, was plotted against the log of the ratio of time from the start of pumping to the time of shut down (t/t') (see figure 4).

No analysis was completed using the Theis recovery analysis due to very rapid water level recovery.

Analytical results of the tests are summarized as follows:

Hydraulic Conductivity

Cooper-Jacob	=	5.2×10^{-3} cm/sec
Theis	=	2.6×10^{-3} cm/sec

THEIS RECOVERY ANALYSIS, I-16 ZONE 1560-1590
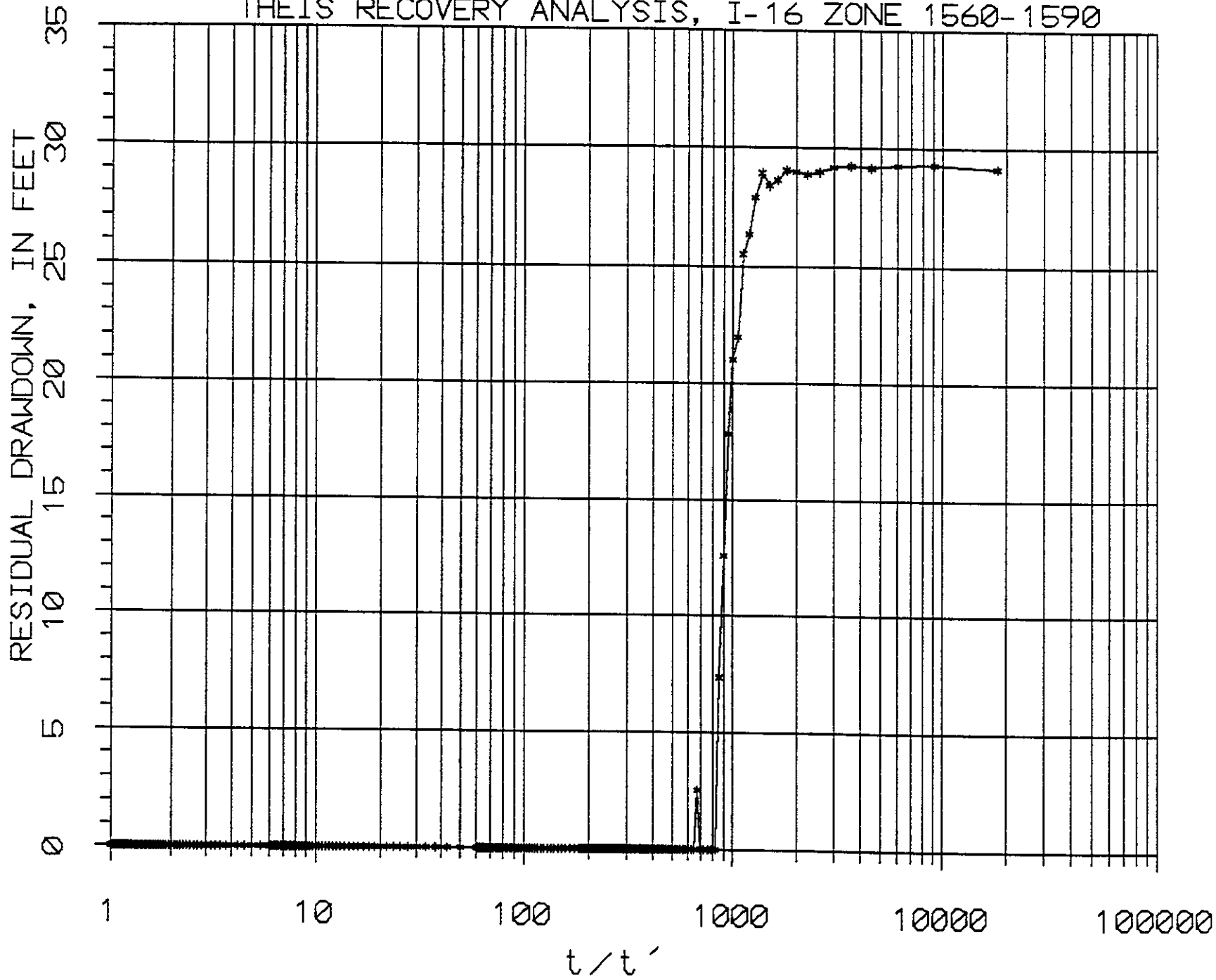
Figure 4.-- Theis Recovery Analysis I-16, zone 1560 to 1590

If you have any questions or comments please feel free to contact me or Leo Swayze.
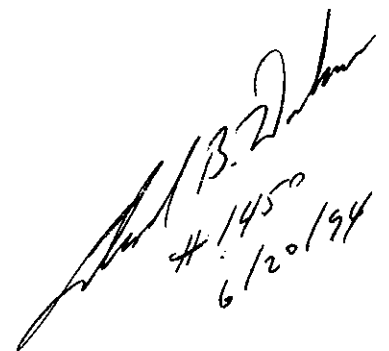
Sincerely,

Edmand B. Workman, P.G.

EBW/na

Appendix I
Specific Conductance Stabilization Data

Packer Test (I-16)
Zone 1560-1590

TIME	TEMP ^{0}C	CONDUCTIVITY umhos
12:00		26,000
12:30		20,000
14:00		14,000
14:30		14,000
15:00		11,000
15:30		11,000
16:00		11,000
16:30		11,000
17:00		11,000
17:30		11,000
18:00		11,000
18:30		11,000
19:00		11,000
19:30		11,000
20:00		11,000
20:30		11,000
21:00		11,000
21:30		11,000

Appendix II
Raw Aquifer Test Data

```
            SE1000C
      Environmental Logger
         06/12  09:43

     Unit#  01513   Test 0

Setups:          INPUT   1
------------     ----------
Type             Level (F)
Mode             TOC
I.D.             00000

Reference           0.000
Linearity           0.280
Scale factor       29.990
Offset              0.120
Delay mSEC         50.000

Step 0   06/11 20:21:59

Elapsed Time   INPUT   1
------------   ----------
   0.0000         0.000
   0.0033         0.000
   0.0066         0.000
   0.0100         0.000
   0.0133         0.000
   0.0166         0.000
   0.0200         0.000
   0.0233         0.000
   0.0266         0.000
   0.0300         0.000
   0.0333         0.000
   0.0366         0.000
   0.0400         0.000
   0.0433         0.000
   0.0466         0.000
   0.0500         0.000
   0.0533         0.000
   0.0566         0.000
   0.0600         0.000
   0.0633         0.000
   0.0666         0.000
   0.0700         0.000
   0.0733         0.000
   0.0766         0.000
   0.0800         0.000
   0.0833         0.000
   0.0866         0.000
   0.0900         0.000
   0.0933         0.000
   0.0966         0.000
   0.1000         0.000
   0.1033         0.000
   0.1066         0.000
   0.1100         0.000
   0.1133         0.000
   0.1166         0.000
   0.1200         0.000
```

0.1233	0.000
0.1266	0.000
0.1300	0.000
0.1333	0.000
0.1366	0.000
0.1400	0.000
0.1433	0.000
0.1466	0.000
0.1500	0.000
0.1533	0.000
0.1566	0.000
0.1600	0.000
0.1633	0.000
0.1666	0.000
0.1700	0.000
0.1733	0.000
0.1766	0.000
0.1800	0.000
0.1833	0.000
0.1866	0.000
0.1900	0.000
0.1933	0.000
0.1966	0.000
0.2000	0.000
0.2033	0.000
0.2066	0.000
0.2100	0.000
0.2133	0.000
0.2166	0.000
0.2200	0.000
0.2233	0.000
0.2266	0.000
0.2300	0.000
0.2333	0.000
0.2366	0.000
0.2400	0.000
0.2433	0.000
0.2466	0.000
0.2500	0.000
0.2533	0.000
0.2566	0.000
0.2600	0.000
0.2633	0.000
0.2666	0.000
0.2700	0.000
0.2733	0.000
0.2766	0.000
0.2800	0.000
0.2833	0.000
0.2866	0.000
0.2900	0.000
0.2933	0.000
0.2966	0.000
0.3000	0.000
0.3033	0.000
0.3066	0.000
0.3100	0.000
0.3133	0.000
0.3166	0.000
0.3200	0.000

0.3233	0.000
0.3266	0.000
0.3300	0.000
0.3333	0.000
0.3500	0.000
0.3666	0.000
0.3833	0.000
0.4000	0.000
0.4166	0.000
0.4333	0.000
0.4500	0.000
0.4666	0.000
0.4833	0.000
0.5000	0.000
0.5166	0.000
0.5333	0.000
0.5500	0.000
0.5666	0.000
0.5833	0.000
0.6000	0.000
0.6166	0.000
0.6333	0.000
0.6500	0.000
0.6666	0.000
0.6833	0.000
0.7000	0.000
0.7166	0.000
0.7333	0.000
0.7500	0.000
0.7666	0.000
0.7833	0.000
0.8000	0.000
0.8166	0.000
0.8333	0.000
0.8500	0.000
0.8666	0.000
0.8833	0.000
0.9000	0.000
0.9166	0.000
0.9333	0.000
0.9500	0.000
0.9666	0.000
0.9833	0.000
1.0000	0.000
1.2000	0.000
1.4000	0.000
1.6000	0.000
1.8000	0.000
2.0000	0.000
2.2000	0.000
2.4000	0.000
2.6000	0.000
2.8000	0.000
3.0000	0.000
3.2000	0.000
3.4000	0.000
3.6000	0.000
3.8000	0.000
4.0000	0.000
4.2000	0.000

4.4000	0.000
4.6000	0.000
4.8000	0.000
5.0000	0.000
5.2000	0.000
5.4000	0.000
5.6000	0.000
5.8000	0.000
6.0000	0.000
6.2000	0.000
6.4000	0.000
6.6000	0.000
6.8000	0.000
7.0000	0.000
7.2000	0.000
7.4000	0.000
7.6000	0.000
7.8000	0.000
8.0000	0.000
8.2000	0.000
8.4000	0.000
8.6000	0.000
8.8000	0.000
9.0000	0.000
9.2000	0.000
9.4000	0.000
9.6000	0.000
9.8000	0.000
10.0000	0.000
11.0000	0.000
12.0000	0.000
13.0000	0.000
14.0000	0.000
15.0000	0.000
16.0000	0.000
17.0000	0.000
18.0000	0.000
19.0000	0.000
20.0000	0.000
21.0000	0.000
22.0000	0.000
23.0000	0.000
24.0000	0.000
25.0000	0.000
26.0000	0.000
27.0000	0.000
28.0000	0.000
29.0000	0.000
30.0000	0.000
31.0000	0.000
32.0000	0.000
33.0000	0.000
34.0000	0.000
35.0000	0.000
36.0000	0.000
37.0000	0.000
38.0000	0.000
39.0000	0.000
40.0000	0.000
41.0000	0.000

42.0000	0.000
43.0000	0.000
44.0000	0.000
45.0000	0.000
46.0000	0.000
47.0000	0.000
48.0000	0.000
49.0000	0.000
50.0000	0.000
51.0000	0.000
52.0000	0.000
53.0000	0.000
54.0000	0.000
55.0000	0.000
56.0000	0.000
57.0000	0.000
58.0000	0.000
59.0000	0.000
60.0000	0.000

```
              SE1000C
       Environmental Logger
          06/12 09:46

     Unit# 01513   Test 1

Setups:          INPUT   1
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Type             Level (F)
Mode             TOC
I.D.             00000

Reference          0.000
Linearity          0.280
Scale factor      29.990
Offset             0.120
Delay mSEC        50.000

Step 0   06/11 21:24:11

Elapsed Time    INPUT   1
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    0.0033          0.000
    0.0066          0.000
    0.0100          0.000
    0.0133          0.000
    0.0166          0.000
    0.0200          0.000
    0.0233          0.000
    0.0266         13.254
    0.0300          7.750
    0.0333         12.446
    0.0366         16.560
    0.0400          2.132
    0.0433          7.875
    0.0466         12.244
    0.0500         12.571
    0.0533          9.607
    0.0566         11.436
    0.0600         15.849
    0.0633         17.713
    0.0666         15.350
    0.0700         15.378
    0.0733         15.388
    0.0766         15.993
    0.0800         18.117
    0.0833         17.415
    0.0866         17.118
    0.0900         17.569
    0.0933         18.030
    0.0966         18.894
    0.1000         19.931
    0.1033         19.566
    0.1066         19.845
    0.1100         20.354
    0.1133         20.421
    0.1166         20.555
    0.1200         20.871
```

0.1233	21.438
0.1266	21.352
0.1300	21.649
0.1333	21.457
0.1366	21.793
0.1400	21.965
0.1433	22.167
0.1466	22.119
0.1500	22.033
0.1533	22.110
0.1566	22.273
0.1600	22.196
0.1633	22.436
0.1666	22.445
0.1700	22.301
0.1733	22.253
0.1766	22.455
0.1800	22.234
0.1833	22.225
0.1866	22.186
0.1900	22.532
0.1933	22.560
0.1966	22.474
0.2000	22.417
0.2033	22.714
0.2066	22.685
0.2100	22.560
0.2133	22.570
0.2166	22.733
0.2200	22.800
0.2233	22.675
0.2266	22.935
0.2300	22.982
0.2333	22.963
0.2366	22.858
0.2400	23.270
0.2433	23.270
0.2466	23.203
0.2500	23.078
0.2533	23.443
0.2566	23.443
0.2600	23.520
0.2633	23.395
0.2666	23.625
0.2700	23.750
0.2733	23.701
0.2766	23.625
0.2800	23.634
0.2833	23.942
0.2866	24.009
0.2900	23.865
0.2933	23.596
0.2966	23.951
0.3000	24.277
0.3033	24.143
0.3066	24.152
0.3100	24.056
0.3133	24.450
0.3166	24.526
0.3200	24.459

0.3233	24.219
0.3266	24.517
0.3300	24.574
0.3333	24.660
0.3500	24.641
0.3666	24.977
0.3833	25.178
0.4000	25.590
0.4166	25.456
0.4333	25.370
0.4500	25.600
0.4666	25.801
0.4833	26.136
0.5000	26.060
0.5166	26.156
0.5333	26.654
0.5500	26.577
0.5666	26.769
0.5833	26.827
0.6000	26.855
0.6166	27.162
0.6333	27.028
0.6500	27.296
0.6666	27.344
0.6833	27.526
0.7000	27.574
0.7166	27.651
0.7333	27.612
0.7500	27.564
0.7666	27.804
0.7833	27.708
0.8000	27.957
0.8166	27.899
0.8333	27.929
0.8500	27.947
0.8666	27.995
0.8833	28.072
0.9000	28.005
0.9166	28.043
0.9333	28.101
0.9500	28.177
0.9666	28.082
0.9833	28.254
1.0000	28.225
1.2000	28.311
1.4000	28.359
1.6000	28.474
1.8000	28.474
2.0000	28.513
2.2000	28.675
2.4000	28.589
2.6000	28.627
2.8000	28.656
3.0000	28.656
3.2000	28.647
3.4000	28.685
3.6000	28.723
3.8000	28.694
4.0000	28.743
4.2000	28.800

4.4000	28.867
4.6000	28.733
4.8000	28.780
5.0000	28.838
5.2000	28.915
5.4000	28.848
5.6000	28.762
5.8000	28.943
6.0000	28.848
6.2000	28.800
6.4000	28.867
6.6000	28.771
6.8000	28.743
7.0000	28.800
7.2000	28.886
7.4000	28.819
7.6000	28.848
7.8000	28.819
8.0000	28.915
8.2000	28.895
8.4000	28.953
8.6000	28.915
8.8000	28.925
9.0000	29.011
9.2000	28.972
9.4000	28.963
9.6000	28.876
9.8000	28.867
10.0000	28.886
11.0000	29.039
12.0000	28.867
13.0000	29.135
14.0000	29.049
15.0000	28.963
16.0000	29.068
17.0000	29.001
18.0000	29.135
19.0000	29.231
20.0000	29.212
21.0000	29.116
22.0000	29.192
23.0000	29.145
24.0000	29.145_
25.0000	29.212
26.0000	29.183
27.0000	29.202
28.0000	29.107
29.0000	29.202
30.0000	29.212
31.0000	29.154
32.0000	29.202
33.0000	29.240
34.0000	29.212
35.0000	29.240
36.0000	29.269
37.0000	29.154
38.0000	29.221
39.0000	29.154
40.0000	29.250
41.0000	29.231

42.0000	29.173
43.0000	29.278
44.0000	29.269
45.0000	29.250
46.0000	29.288
47.0000	29.336
48.0000	29.202
49.0000	29.173
50.0000	29.183
51.0000	29.403
52.0000	29.212
53.0000	29.317
54.0000	29.192
55.0000	29.250
56.0000	29.221
57.0000	29.240
58.0000	29.327
59.0000	29.260
60.0000	29.192

```
          SE1000C
    Environmental Logger
        06/12 09:49

  Unit# 01513  Test 2

Setups:          INPUT  1
-------------    ---------
Type             Level (F)
Mode             TOC
I.D.             00000

Reference          0.000
Linearity          0.280
Scale factor      29.990
Offset             0.120
Delay mSEC        50.000

Step 0   06/11 22:25:28

Elapsed Time    INPUT  1
------------    ---------
   0.0000         29.097
   0.0033         29.164
   0.0066         29.307
   0.0100         29.288
   0.0133         29.183
   0.0166         29.260
   0.0200         29.202
   0.0233         28.991
   0.0266         28.895
   0.0300         29.001
   0.0333         29.068
   0.0366         28.647
   0.0400         28.407
   0.0433         28.943
   0.0466         27.899
   0.0500         26.366
   0.0533         25.514
   0.0566         21.985
   0.0600         21.035
   0.0633         17.838
   0.0666         12.571
   0.0700          7.345
   0.0733          0.000
   0.0766          0.000
   0.0800          0.000
   0.0833          0.000
   0.0866          0.000
   0.0900          2.536
   0.0933          0.000
   0.0966          0.000
   0.1000          0.000
   0.1033          0.000
   0.1066          0.000
   0.1100          0.000
   0.1133          0.000
   0.1166          0.000
   0.1200          0.000
```

0.1233	0.000
0.1266	0.000
0.1300	0.000
0.1333	0.000
0.1366	0.000
0.1400	0.000
0.1433	0.000
0.1466	0.000
0.1500	0.000
0.1533	0.000
0.1566	0.000
0.1600	0.000
0.1633	0.000
0.1666	0.000
0.1700	0.000
0.1733	0.000
0.1766	0.000
0.1800	0.000
0.1833	0.000
0.1866	0.000
0.1900	0.000
0.1933	0.000
0.1966	0.000
0.2000	0.000
0.2033	0.000
0.2066	0.000
0.2100	0.000
0.2133	0.000
0.2166	0.000
0.2200	0.000
0.2233	0.000
0.2266	0.000
0.2300	0.000
0.2333	0.000
0.2366	0.000
0.2400	0.000
0.2433	0.000
0.2466	0.000
0.2500	0.000
0.2533	0.000
0.2566	0.000
0.2600	0.000
0.2633	0.000
0.2666	0.000
0.2700	0.000
0.2733	0.000
0.2766	0.000
0.2800	0.000
0.2833	0.000
0.2866	0.000
0.2900	0.000
0.2933	0.000
0.2966	0.000
0.3000	0.000
0.3033	0.000
0.3066	0.000
0.3100	0.000
0.3133	0.000
0.3166	0.000
0.3200	0.000

0.3233	0.000
0.3266	0.000
0.3300	0.000
0.3333	0.000
0.3500	0.000
0.3666	0.000
0.3833	0.000
0.4000	0.000
0.4166	0.000
0.4333	0.000
0.4500	0.000
0.4666	0.000
0.4833	0.000
0.5000	0.000
0.5166	0.000
0.5333	0.000
0.5500	0.000
0.5666	0.000
0.5833	0.000
0.6000	0.000
0.6166	0.000
0.6333	0.000
0.6500	0.000
0.6666	0.000
0.6833	0.000
0.7000	0.000
0.7166	0.000
0.7333	0.000
0.7500	0.000
0.7666	0.000
0.7833	0.000
0.8000	0.000
0.8166	0.000
0.8333	0.000
0.8500	0.000
0.8666	0.000
0.8833	0.000
0.9000	0.000
0.9166	0.000
0.9333	0.000
0.9500	0.000
0.9666	0.000
0.9833	0.000
1.0000	0.000
1.2000	0.000
1.4000	0.000
1.6000	0.000
1.8000	0.000
2.0000	0.000
2.2000	0.000
2.4000	0.000
2.6000	0.000
2.8000	0.000
3.0000	0.000
3.2000	0.000
3.4000	0.000
3.6000	0.000
3.8000	0.000
4.0000	0.000
4.2000	0.000

4.4000	0.000
4.6000	0.000
4.8000	0.000
5.0000	0.000
5.2000	0.000
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5.6000	0.000
5.8000	0.000
6.0000	0.000
6.2000	0.000
6.4000	0.000
6.6000	0.000
6.8000	0.000
7.0000	0.000
7.2000	0.000
7.4000	0.000
7.6000	0.000
7.8000	0.000
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8.6000	0.000
8.8000	0.000
9.0000	0.000
9.2000	0.000
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9.6000	0.000
9.8000	0.000
10.0000	0.000
11.0000	0.000
12.0000	0.000
13.0000	0.000
14.0000	0.000
15.0000	0.000
16.0000	0.000
17.0000	0.000
18.0000	0.000
19.0000	0.000
20.0000	0.000
21.0000	0.000
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23.0000	0.000
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25.0000	0.000
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27.0000	0.000
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29.0000	0.000
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41.0000	0.000

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51.0000	0.000
52.0000	0.000
53.0000	0.000
54.0000	0.000
55.0000	0.000
56.0000	0.000
57.0000	0.000
58.0000	0.000
59.0000	0.000
60.0000	0.000