Technical Advisory Group

City of Fort Lauderdale

V. P. Amy, Geraghty & Miller, Inc

GERAGHTY
& MILLER, INC.

Consulting Ground-Water Geologists and Hydrologists

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CONSULTING GROUND-WATER GEOLOGISTS AND HYDROLOGISTS

Telephone: 305/ 683-3033

2 April 1981
P118FL1

MEMORANDUM

TO: Technical Advisory Group
City of Fort Lauderdale

FROM: V. P. Amy, Geraghty & Miller, Inc.

RE: Intermediate Casing Point, Test-Injection Well, City of Fort Lauderdale, Ft. Lauderdale, Florida

Attached is our report on the recommendation regarding the change in the setting point for the 34-inch casing in the test-injection well.

This recommendation is made in an effort to prevent the occurrence of a future problem. Setting the 34-inch casing some 70 feet shallower will not compromise its intended purpose and should aid in preventing a problem. We will keep you advised of the results of the gyroscopic surveys and other events as they occur.

Distribution

Technical Advisory Group

R. Duke, DER
G. Coker, EPA
B. Amos, EPA
F. Meyer, USGS
A. Kreitman, SFWMD
L. Wedderburn, SFWMD
R. Knittel, DER
V. Howard, BCEQCB

City of Fort Lauderdale

W. R. Mehner
B. Sawyer
A. B. Roberts

Also

R. J. Kerrn, Alsay-Pippin
P. Robinson, Hazen & Sawyer

INTERMEDIATE CASING POINT
TEST-INJECTION WELL
CITY OF FORT LAUDERDALE
FORT LAUDERDALE, FLORIDA

At the March 5, 1981, meeting with the Technical Advisory Group, the results of the pilot hole drilling, logging, and testing were discussed and recommendations presented regarding the setting points for the outer (34-inch) and inner (24-inch) casings. It was recommended that the 34-inch casing be set at 1970 feet for the reasons listed below.

Dolomite and limestone occur in the interval between approximately 2000 and 2100 feet. The upper contact between this unit and the overlying limestone is gradual and is marked by the appearance of dolomite interbedded with the limestone, grading into dolomite. The dolomite is indicated on the induction log by the presence of high resistivity. Also, because it is comparatively hard, it does not wash out during drilling, so that it shows as a pronounced "gauge-size" (or nearly so) hole on the caliper log.

When this section was drilled, a cavity was encountered at ±2096 feet. Examination of the caliper log reveals that some over-size portions are present in the dolomite; these may be due to fractured rock which fell in or was drilled out, giving the hole a rugose appearance on the caliper log. The television survey, which was performed while the well was being pumped, revealed that flow was entering the borehole at 2075 feet (that depth is based on the camera odometer and may be in error).

The specifications originally called for a setting point of 2000 feet for the 34-inch casing to seal off water containing less than 10,000 mgl of total dissolved solids. That point was selected based on the reasonable assumption that salt water (35,000 mgl TDS) is present at this depth.

At the March 5 meeting, it was recommended and accepted by the Group that a setting of ±1970 feet be used. This depth rather than a deeper one was selected to prevent the possible

loss of cement around the base of the casing because of the nature of the dolomite. At that point, 1970 feet, the base of the casing would be set in a fine- to medium-grained, chalky limestone. This would also permit the cement plug called for in the specifications to be set at the top of the dolomite or in the interbedded limestone and dolomite to effect a seal and prevent cement loss.

Following the meeting, the Contractor proceeded to ream the hole to ±1970 feet and prepare for setting the 34-inch casing. During the reaming operations, directional surveys were made by the Contractor at the prescribed intervals. After each survey was made, the film was analyzed and the position of the hole was calculated by the minimum curvature method. Surveys also were performed during the drilling of the pilot hole so that the relative positions of the reamed and pilot holes could be monitored as the work progressed.

Comparison of the survey data reveals that the plotted position of the centers of the holes deviate from each other, with the reamed hole plot showing a greater overall inclination from the vertical than the pilot hole surveys. As a consequence, the plotted position of the ream appears to be further from the common reference point for the surveys (the base of the 42-inch casing at 950 feet). This departure can be first seen in the surveys at 1188 and 1189 feet, and becomes more apparent with increasing depth.

The distances between the survey points below 1700 feet are listed in the following table. Copies of the survey data and plots showing the relationships between position are attached.

Survey Depth		Distance
Reamed Hole	Pilot Hole	(ft)
1702	1692	2.4
1772	1754	2.55
1838	1816	2.85
1901	1878	2.90
1934	1941	2.80

Much of the pilot hole is overgauge because of the nature of the limestone. Below 1700 feet, the diameter is 18 to 20 inches, with the exception of the interval below 1950 feet where the diameter reduces somewhat (to 15 inches) owing to

the presence of the interbedded limestone and dolomite. The reamed portion of the hole is in excess of 57 inches in diameter (the limit of the Schlumberger caliper tool). Consequently, the plotted positions of the holes overlap so that effective communication exists.

As noted previously, the reamed portion of the hole is further from the vertical than the pilot hole. Thus, the position of the pilot hole is located on the low side of the reamed hole. According to the survey data, this relationship is quite consistent. If the 34-inch casing is set and centralized at 1970 feet, this would offset the position of the center of the next reaming (nominal 34-inch-diameter) relative to the pilot hole, based on the survey data. This would raise the possibility that the next reaming may depart from the track of the pilot hole.

To avoid this possibility, it is recommended that a shallower casing setting be employed. This would permit the stage bit used for the next ream to re-enter a previously drilled section of hole rather than drilling new hole at the outset, and should allow the bit to track the low side of the hole and stay on the course of the pilot hole.

Review of the data indicates that a setting of approximately 1900 feet (proposed by the Contractor) should bring the casing back to a point that would allow the ream bit to re-enter the "old ream" hole, giving the tool string the flexibility to seek the original path of the pilot hole. Preferably, the casing would not be centralized at the bottom to permit it to be in as close contact to the "low side" of the reamed hole, placing it as close to the plotted position of the pilot hole, as possible. Examination of the caliper log reveals that most of the reamed hole is well in excess of 40 inches in diameter (the approximate diameter of the centralizers). Furthermore, the hole is reasonably straight (about 7 feet off center in about 1000 feet) so that centralizers placed further up the casing would tend to provide stand-off. That, coupled with the larger diameter of the hole, should be more than enough to provide an adequate sheath of cement around the casing. Also, the 24-inch casing will be set inside the 34-inch pipe and cemented, thereby providing additional protection, so that it is not absolutely critical to centralize the 34-inch casing.

The procedure that the Contractor plans to follow will consist of installing the 34-inch casing to approximately 1900 feet (pad datum). He will install the tool string in the hole with a 32-inch bit attached to provide centralization, and then perform a gyroscopic survey of the casing to relate its position to the plotted position of the pilot hole. The hole will then be sounded and back-filled with crushed rock or some other suitable material and a cement plug (about 10 feet thick) set on top of the gravel. The top of the cement plug will be left below the bottom of the casing. The 34-inch casing will be cemented in place. After cementing, the plug and gravel will be drilled out slowly; directional surveys will be run at 30-foot intervals in order to check the hole position. This procedure will be followed until the Contractor has provided reasonable assurance that the reaming is tracking the pilot hole.

Setting the casing at the 1900-foot depth will not compromise the well's construction, as the casing will still be seated in the same type of material as that found at 1970 feet. Also, water containing less than 10,000 mgl of TDS still will be protected as the casing still will be seated below the point where water of this quality occurs. A copy of the analysis of a water sample collected after 48 hours of pumping during the Floridan aquifer test (hole open from 950 to 1500 feet) is attached. It shows that the water produced from this zone (or zones) contains water with 13,038 mgl of TDS.

Review of the records indicates no unusual problems associated with performing the various surveys. The data indicate a departure in the track of the two holes. In the bottom 100 feet or so, the amount of departure has remained about the same. That, combined with the over-size nature of both the pilot and reamed holes indicates that no problem exists now. The fact that the tracks are parallel to each other suggests that the lead bit is tracking the pilot hole and possibly that much of the departure is "apparent" due to inherent instrument error. In any event, prudence dictates that measures be taken now, when the opportunity exists, to avoid a potential future problem.

Respectfully submitted,
GERAGHTY & MILLER, INC.

Vincent P. Amy

Vincent P. Amy

April 2, 1981

GEO TEC inc. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-7280

LAB ID 86122

ANALYSIS REPORT

SAMPLE NO. 12-250, 12-251

Geraghty & Miller, Inc.
Attn: Jim Wheatley
1675 Palm Beach Lake Blvd. - Suite 404
West Palm Beach, FL 33401

DATE REC'D 2/27/81

TIME REC'D

PROJECT NO.

DATE COLLECTED BY client TIME

LOCATION FORT LAUDERDALE PURPOSE
TEST INJECTION WELL

Fwd Magnetic tape & sample 2 to Gordon 3/27/81

	Chloride, mg/l	TDS, mg/l
DST2A TIW OST2A (2568-2695) 2/24/81 1650 (DRILL STEM #2A	NOT REPRESENTATIVE DUE TO INVASION 12,593	21,216
Floridan 2100 9 pm 10:00 1/25/81 48 hr	7763	13,038

DATE 3/5/81 BY Gordon G Curl

GEO TEC

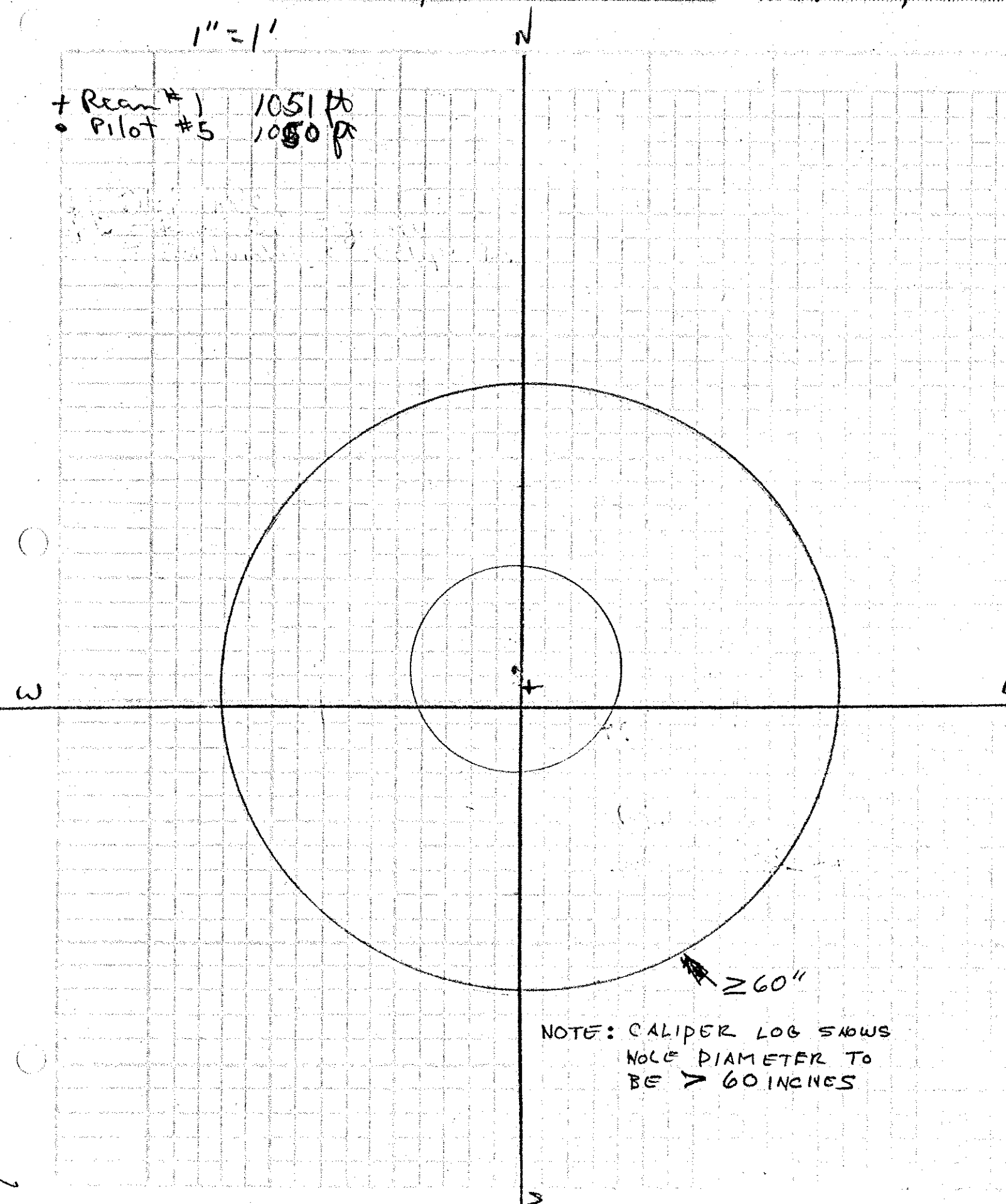
GERAGHTY & MILLER
Ground-Water Consultants

FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 1 of 16
By JAW Chkd.
Job P118 FL1

1" = 1'

+ Ream #1 1051 ft
• Pilot #5 1050 ft



NOTE: CALIPER LOG SHOWS HOLE DIAMETER TO BE > 60 INCHES

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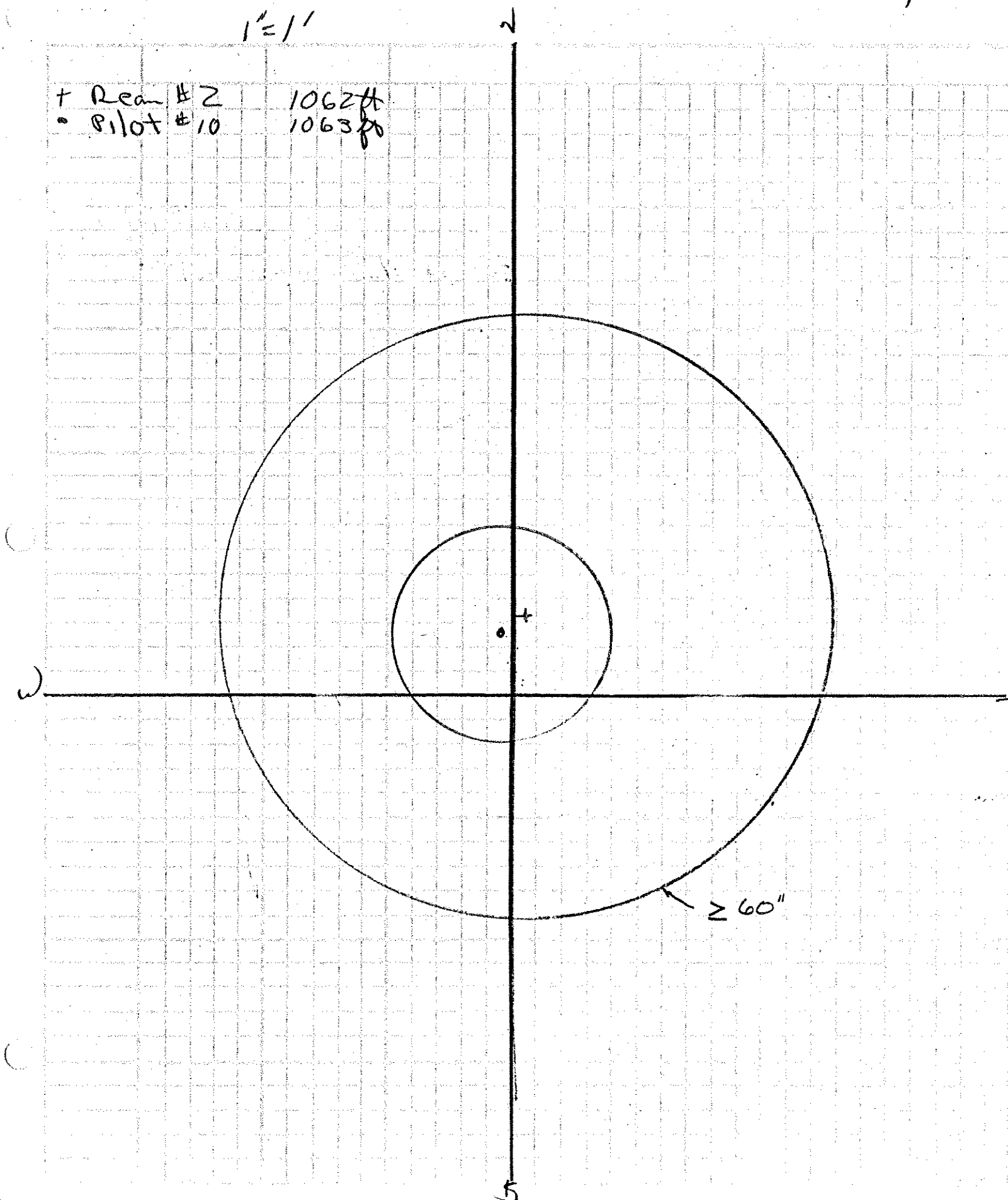
Ground-Water Consultants

FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 2 of 16
By Jan Chkd.
Job P118.FL

1" = 1'

+ Rea. #2 1062ft
• Pilot #10 1063ft



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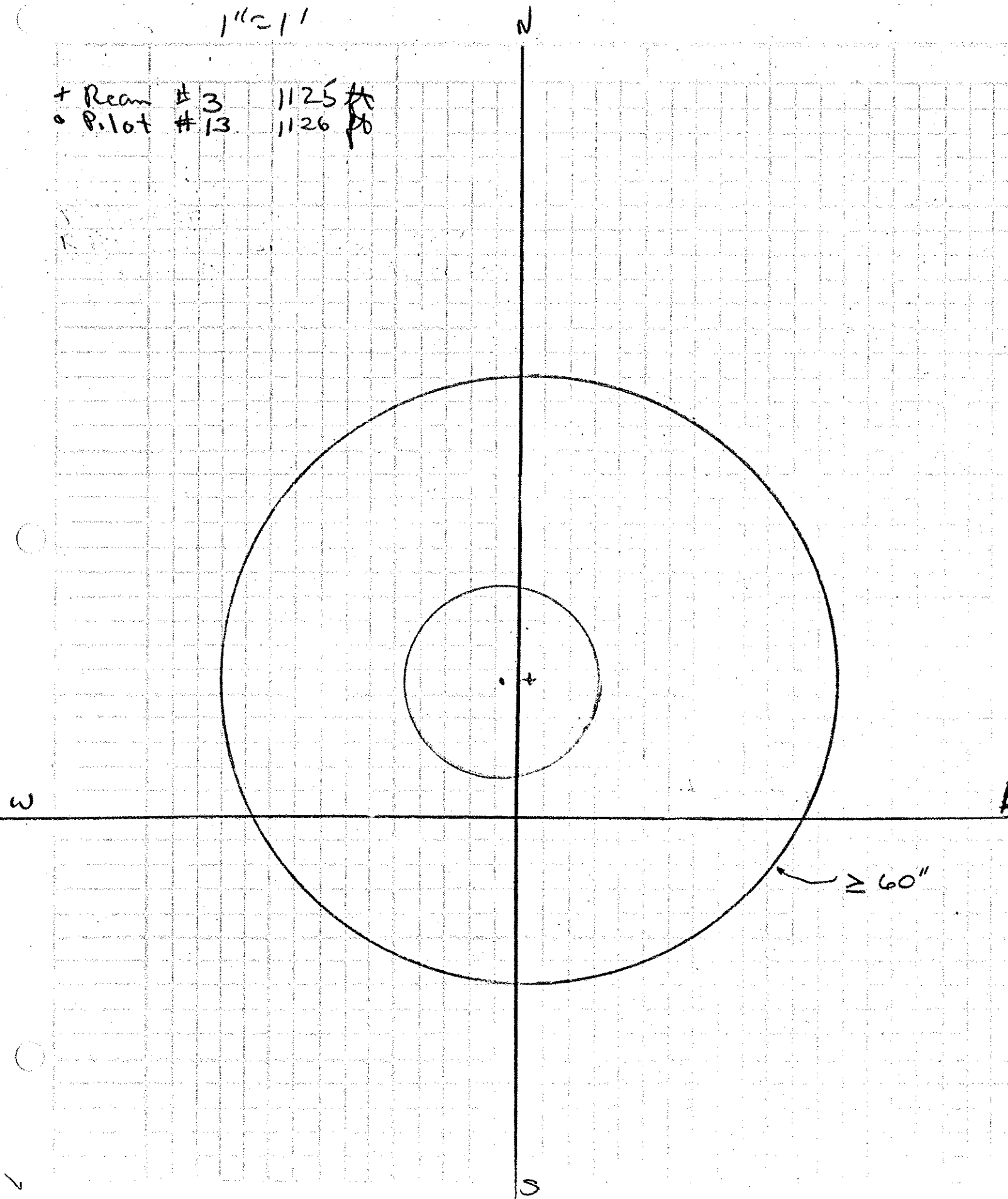
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 3 of 16
By JAW Chkd.
Job P118 FL



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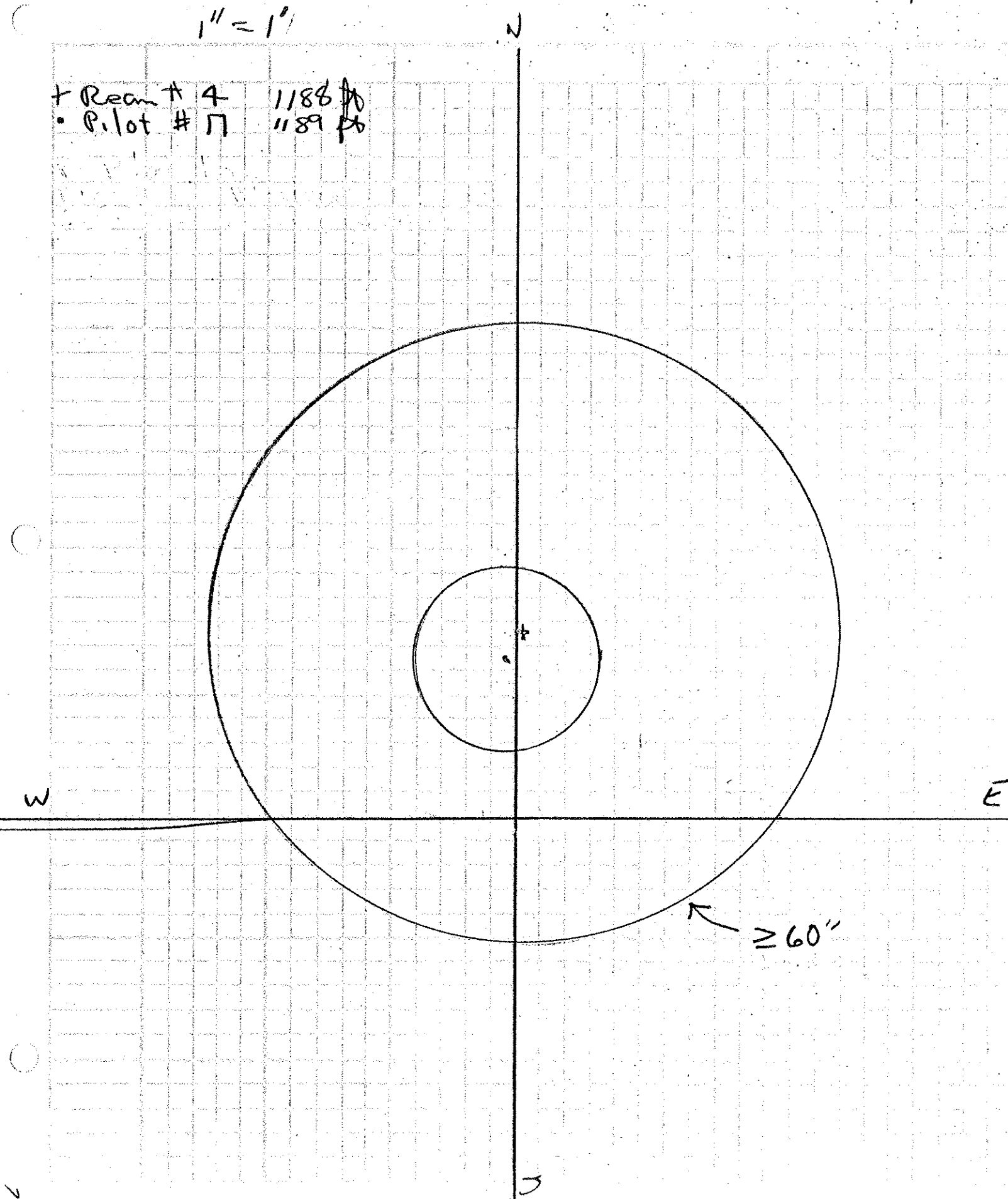
Ground-Water Consultants

FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 4 of 16
By Jaw Chkd.
Job P118.F4



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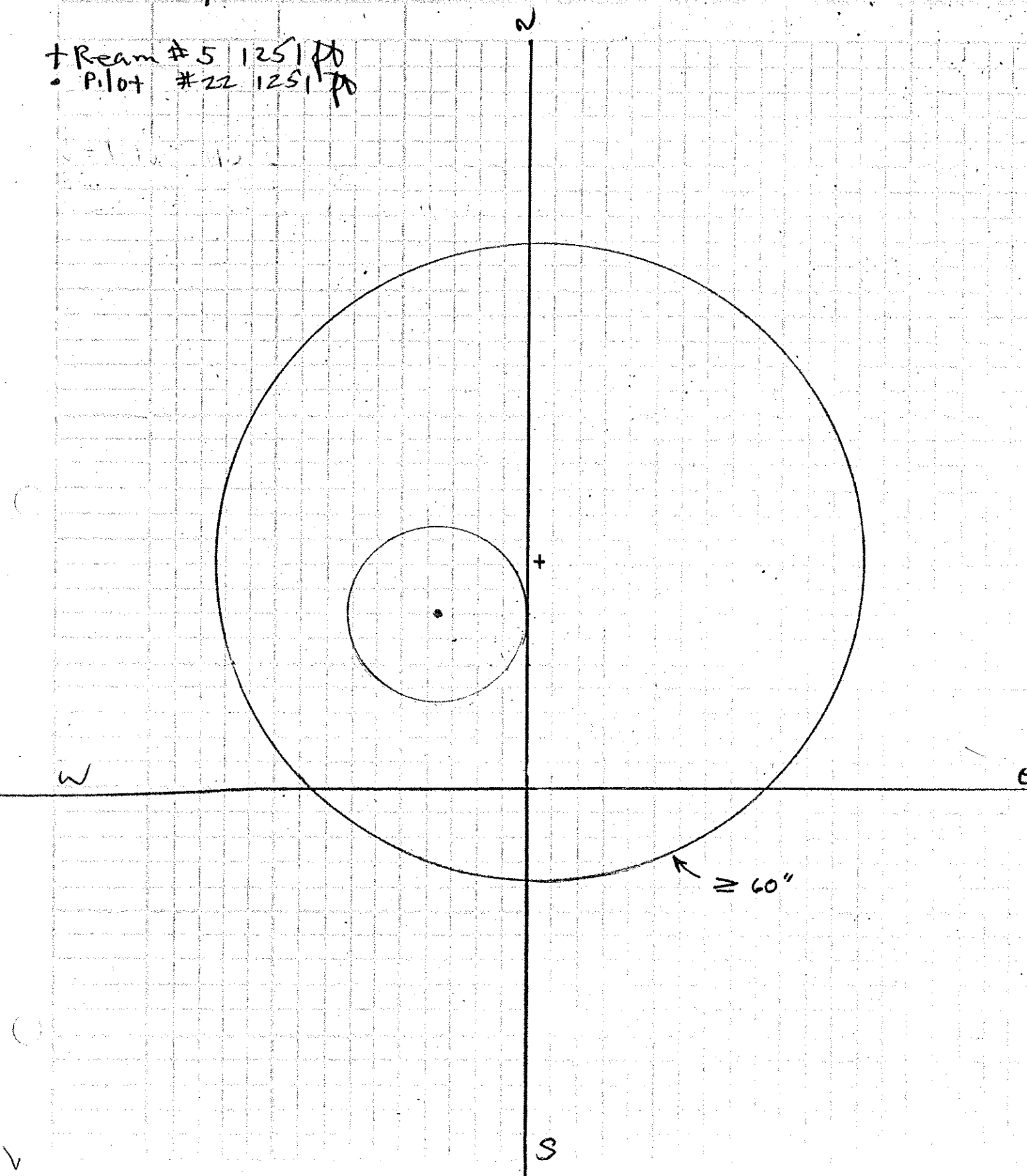
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 ~5 of 16
By JCW Chkd.
Job P116 FL

1" = 1'



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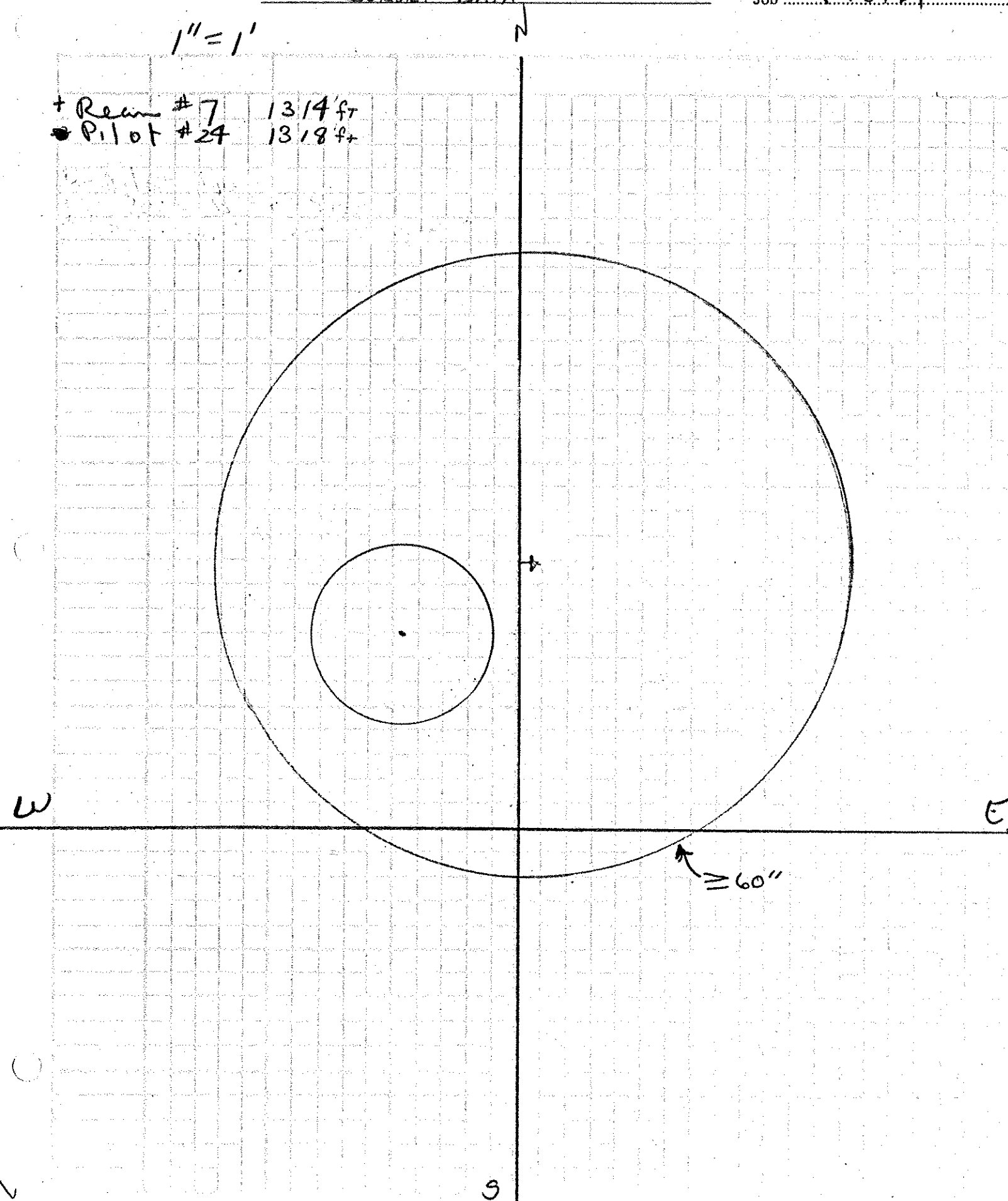
Fort Lauderdale Injection Well
Comparison of Directional Survey Data

Date 3/25 6 of 16
By JAW Chkd.
Job P118FL1

1" = 1'

+ Reamer #7 1314 ft
• Pilot #24 1318 ft



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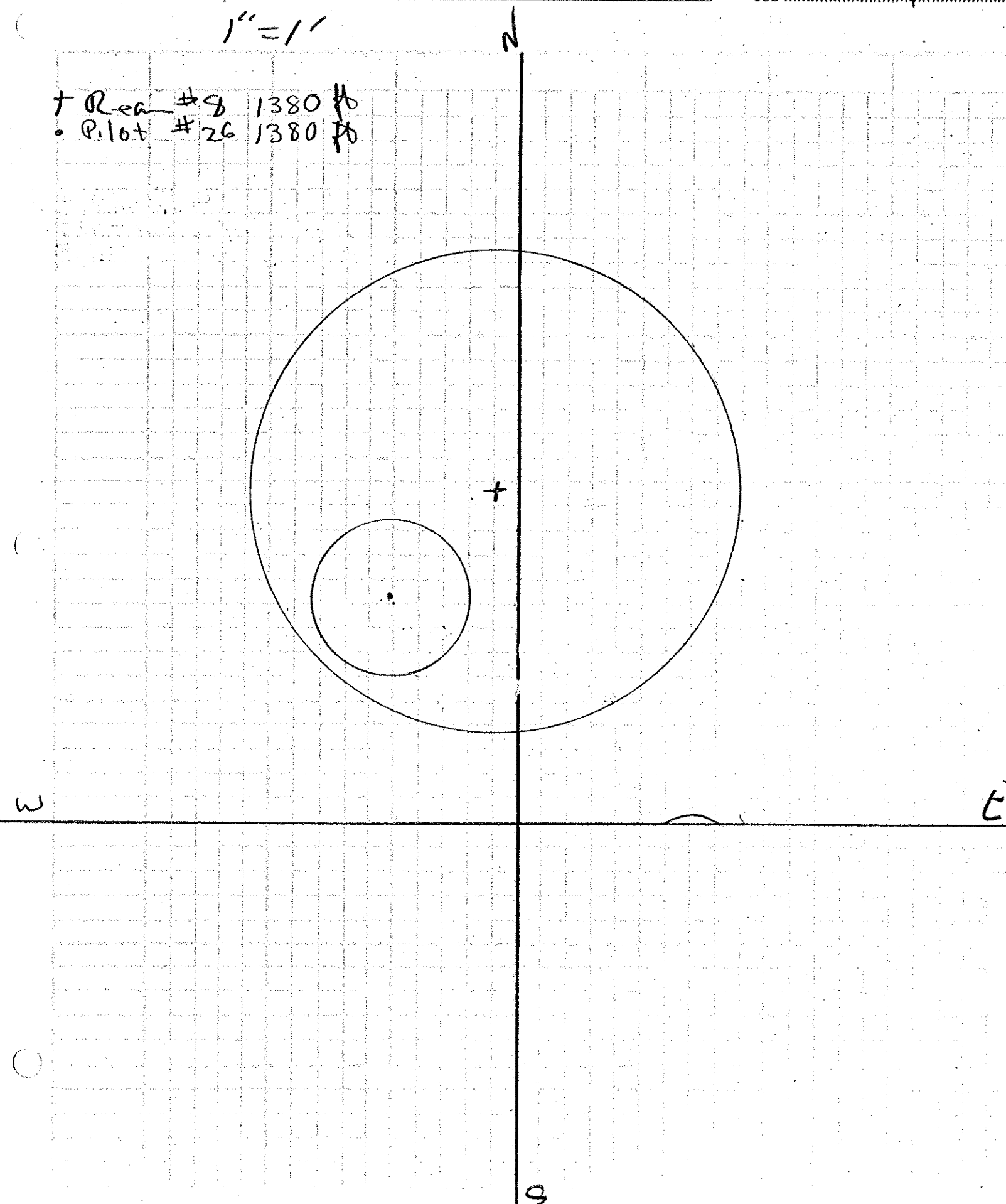
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 7 of 16
By JAW Chkd.
Job 8118 FL

1" = 1'

+ Rea #8 1380 ft
• Pilot #26 1380 ft



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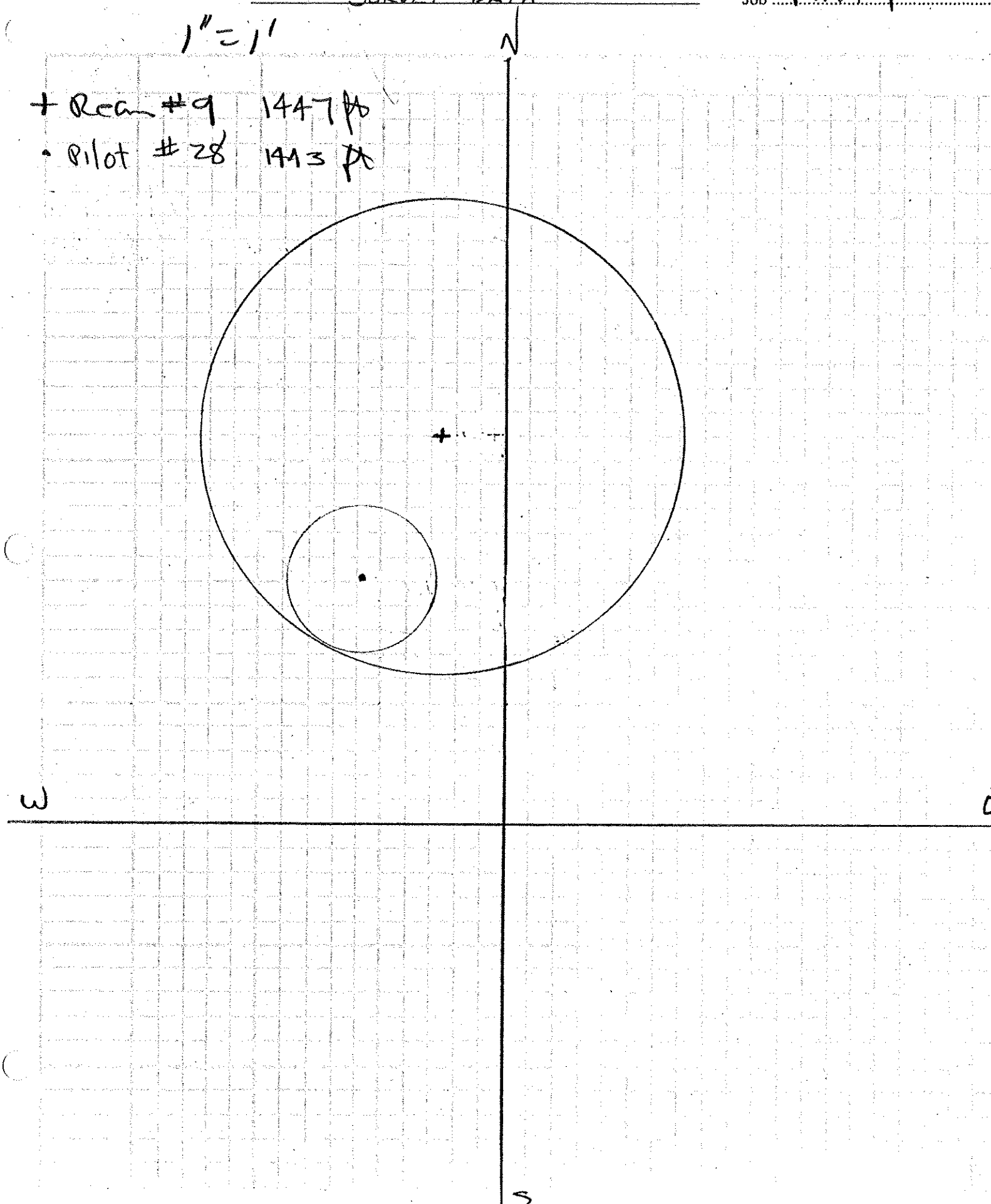
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 9 of 16
By JAW Chkd.
Job P118 FL

1" = 1'

+ Rea #9 1447 ft
• Pilot #28 1443 ft



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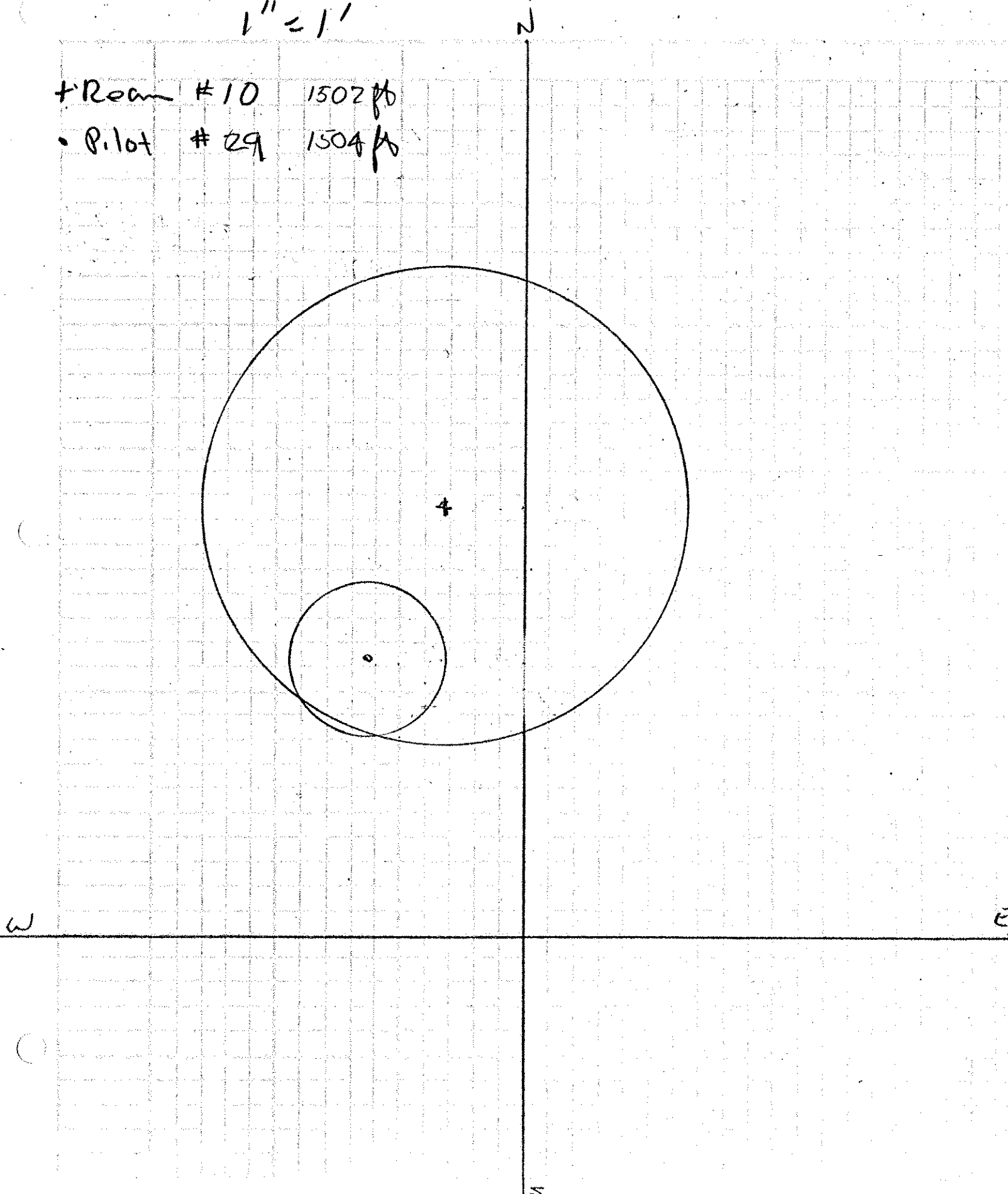
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 9 of 16
By JAW Chkd
Job P118 FLJ

1" = 1'

+ Ream #10 1502 ft
• Pilot #29 1504 ft



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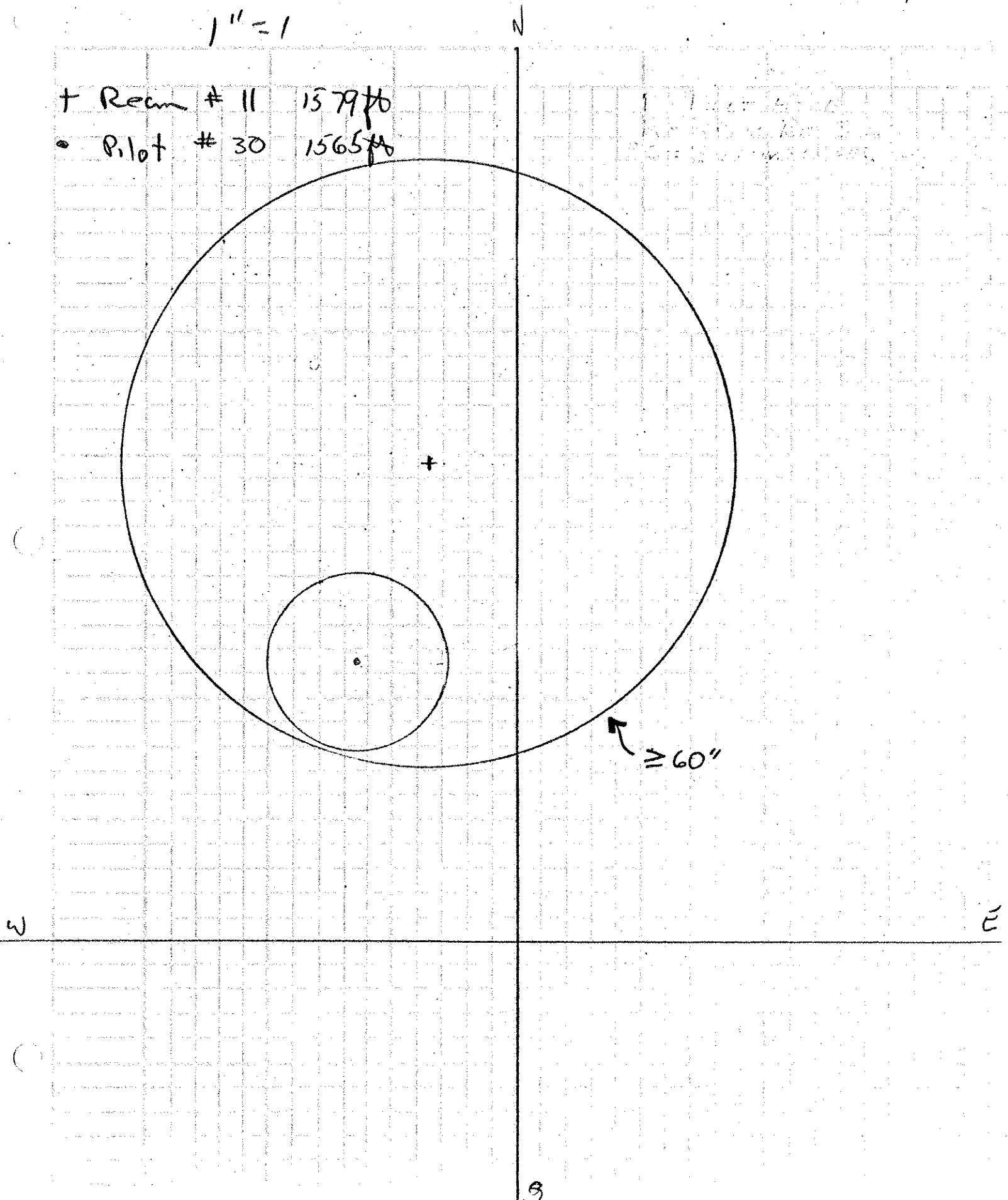
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 10 of 160
By JAW Chkd.
Job P116FL



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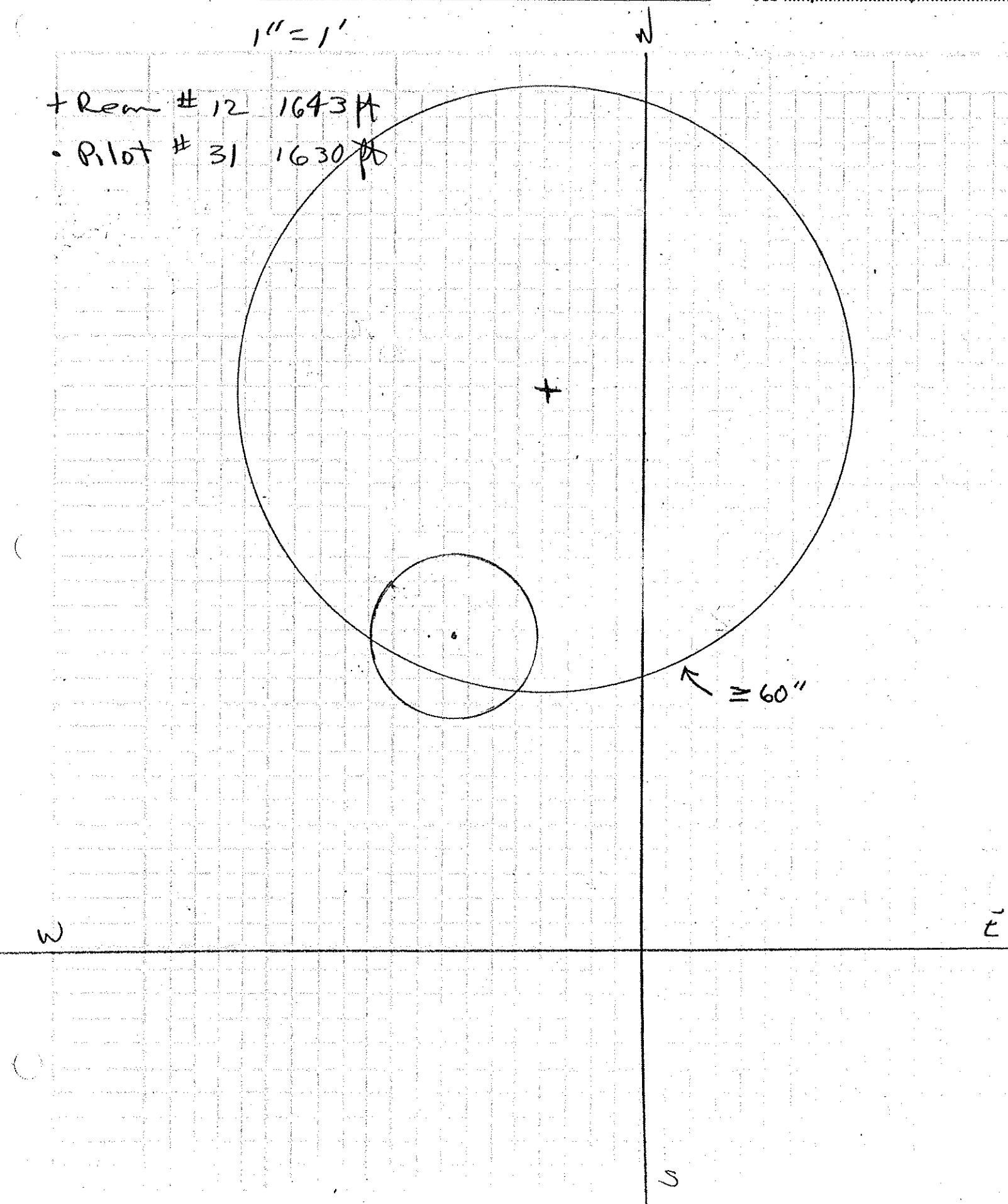
FORT LAUDERDALE INJECTION WELL COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 11 of 16
By law Chkd
Job P118 #21

1" = 1'



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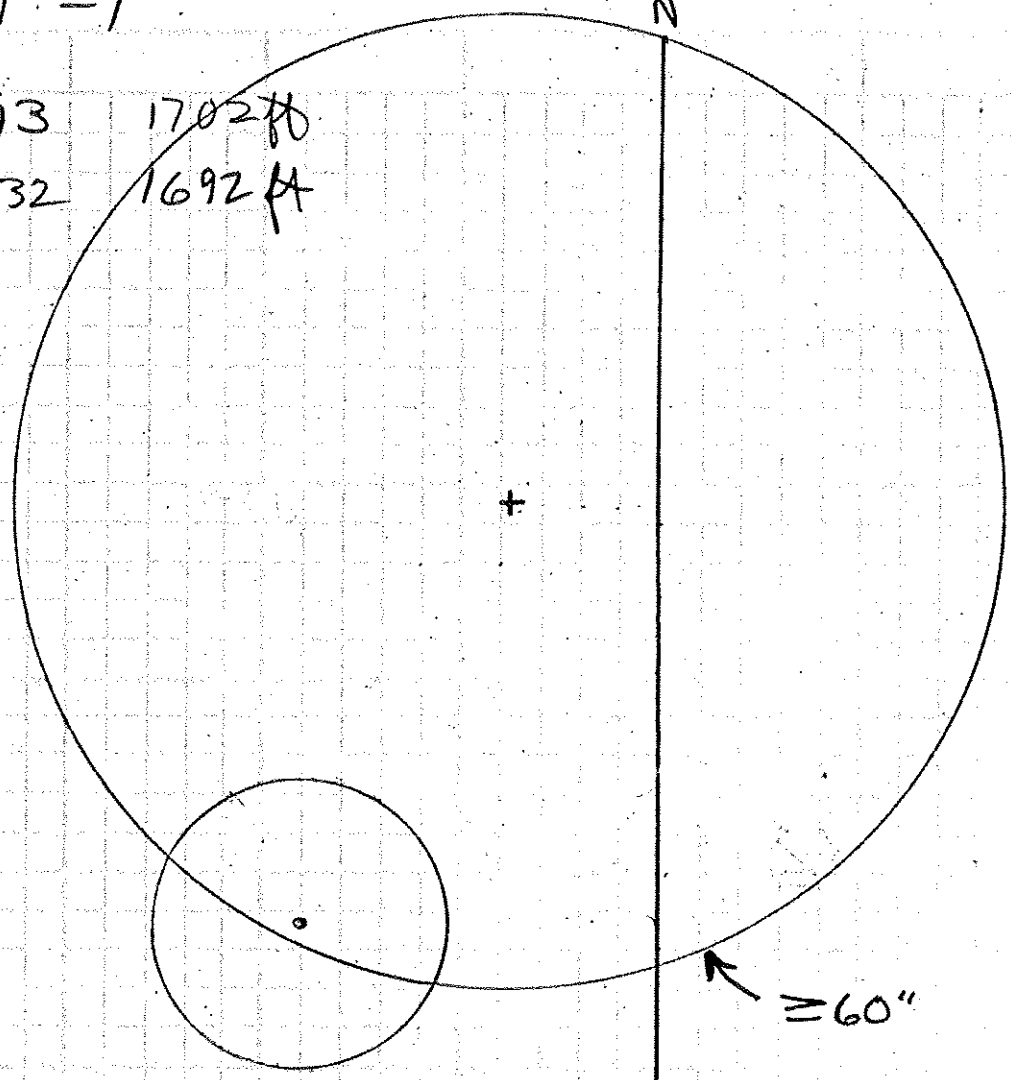
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL
SURVEY DATA

Date 3/25 12 of 16
By JGW Chkd.
Job P118 FL

1" = 1'

+ Recon # 13 1702 ft
∘ Pilot # 32 1692 ft



E

W

S

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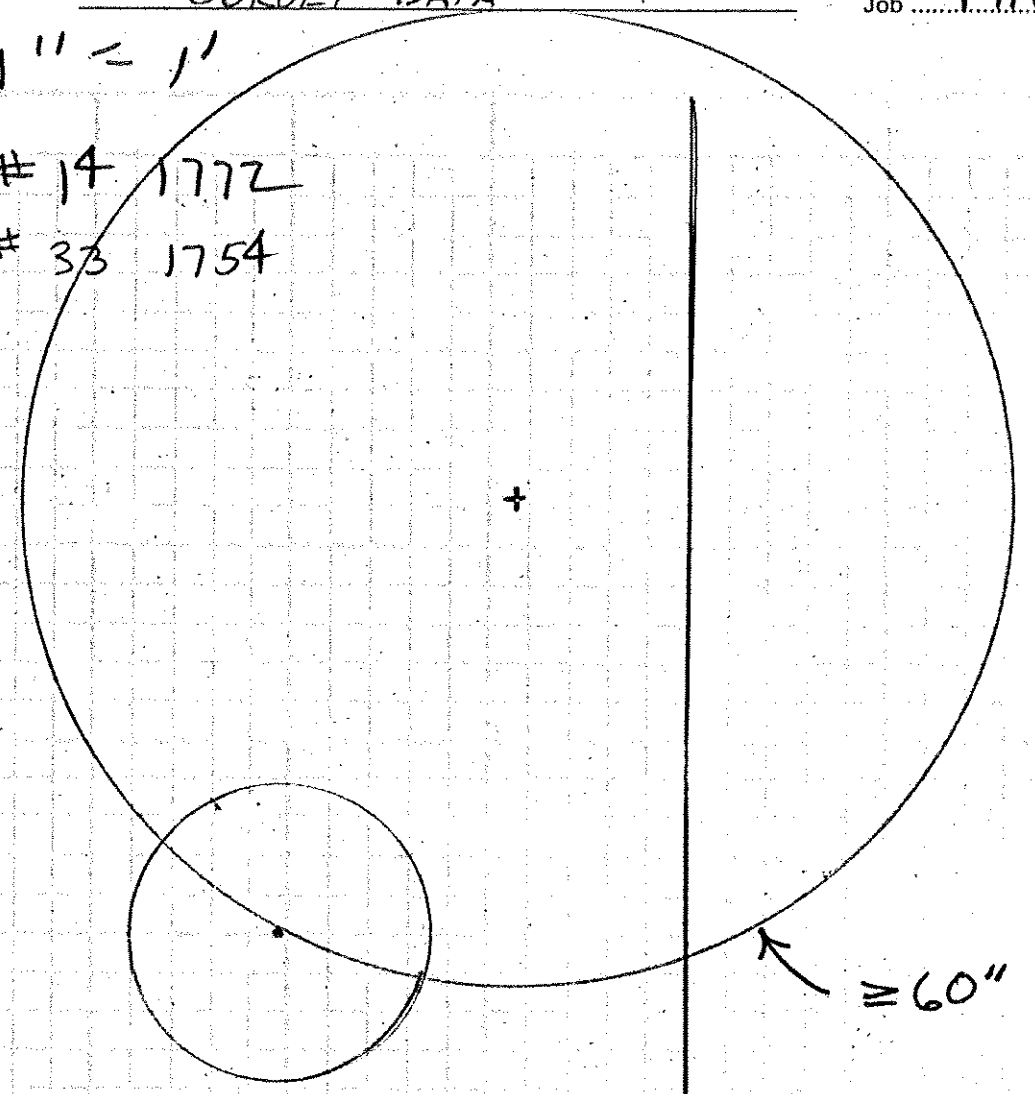
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/25 13 of 16
By JAW Chkd
Job P118FL1

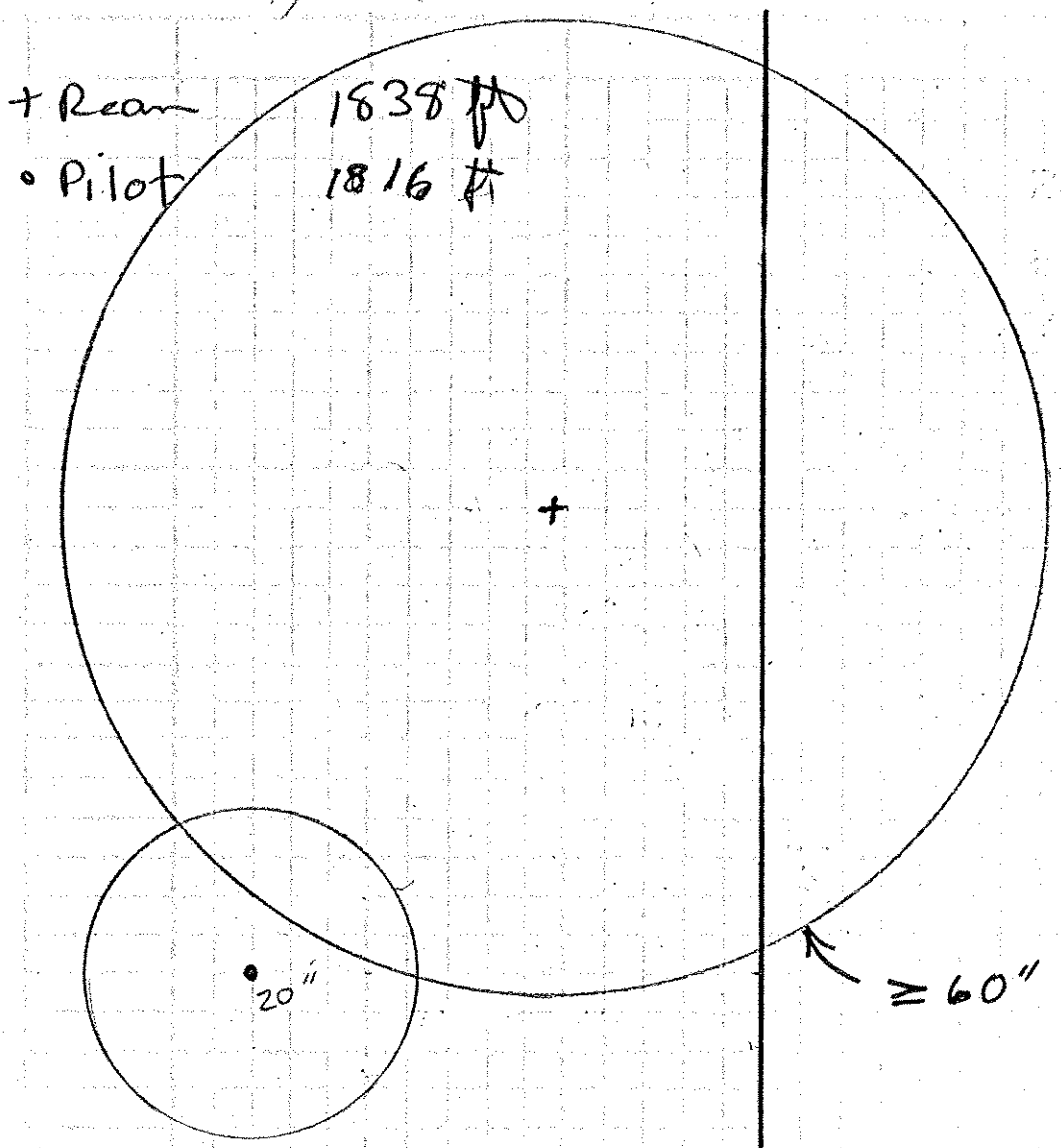
1" = 1'

+ Ream # 14 1772

• Pilot # 33 1754



1" = 1'



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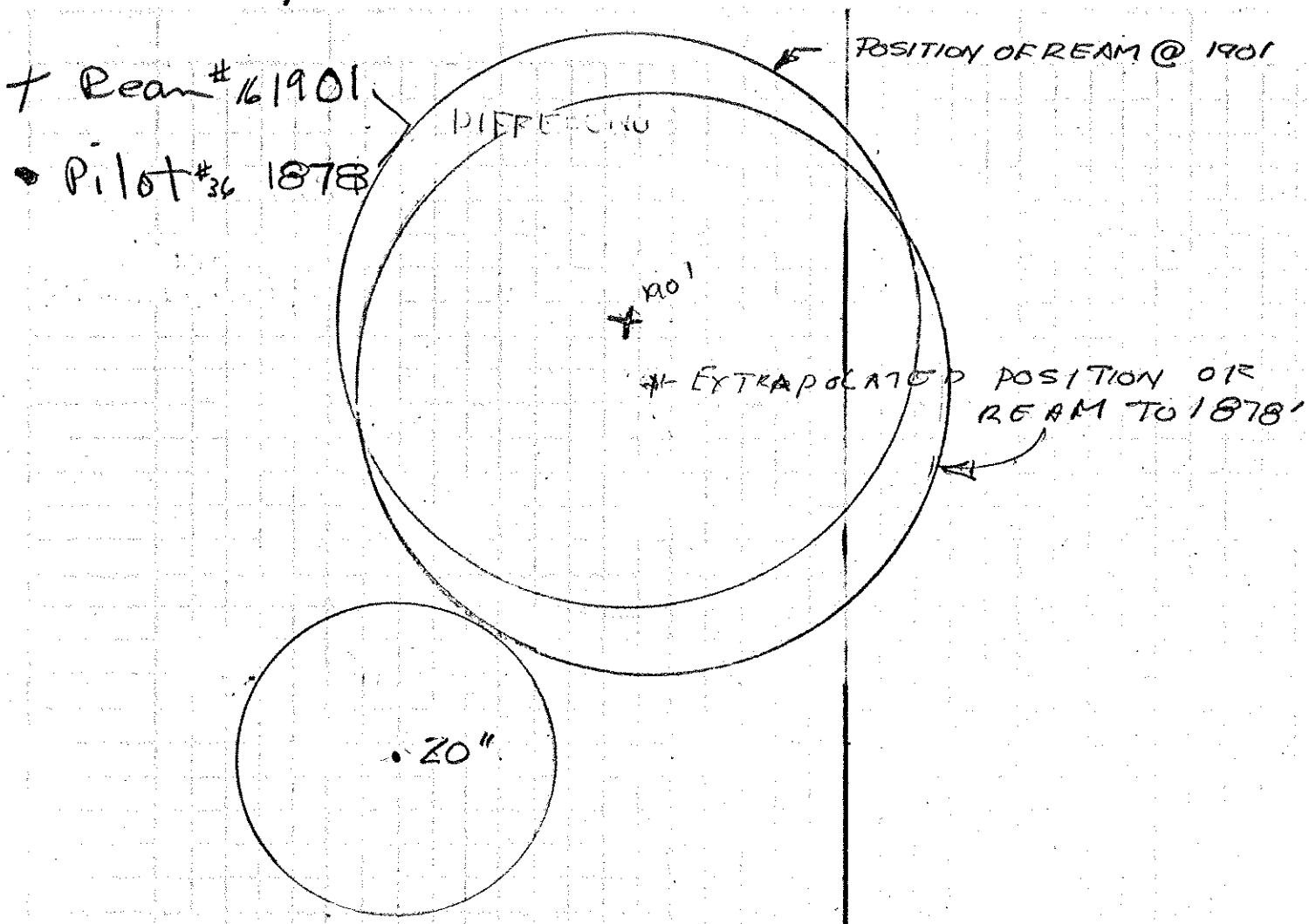
FORT LAUDERDALE INJECTION WELL
COMPARISON OF DIRECTIONAL SURVEY DATA

Date 3/26 15 of 16
By JAW Chkd.
Job P116FL1

1" = 1'



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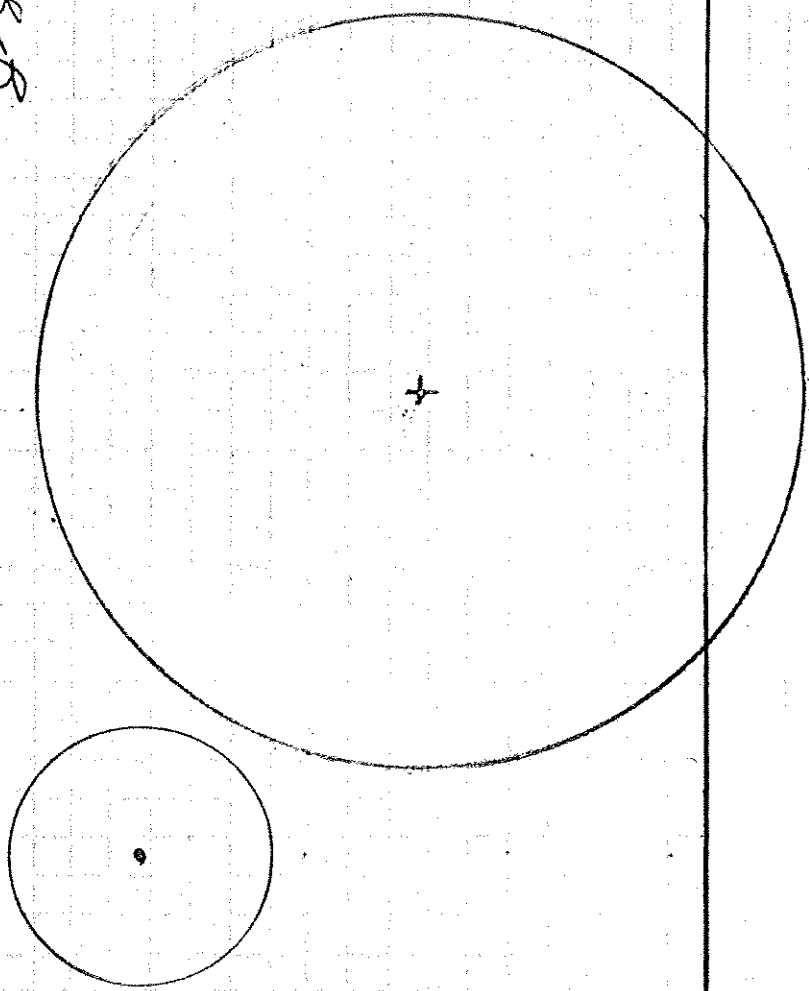
Ground-Water Consultants

Fort Lauderdale Injection Well
Comparison of Directional Survey Data

Date 3/29 16 of 16
By JAW Chkd.
Job P118FL

1" = 1'

+ Ream #17 1934 ft
• Pilot #40 1941 ft



SURVEY TABULATION SHEET

Correction 2.50°

sperry-sun

SHEET NO. 1 of 2

CUSTOMER _____

WELL NO. FORT LAUDERDALE - INJ. WELL

FIELD Pilot Hole

COUNTY/PARISH _____ STATE _____

Survey # I

SURVEY JOB NO. _____

SURVEY DATE 1981

TYPE OF SURVEY _____

N / W / E / S

METHOD OF CALCULATION: AVERAGE ANGLE ☐ MINIMUM CURVATURE ☒ TANGENTIAL ☐ TRAPEZOIDAL ☐

AZIMUTH

1-HOLE SIZE

CORRECTED TIME	MEASURED DEPTH COURSE	MEASURED DEPTH TOTAL	VERTICAL DEPTH COURSE	VERTICAL DEPTH TOTAL	INCLINATION DEG.	INCLINATION MIN.	COURSE DEV.	DIRECTION OF INCLINATION OBSERVED			CORR.	DIRECTION OF INCLINATION CORRECTED			DOG LEG °/100'	COURSE DISPLACEMENT NORTH	COURSE DISPLACEMENT SOUTH	COURSE DISPLACEMENT EAST	COURSE DISPLACEMENT WEST	TOTAL DISPLACEMENT NORTH	TOTAL DISPLACEMENT SOUTH	TOTAL DISPLACEMENT EAST	TOTAL DISPLACEMENT WEST	AVERAGE INCLINATION DEG.	AVERAGE INCLINATION MIN.	(meters) AVERAGE DIRECTION
		950				°			°				°														
5	50	1000				37		N	2	W	+2.5	N	4.5	W	355.5	0.23			0.02	0.23			0.02			20.5
6	32	1032				25		N	36	W	+2.5	N	38.5	W	321.5	0.24			0.08	0.47			0.10			21.0
10	31	1063				27		N	25	E	-2.5	N	22.5	E	22.5	0.20			0.02	0.67			0.13			18.0
12	26	1089				26		N	9	E	-2.5	N	6.5	E	6.5	0.19		0.05		0.86			0.08			18.0
13	37	1126				22		N	26	W	+2.5	N	28.5	W	331.5	0.24			0.04	1.11			0.12			18.5
16	31	1157				19		N	85	W	+2.5	N	87.5	W	272.5	0.09			0.13	1.20			0.25			18.0
17	32	1189				22		N	33	W	+2.5	N	35.5	W	324.5	0.09			0.15	1.29			0.40			18.0
21	31	1220				22		S	78	W	-2.5	S	75.5	W	255.5	0.06			0.15	1.34			0.55			17.0
22	31	1251				24		N	35	W	+2.5	N	37.5	W	322.5	0.06			0.16	1.40			0.71			17.0
23	32	1283				14		N	85	W	+2.5	N	87.5	W	272.5	0.09			0.13	1.49			0.85			17.0
24	35	1318				18		N	5	W	+2.5	N	7.5	W	352.5	0.09			0.08	1.59			0.93			17.0
25	31	1349				13		N	12	W	+2.5	N	14.5	W	345.5	0.14			0.03	1.72			0.95			16.0
26	31	1380				14		N	43	W	+2.5	N	45.5	W	314.5	0.10			0.06	1.83			1.01			15.0
27	31	1411				12		N	32	W	+2.5	N	34.5	W	325.5	0.09			0.08	1.91			1.09			16.0
28	32	1443				16		N	22	W	+2.5	N	22.5	W	337.5	0.11			0.06	2.03			1.15			14.0
29	61	1504				9		N	25	W	+2.5	N	27.5	W	332.5	0.20			0.09	2.23			1.24			15.0
30	61	1565				6		N	6	E	-2.5	N	3.5	E	3.5	0.12			0.03	2.36			1.27			17.0
31	65	1630				28		N	57	W	+2.5	N	59.5	W	300.5	0.19			0.22	2.55			1.50			16.5
32	62	1692				12		N	50	W	+2.5	N	52.5	W	307.5	0.19			0.30	2.74			1.80			18.0
33	62	1754				26		N	30	W	+2.5	N	32.5	W	327.5	0.26			0.21	3.00			2.01			18.0
35	62	1816				28		N	36	W	+2.5	N	38.5	W	321.5	0.40			0.28	3.40			2.30			20.0
36	62	1878				35		N	26	W	+2.5	N	28.5	W	331.5	0.47			0.31	3.87			2.61			20.0
40	63	1941				38		N	13	W	+2.5	N	15.5	W	344.5	0.62			0.25	4.49			2.85			17.5
41	61	2002				30		N	5	W	+2.5	N	7.5	W	352.5	0.59			0.12	5.08			2.98			14.0
41A	58	2060				34		N	6	E	-2.5	N	3.5	E	3.5	0.54			0.02	5.62			2.99			10.5
42	34	2094				35		N	43	E	-2.5	N	40.5	E	40.5	0.30		0.12		5.92			2.87			9.0
43B	33	2127				34		N	28	E	-2.5	N	25.5	E	25.5	0.28		0.18		6.19			2.69			17.5
44D	62	2189				45		N	69	E	-2.5	N	66.5	E	66.5	0.44		0.50		6.63			2.19			17.0
45	62	2251				43		N	16	E	-2.5	N	73.5	E	73.5	0.27		0.74		6.90			1.44			15.5
46	61	2312				29		N	33	E	-2.5	N	30.5	E	30.5	0.33		0.50		7.23			0.95			17.0
DONE BY:																										
CHKD. BY:																										

101-4 25 (9-76) 10M

SURVEY TABULATION SHEET

Correction 2.5°

sperry-sun

SHEET NO. 2 of 2

CUSTOMER

WELL NO. FORT LAUDERDALE INV. WELL

FIELD PILOT HOLE

COUNTY/PARISH STATE

SURVEY #

N + ~ W E ~ + S

METHOD OF CALCULATION: AZIMUTH

- AVERAGE ANGLE ☐
- MINIMUM CURVATURE ☐
- TANGENTIAL ☐
- TRAPEZOIDAL ☐

SURVEY JOB NO.

SURVEY DATE 1981

TYPE OF SURVEY

Hole Size

CORRECTED TIME	MEASURED DEPTH		VERTICAL DEPTH		INCLINATION		COURSE DEV.	DIRECTION OF INCLINATION							DOG LEG	COURSE DISPLACEMENT				TOTAL DISPLACEMENT				AVERAGE INCLINATION		AVERAGE DIRECTION
	COURSE	TOTAL	COURSE	TOTAL	DEG.	MIN.		OBSERVED			CORR.	CORRECTED			°/100'	NORTH	SOUTH	EAST	WEST	NORTH	SOUTH	EAST	WEST	DEG.	MIN.	
47	63	2375				33		N	76	E	-2.5	N	76.5	E	76.5	0.30		0.43		7.53			0.52			17.0
48	62	2437				28		N	80	E	-2.5	N	77.5	E	77.5	0.12		0.54		7.66		0.02				15.0
49	61	2498				20		S	84	E	-2.5	N	81.5	E	81.5	0.08		0.42		7.74		0.44				15.0
50	63	2561				31		S	78	E	-2.5	N	75.5	E	75.5	0.10		0.46		7.83		0.98				12.5
51	63	2624				21		S	84	E	-2.5	N	81.5	E	81.5	0.10		0.47		7.93		1.36				12.0
52	61	2685				23		N	77	E	-2.5	N	74.5	E	74.5	0.08		0.38		8.02		1.74				12.0
53	62	2747				17		S	83	E	-2.5	N	80.5	E	80.5	0.08		0.35		8.10		2.09				15.0

DONE BY:

CHKD. BY:

101-4.25 (9-76) 10M

Correction 2.5

SURVEY TABULATION SHEET

sperry-sun

SHEET NO. 1 of

CUSTOMER

WELL NO. FORT LAUDERDALE - IN WORK

FIELD 40' REAM

COUNTY/PARISH STATE

SURVEY #

SURVEY JOB NO.

SURVEY DATE 1981

TYPE OF SURVEY

N / E / S / W

METHOD OF CALCULATION: AVERAGE ANGLE ☐ MINIMUM CURVATURE ☒ TANGENTIAL ☐ TRAPEZOIDAL ☐

AZIMUTH

Hole Size

CORRECTED TIME	MEASURED DEPTH COURSE	MEASURED DEPTH TOTAL	VERTICAL DEPTH COURSE	VERTICAL DEPTH TOTAL	INCLINATION DEG.	INCLINATION MIN.	COURSE DEV.	DIRECTION OF INCLINATION OBSERVED	CORR.	DIRECTION OF INCLINATION CORRECTED	DOG LEG °/100'	COURSE DISPLACEMENT NORTH	COURSE DISPLACEMENT SOUTH	COURSE DISPLACEMENT EAST	COURSE DISPLACEMENT WEST	TOTAL DISPLACEMENT NORTH	TOTAL DISPLACEMENT SOUTH	TOTAL DISPLACEMENT EAST	TOTAL DISPLACEMENT WEST	AVERAGE INCLINATION DEG.	AVERAGE INCLINATION MIN.	AVERAGE DIRECTION
		950				0		0		0												
1	51	1001				23		N 27 E	-2.5	N 24.5 E	24.5	0.16		0.07		0.16		0.07				60+
2	61	1062				34		N 5 W	+2.5	N 7.5 W	352.5	0.48		0.05		0.64		0.12				60+
3	63	1125				18		N 3 E	-2.5	N 0.5 E	0.5	0.47			0.01	1.11		0.08				60+
4	63	1188				25		N 4 W	+2.5	N 6.5 W	353.5	0.39			0.02	1.51		0.05				60+
5	63	1251				12		N 47 E	-2.5	N 44.5 E	44.5	0.31		0.05		1.81		0.10				60+
7	63	1314				35		N 11 W	+2.5	N 13.5 W	346.5	0.39		0.00		2.20		0.11				60+
8	66	1380				31		N 42 W	+2.5	N 44.5 W	316.5	0.54			0.29	2.74			0.18			48
9	67	1447				28		N 28 W	+2.5	N 26.5 W	334.5	0.46			0.33	3.20			0.51			47
10	55	1502				8		N 4 W	+2.5	N 6.5 W	353.5	0.27			0.10	3.47			0.61			47
11	77	1579				37		N 6 W	+2.5	N 8.5 W	351.5	0.50			0.07	3.97			0.69			60+
12	64	1643				28		N 3 W	+2.5	N 5.5 W	354.5	0.60			0.08	4.57			0.76			60+
13	59	1702				10		N 11 E	-2.5	N 8.5 E	8.5	0.32			0.01	4.89			0.77			60+
14	70	1772				23		N 19 W	+2.5	N 21.5 W	338.5	0.32			0.07	5.21			0.84			60+
15	66	1838				42		N 17 W		N 19.5 W		0.59			0.22	5.80			1.06			60+
16	63	1901				42		N 19 W		N 21.5 W		0.72			0.27	6.52			1.33			48
17	33	1934				40		N 3 W		N 5.5 W		0.36			0.09	6.90			1.42			47
DONE BY:																						
CHKD. BY:																						

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