JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. RFL-09-89-14-02-9 DISCIPLINE HYDRO NO. OF SHEETS 17

PROJECT:
Rifle UMTRA Project

SITE:
Ester Gulch Site

FEATURE:
Analysis of Monitor Well Recovery Data Using the Skalbistyke Bail Method.

SOURCES OF DATA:
1) Water level measurements at Ester Gulch, collected by the TAC
2) DOE Well completion records for monitor well 963, 701, 702 and 703
3) DOE Borehole logs for wells 963, 701, 702 and 703

SOURCES OF FORMULAE & REFERENCES:

DOE (Department of Energy), 1989. Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Sites at Rifle, Colorado, (preliminary final), prepared by Jacobs Engineering Group, Inc, for the U.S. Department of Energy at the Albuquerque Operations Office.

Ferris, J.G., Knowles, D.B., Brown, R.H. and R.W. Stallman (Ferris et al.), 1962. Theory of Aquifer Tests. United States Geological Survey Water-Supply Paper 1536-E. United States Government Printing Office, Washington, 1962. pp 103-104.

PRELIMINARY CALC. [X] FINAL CALC. [ ] SUPERSEDES CALC. NO. ____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
	RFL-09-89-14-02-a	T Doering	9/21/89	K Lambert	9/22/89	[illegible]	4/27/89

9/89

1

TG 9/21/89

KAL 9/22/89

Analysis of Monitor Well Recovery Data Using the Skibitzke Bailer Method

Purpose:

To estimate the hydraulic conductivity of the saturated zone of the Wasatch Formation at Estes Gulch by evaluating well recovery data.

Methods and Procedures:

The Skibitzke method (Ferris, Knowles, et al, 1962) was used to analyze monitor well recovery data to determine the hydraulic conductivity of the Wasatch Formation. Four monitor wells are completed beneath the potentiometric surface at Estes Gulch. Due to the extremely low hydraulic conductivity of the bedrock, water levels in these wells have slowly risen over time (Figure 1), as they equilibrate with the potentiometric surface in the Wasatch Formation. Although water levels in the monitor wells have not yet reached equilibrium, the well recovery data can still be analyzed to estimate the hydraulic conductivity of the Wasatch Formation.

Water level increases for two time periods (December 10, 1988 to March 24, 1989, and April 22, 1989 to June 14, 1989) were analyzed for each monitor well using the Skibitzke method. These time periods were selected because no sampling or pumping of the wells was conducted during these intervals.

Because the potentiometric surface at Estes Gulch is currently unknown as equilibrium has not been reached in the monitor wells, the hydraulic conductivities were calculated using various estimated static water levels, and were determined to be relatively insensitive to the value of this parameter.

Assumptions:

1) The aquifer is confined.

2) The aquifer has relatively low transmissibility.

3) Porosity in the (clean sand) gravel pack is approximately 35 percent.

4) Volume removed is equal to the volume beneath the estimated static water level in the casing (the potentiometric surface) and in the gravel pack.

5) The "well bailing" was effectively done when the monitor well boreholes were drilled, and all water was removed instantaneously.

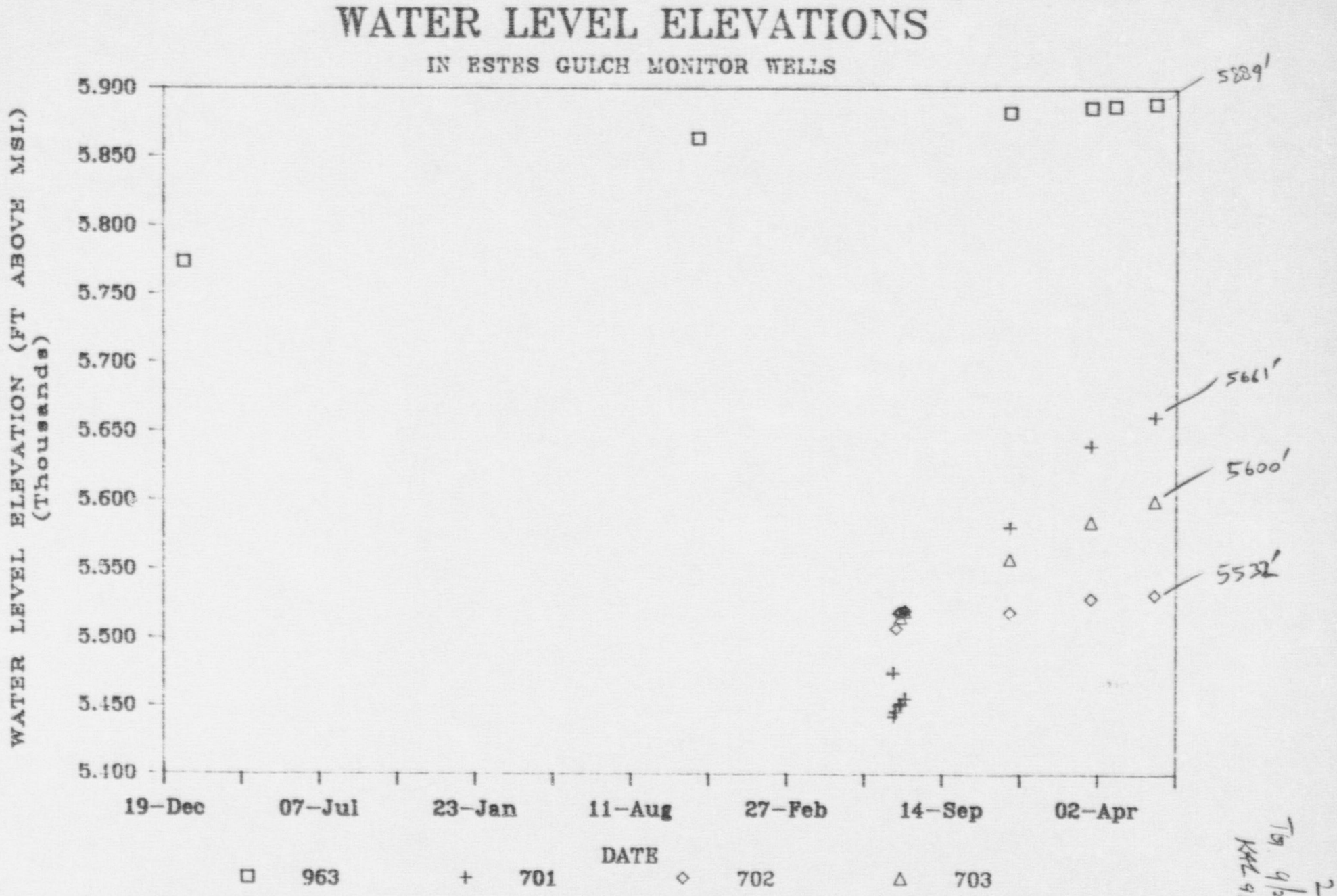


Figure 1. Water Level Elevations at the Estes Gulch Site

TG 9/21/89
KHC 9/22/89

2

3

TG 9/21/89

KTL 9/22/89

Data Sources:

All water level data was collected by the water sampling crew during their visits to the Estes Gulch site. Water level data is currently maintained on the TIMS (Technical Information Management System) computer and in Document Control at the DOE Project Office.

Well completion records for the monitor wells are presented in Attachment A.

All data used in these calculations are presented in the Rifle pfRAP (DOE, 1989).

Calculations

The equation used to estimate the hydraulic conductivity was

$$T = \frac{V}{4\pi s' t} \qquad 1)$$

where [Ferris et al, 1962]

T = transmissivity (ft^2/day)
V = volume of water removed (ft^3)
t = length of time since bailing stopped ($days$)
s' = residual drawdown (ft)

Since the transmissivity is the product of the hydraulic conductivity (K) the thickness of the contributing interval (b)

$$T = K b$$

the hydraulic conductivity can be solved for as follows:

$$K = \frac{V}{4\pi s' t b} \qquad 2)$$

where

K = the hydraulic conductivity (ft/day)
b = the thickness of the contributing interval (ft) KB

and the other parameters are defined above.

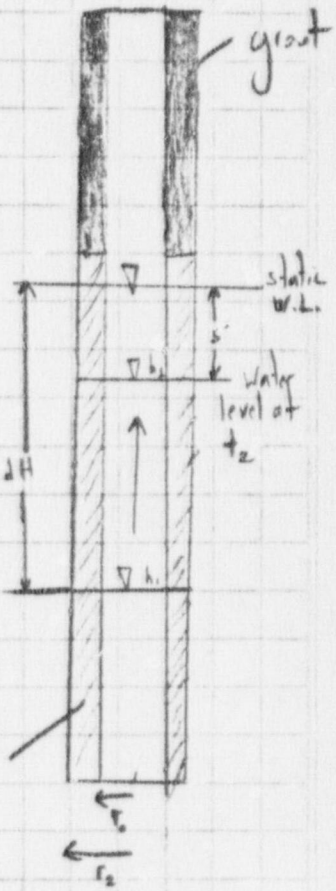
The volume of water removed (V) was estimated using the estimated static water level, the depth to water at t_1, the radius of the borehole (r_2), the radius of the well casing (r_1), and an estimated porosity (n) of 0.35 in the gravel pack. For example, in the problem to the right,

V = Volume in casing + Volume in gravel pack

$$= \left[\pi r_1^2 \, dH\right] + \pi \, dH \, n \left(r_2^2 - r_1^2\right)$$

or

$$\boxed{V = \pi \, dH \left[r_1^2 + 0.35\left(r_2^2 - r_1^2\right)\right]}$$



Of course, if the static water level was located above the gravel pack, then the volume component in the gravel pack should not be included in the estimate of "V."

In the figure to the right, the length of time (t) is equal to the time (in days) for the water level to rise from h_1 to h_2.

The parameters for each calculation and the calculation results are listed in Table 1.

JACOBS ENGINEERING

SHEET NO. ____ JOB NO. ____

DATE ____ BY ____ CHKD. ____ SUBJECT Slug Tests - Baker Recovery

Well #	Borehole D (in)	Casing D (in)	Total Depth (ft)	Static DTW (ft)	SAT Thick (ft)	Date #1	Date #2	Δt (days)	h_1 (ft)	V (ft^3)	h_2 (ft)	s' (ft)	K ft/d	K cm/s*	$\bar{K}$
701	8	4	543	3.00	243	12/10/88	3/24/89	104	397.2	17.4	338.5	38.5	1.4E-6	5.0E-10	
701	8	4	543	300	243	4/22/89	6/14/89	53	341.3	7.39	312.	17.0	2.7E-6	9.5E-10	
701	8	4	543	150	355	12/10/88	3/24/89	104	397.2	40.7	338.5	188.5	4.7E-7	1.6E-10	3.9×10^{-10}
701	8	4	543	150	355	4/22/89	6/14/89	53	341.3	30.7	317	167.0	7.8E-7	2.7E-10	
702	8	4	502	450	52.0	12/10/88	3/24/89	104	4.	6.82	478.5	28.5	3.5E-6	1.2E-9	
702	8	4	502	450	52.0	4/23/89	6/14/89	52	480.41	5.44	475.4	25.4	6.3E-6	2.2E-9	
702	8	4	502	150	82.0	12/10/88	3/24/89	104	488.1	35.74	378.5	228.5	1.5E-6	5.1E-10	
702	8	4	502	150	82.0	4/23/89	6/14/89	52	480.41	34.7	475.4	325.4	2.0E-6	7.0E-10	9.9×10^{-10}
703	8	4	502	400	102.0	12/10/88	3/24/89	104	452.5	9.39	425.2	25.2	2.8E-6	9.9E-10	
703	8	4	502	400	102.0	4/23/89	6/14/89	52	423.2	4.15	410.	10.0	6.2E-6	2.2E-9	
703	8	4	502	150	102	12/10/88	3/24/89	104	452.5	31.21	425.2	275.2	8.5E-7	3.0E-10	
703	8	4	502	150	102	4/23/89	6/14/89	52	423.2	25.07	410.	260.0	1.5E-6	5.3E-10	7.7×10^{-10}
963	8	4	302	150	55.5	12/10/88	3/24/89	104	160.89	0.95	157.15	7.2	1.8×10^{-6}	6.5×10^{-10}	
963	8	4	302	150	55.5	4/23/89	6/14/89	52	156.13	0.53	154.55	4.6	3.2×10^{-6}	1.1×10^{-9}	8.5×10^{-10}

Gravel = 488

Gravel = 410

Gravel = 400

Gravel = 246.5

Table 1. Parameters used in the Hvorslev calculations and the predicted hydraulic conductivities.

$\bar{K} = 7 \times 10^{-10}$ cm/s

KAH 9/22/89

9/21/89 (C)

* cm/s = ft/day $\times 3.53 E-4$

7

TG
9/21/89

RAL
9/22/89

Conclusions and Recommendations:

The hydraulic conductivities calculated using the Skibitzke method are as follows:

Monitor well	Hydraulic Conductivity (cm/s)
963	9 X 10-10
701	4 X 10-10
702	1 X 10-9
703	8 X 10-10

Geometric Mean: K = 7 X 10-10 cm/s

The Skibitzke method yields only rough estimates of the hydraulic conductivity of the formation. However, these low values are good indicators of the low yield of the Wasatch Formation, and are reasonably consistent with other field and laboratory measurements of hydraulic conductivity in the Wasatch Formation (Calculations RFLO889140300, RFLO8991302a, and RFLO9891403b).

Monitor well 702 is located within the fault zone south of the disposal cell footprint. Although one might expect that the hydraulic conductivity within the fault zone would be significantly greater than the conductivities measured elsewhere, the data above indicates that this is not the case. Therefore, it is reasonable to conclude that contaminant migration along the fault zone will not be significant.

8

T6
9/21/89
KAL
9/22/89

REFERENCES

DOE (Department of Energy), 1989. Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Sites at Rifle, Colorado, (preliminary final), prepared by Jacobs Engineering Group, Inc, for the U.S. Department of Energy at the Albuquerque Operations Office.

Ferris, J.G., Knowles, D.B., Brown, R.H. and R.W. Stallman (Ferris et al.), 1962. Theory of Aquifer Tests. United States Geological Survey Water-Supply Paper 1536-E. United States Government Printing Office, Washington, 1962. pp 103-104.

9

TG
9/21/89

KH
9/22/89

ATTACHMENT A

WELL COMPLETION RECORDS

10
TG 9/21/89
KA 9/22/89

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WELL COMPLETION RECORD

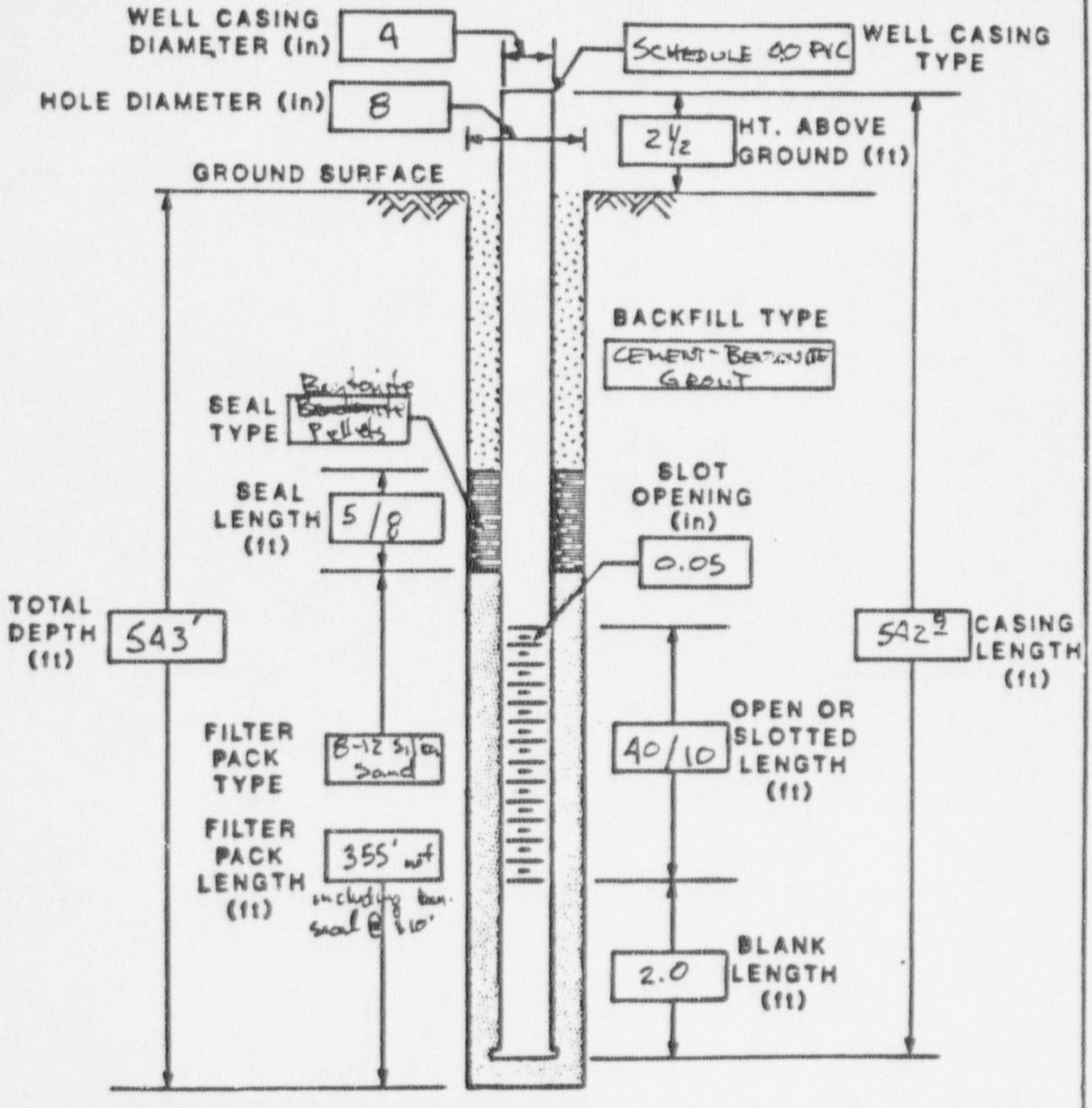
SITE ID: RFL-08 LOCATION ID: 701 DATE INSTALLED: 7/13/88

APPROX. SITE COORDINATES: (FT.) N UK E UK

OPEN AREA PER LINEAL FT. ($IN^2/FT.$) UK

FORMATION OF COMPLETION: Wasatch FM

FIELD REP.: SMITH/METZLER DRILLER: BOYLE BROS.



COMMENTS: two screened intervals used at 541 to 501 and 280 to 270 foot depths, two seals used at 310 to 305 and 171 to 180'

JEG-AL-ENG-3 (3/84)

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Tb 9/21/89
KAL 9/22/89

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: RFL-08 LOCATION ID: 701 FIELD REP: SMITH / METZLER

APPROX. SITE COORDINATES (FT.): N NK E NK

GROUND ELEVATION (FT. MSL): ? NK COMPLETION DATE: 7/15/88

BOREHOLE SUMMARY

DRILLER: Boyles Bros, Boyd

RIG TYPE: FAILING 1500 ROTARY

BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.) ●	FLUID TYPE
TRI-CONE	8.0"	543.0 ~~447.0~~	AIR

CASING SUMMARY

CASING TYPE ●	DESCRIPTION	DIA. (in.)	END DEPTH ◆ (ft.)
~~P~~	~~Steel casing~~		
P	Steel protective pipe	8/10	
B	Schedule 40 PVC	4	270
S	Schedule 40 PVC	4	280
B	Schedule 40 PVC	4	503
S	Schedule 40 PVC	4	513
B	Schedule 40 PVC	4	543

● P-Protective B-Screen B-Blank O-Open N-None

◆ Depth from Top of Casing

WELL CONSTRUCTION

TYPE CODE ●	DESCRIPTION	END DEPTH ◆ (ft.)
B	Cement-bentonite grout	171
F	bentonite pellets ~~seal~~	179
F	8-12 silica sand	302
S	bentonite pellet seal	310
F	8-12 silica sand	543

● B - Backfill S - Seal F - Filter Pack

◆ Depth from Ground Surface

CONSTRUCTION TIME LOG

ACTIVITY	START DATE	START TIME	END TIME
DRILLING	7-9-88	~~7:55~~ AM	6:15 PM
	7-10-88	9:50 AM	4:50 PM
	7-11-88	7:30 AM	3:00 PM
CASING	7/12/88	1:20 pm	3:00 pm
	7/13/88	7:00 am	10:30 am
FILTER PACK	7/13		
	7/14		
SEAL	7/13		
	7/14		
BACKFILL	~~7/15~~		
	7/15		
DEVELOPMENT			
	7/15		
OTHER			

WELL DEVELOPMENT

bailed until water appeared, 3 times, very little water

COMMENTS: basically a dry hole, emptied water out of hole w/ 3 bailer runs

JEQ-AL-ENG-1 (8/84)

12
T6 9/21/95
HAL 9/20/95

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WELL COMPLETION RECORD

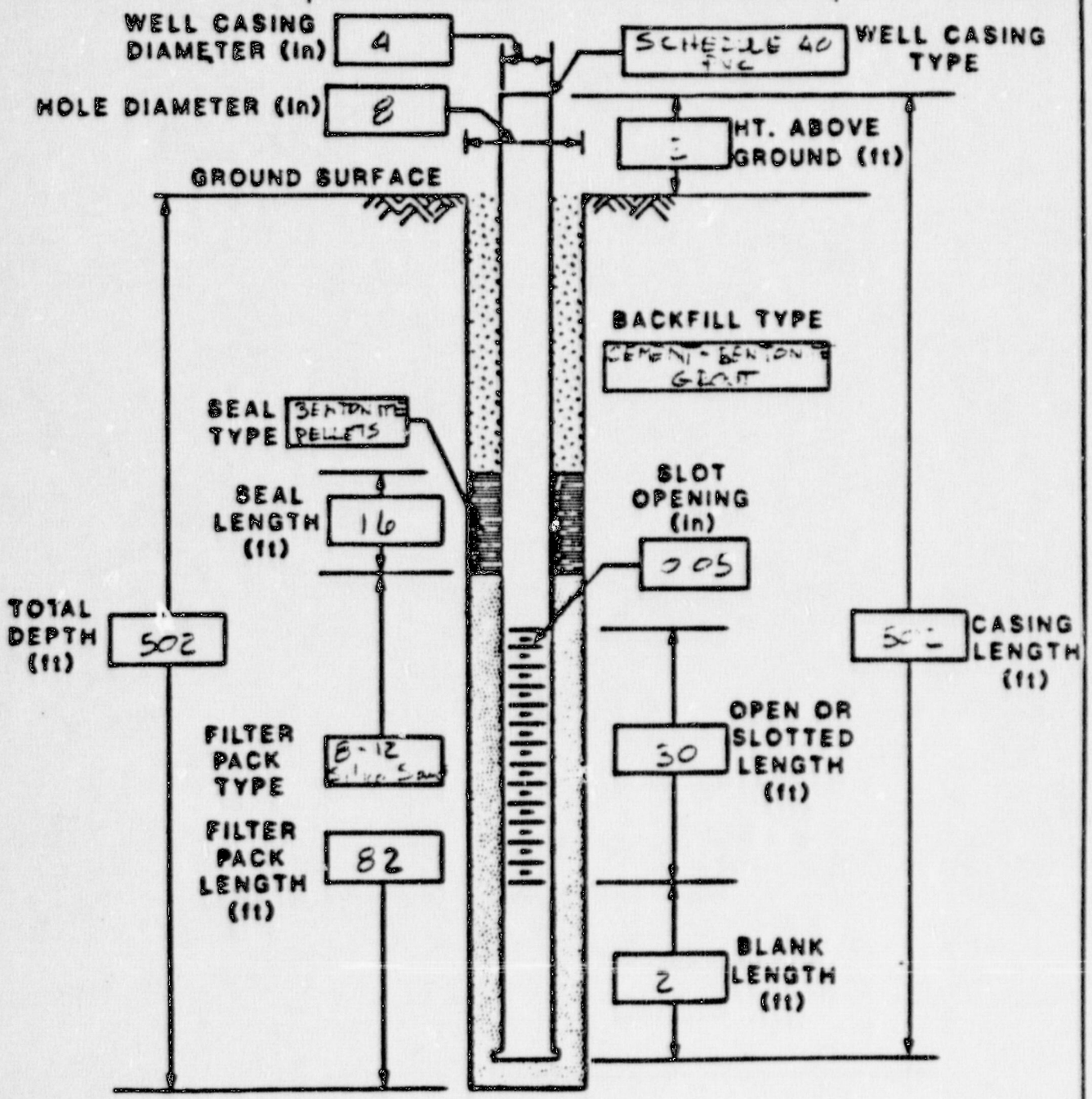
SITE ID: RFL-08 LOCATION ID: 702 DATE INSTALLED: 7/18/12-

APPROX. SITE COORDINATES: (FT.) N NK E NK

OPEN AREA PER LINEAL FT. (IN^2/FT.) NK

FORMATION OF COMPLETION: Wa

FIELD REP.: G. SMITH / G. [illegible] DRILLER: [illegible]



COMMENTS: _____

13 T6 8/21/K KAL 11/22/

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BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: BFL-08 LOCATION ID: 702 FIELD REP: G. SMITH/G. LINDSEY

APPROX. SITE COORDINATES (FT.): N NK E NK

GROUND ELEVATION (FT. MSL): NK COMPLETION DATE: 7/19/85

BOREHOLE SUMMARY

DRILLER: BOYLES BROS/MIKE BOYD

RIG TYPE: FAILING 1500

BIT TYPE	HOLE DIA. (in.)	END DEPTH● (ft.)	FLUID TYPE
GB	10	10	AIR
GB	7 7/8 (8)	502	AIR

CASING SUMMARY

CASING TYPE●	DESCRIPTION	DIA. (in.)	END DEPTH◆ (ft.)
P	STEEL PIPE	6	6
B	SCHEDULE 40 PVC BLANK	4	470
S	SCHEDULE 40 PVC 10 SLOT	4	500
P	SCHEDULE 40 PVC	4	502

● P-Protective S-Screen B-Blank O-Open N-None

◆ Depth from Top of Casing

WELL CONSTRUCTION

TYPE CODE●	DESCRIPTION	END DEPTH● (ft.)
B	CEMENT - BENTONITE GROUT	404
S	BENTONITE PELLETS	420
F	#-12 SILICA SAND	502

● B - Backfill S - Seal F - Filter Pack

● Depth from Ground Surface

CONSTRUCTION TIME LOG

ACTIVITY	START DATE	START TIME	END TIME
DRILLING	7/15		
	7/16	11:30 am	5:00 pm
	7/17	8:30 am	12:00 pm
CASING	7/18	8:00 am	10:20 pm
FILTER PACK	7/18	10:30 am	11:[illegible]
SEAL	7/18	11:30 am	1:30 pm
BACKFILL	7/18	2:50 pm	4:30 pm
	7/19	8 am	4:30 pm
DEVELOPMENT			
OTHER			

WELL DEVELOPMENT

COMMENTS:

JEG-AL-ENG-1 (8/84)

14

Tb 9/21/89

KAL 9/22/89

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WELL COMPLETION RECORD

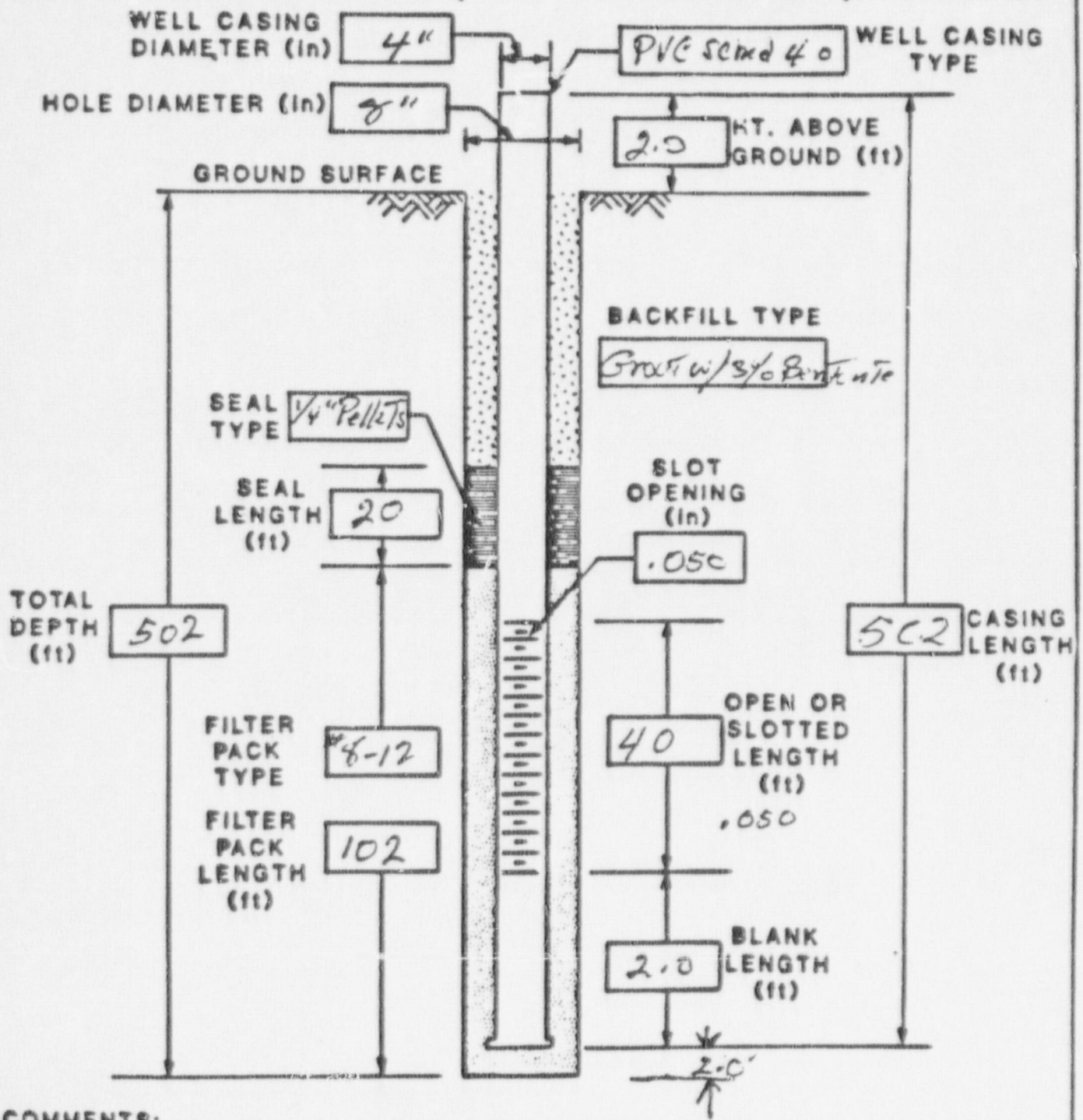
SITE ID: RFL-08 LOCATION ID: 703 DATE INSTALLED: 7/21,22

APPROX. SITE COORDINATES: (FT.) N 56,600 E 53,180

OPEN AREA PER LINEAL FT. (IN^2/FT.) _____

FORMATION OF COMPLETION: WASATCH

FIELD REP.: Gerald Lindsey DRILLER: Mike Boyd



COMMENTS: _____

15
JG 9/21/88
KKL 9/22/88

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BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: RFL-08 LOCATION ID: 703 FIELD REP: Gerald Lindsey
APPROX. SITE COORDINATES (FT.): N 56,600 E 53,150
GROUND ELEVATION (FT. MSL): 6007 COMPLETION DATE: 7-22-88

BOREHOLE SUMMARY

DRILLER: Mike Boyd
RIG TYPE: Failing 25

BIT TYPE	HOLE DIA. (in.)	END DEPTH ● (ft.)	FLUID TYPE
Fishtail	10	10	Air only
Grad. PT	8	502	Air only

CASING SUMMARY

CASING TYPE●	DESCRIPTION	DIA. (in.)	END● DEPTH (ft.)
PVC	Sump	4	500
	Screen .050	4	488
	Blank Sch 40	4	458

● P-Protective S-Screen B-Blank O-Open N-None
◆ Depth from Top of Casing

WELL CONSTRUCTION

TYPE CODE●	DESCRIPTION	END◆ DEPTH (ft.)
F	Sandpack #8-12	502
S	Bentonite Pellets 1/4"	
B	Grout 7½ gal/sack mix	

● B - Backfill S - Seal F - Filter Pack
◆ Depth from Ground Surface

CONSTRUCTION TIME LOG

ACTIVITY	START DATE	START TIME	END TIME
DRILLING	7/20/88	8:55A	7/21 10:40 A
CASING	7/21/88	2:27P	4:05
FILTER PACK	7/21/88	4:05	4:42
SEAL	7/21/88	4:40	4:50
BACKFILL	7/22/88		
DEVELOPMENT			
OTHER			

WELL DEVELOPMENT

COMMENTS: No water in borehole after completion.

16
TL 9/21/89

KAL 9/22/89

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WELL COMPLETION RECORD

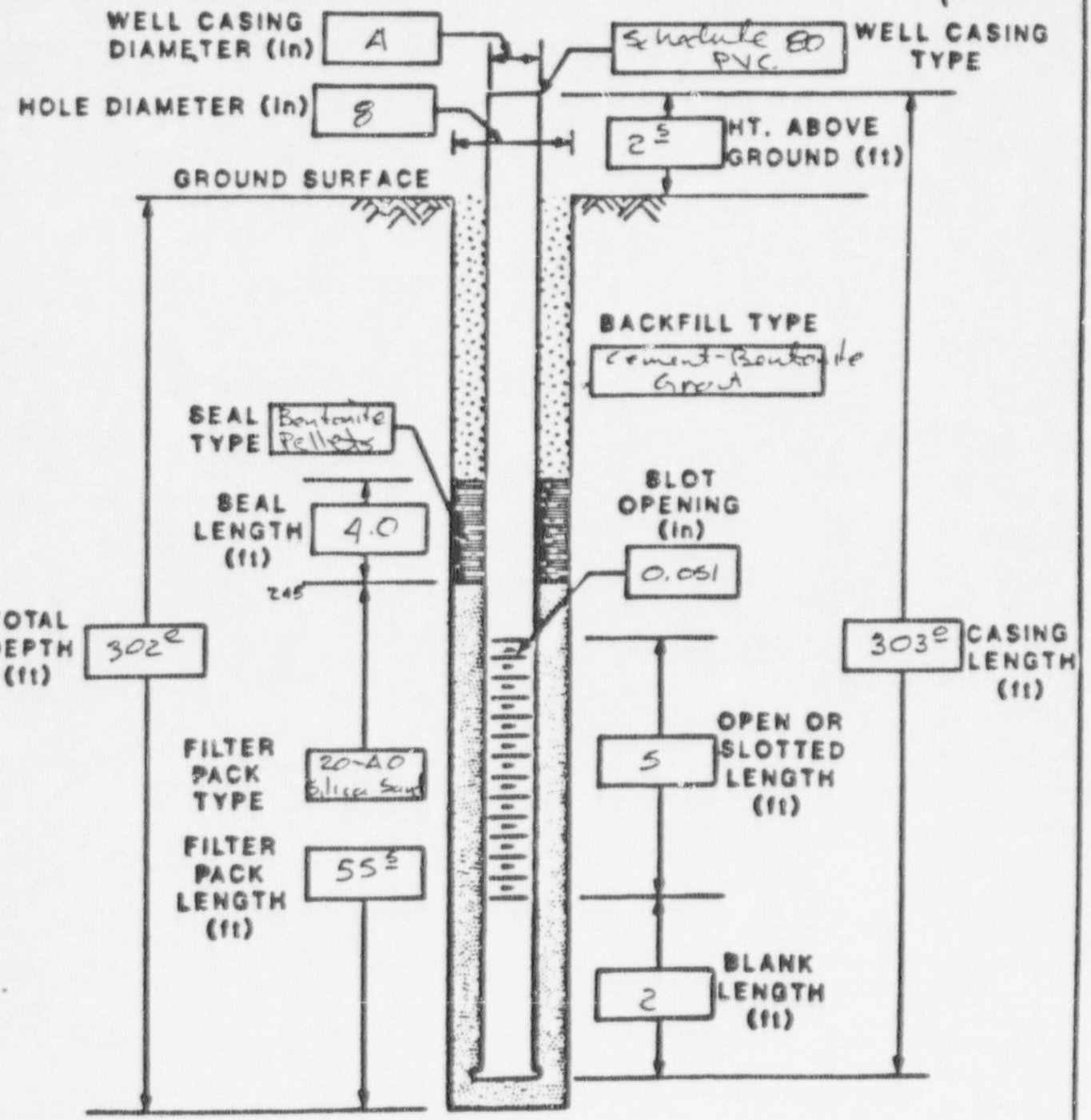
SITE ID: RFL 08 LOCATION ID: 963 DATE INSTALLED: Nov. 1, 1985

APPROX. SITE COORDINATES: (FT.) N NK E NK

OPEN AREA PER LINEAL FT. ($IN^2/FT.$) NK

FORMATION OF COMPLETION: lower siltstone interval

FIELD REP.: G. SMITH DRILLER: Himes Drilling Co



COMMENTS: _____

JEG-AL-ENG-3 (3/84)

17

T6 9/21/89

KA 9/22/89

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BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: RFL 08 LOCATION ID: 963 FIELD REP: G. SMITH

APPROX. SITE COORDINATES (FT.): N NK E NK

GROUND ELEVATION (FT. MSL): NK COMPLETION DATE: Nov 2 1989

BOREHOLE SUMMARY

DRILLER: Himes Drilling Co

RIG TYPE: Failing 1500 Hydramaster

BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE
GB-roller	5	302	AIR*
GB-roller	7 7/8	302	AIR*

* water injection lower 150 ft

CASING SUMMARY

CASING TYPE	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)
P	Galvanized Steel	8	7
B	Schedule 80 PVC	4	296
S	Schedule 80 PVC	4	301
B	Schedule 80 PVC	4	303

P-Protective S-Screen B-Blank O-Open N-None

Depth from Top of Casing

WELL CONSTRUCTION

TYPE CODE	DESCRIPTION	END DEPTH (ft.)
B	Cement-Bentonite Grout	24
S	Bentonite Pellets	245
F	20-40 Silica Sand	300
B	Hole cave material	302

B - Backfill S - Seal F - Filter Pack

Depth from Ground Surface

CONSTRUCTION TIME LOG

ACTIVITY	START DATE	START TIME	END TIME
DRILLING 5" roller	10/31	12:30 pm	5:15 pm
8" roller	11/1	10:15 am	3:30 pm
CASING	11/1	3:30 pm	4:10 pm
FILTER PACK	11/1	4:10 pm	4:45 pm
SEAL	11/1	4:45 pm	5:00 pm
BACKFILL	11/1	5:30 pm	5:45 pm
	11/2	6:30 am	7:25 am
	11/2	8:10 am	8:30 am
DEVELOPMENT AIR LIFT	11/3	9:50 am	10:05 am
BAILING	11/3	10:10 am	12:30 pm
OTHER	11/8	8:00 am	2:09 pm

WELL DEVELOPMENT

Air lifted in stages depths, 100, 200, 260, 280, 300 feet

Water in well air lifted, ~~stop added~~ blown injection water added to facilitate cleaning filter pack, return water became cloudier w/ time, air lifting stopped. Hand bailed 4 hrs never clear

COMMENTS: pellets were place by dumping slowly & letting them free fall. 10 gal water added at end to wash all down & hydrate