B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 5-13-86 — Unit

Lease Ballard Grayburg San Andres

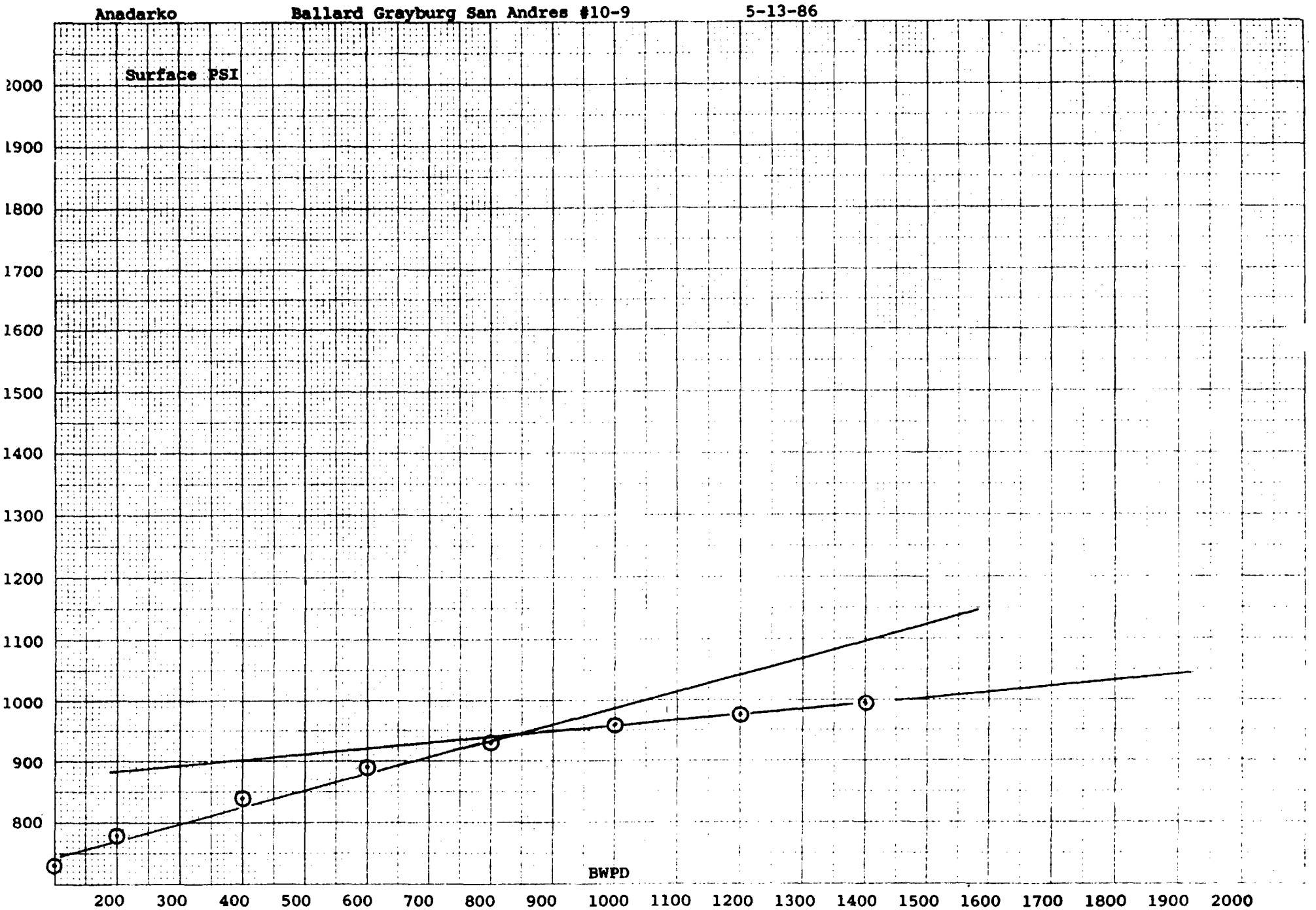
Total Depth — Plug Back TD — Elevation — Well # 10-9

Csg size 4½ Wt d Set at — Perfs: From 2602 To 2806 — Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
12:45	Start			560			
12:50		100		720			
12:55		100		725			
1:00	:15	100		730			
1:05		200		755			
1:10		200		770			
1:15	:30	200		780			
1:20		400		820			
1:25		400		830			
1:30	:45	400		840			
1:35		600		870			
1:40		600		880			
1:45	1:00	600		890			
1:50		800		915			
1:55		800		920			
2:00	1:15	800		930			
2:05		1000		950			
2:10		1000		955			
2:15	1:30	1000		960			
2:20		1200		970			
2:25		1200		970			
2:30	1:45	1200		975			
2:35		1400		985			
2:40		1400		990			
2:45	2:00	1400		995			
			ISIP	930			
2:46				910			
2:47				910			
2:48				900			
2:49				900			
2:50				900			Total BBLS. 58.1


Anadarko
Ballard Grayburg San Andres #10-9
5-13-86
Surface PSI
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
BWPD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000

Anadarko
Ballard Grayburg San Andres #10-9
5-13-86

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-14-86 — Unit

Lease Ballard Grayburg San Andre

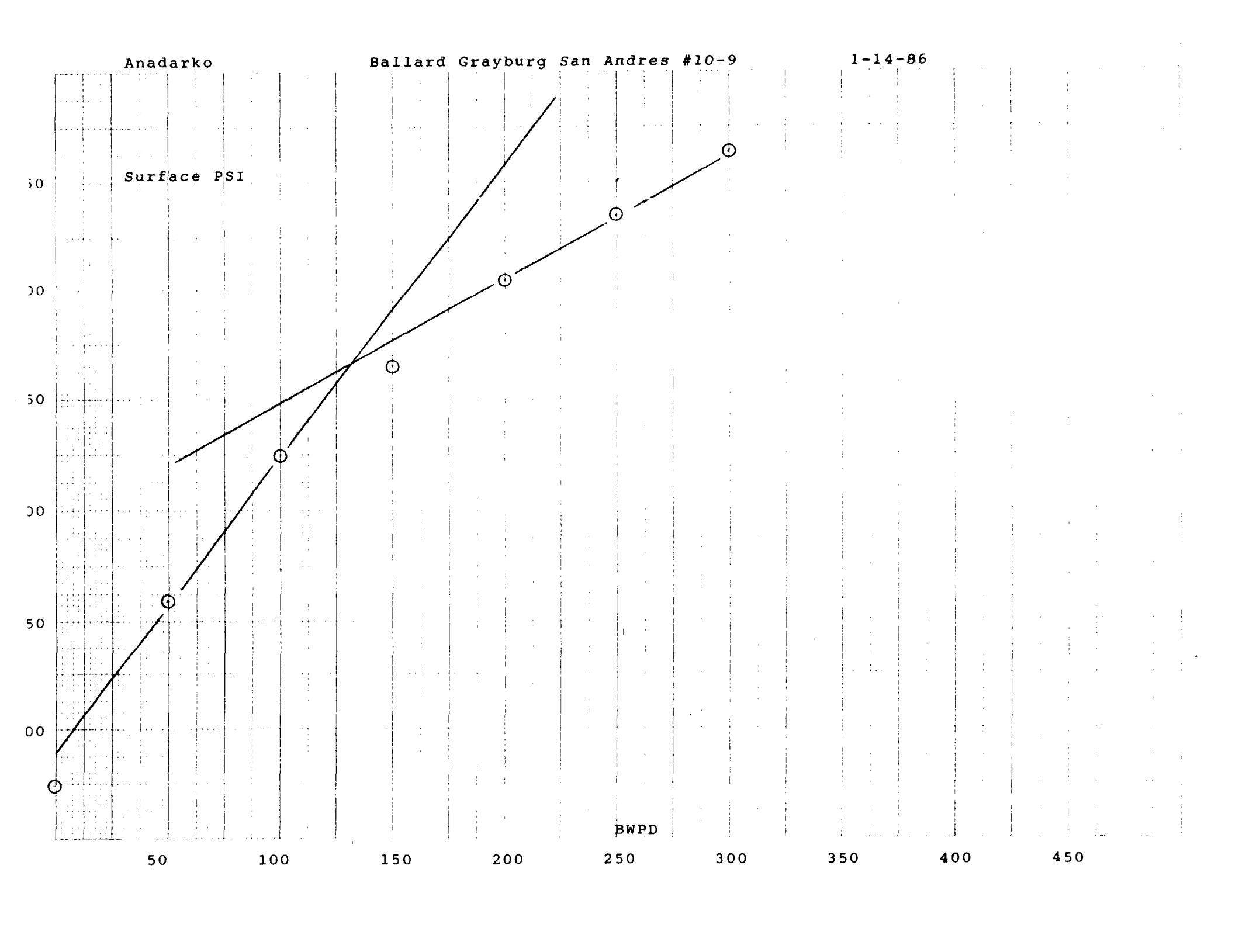
Total Depth — Plug Back TD — Elevation — Well # 10-9

Csg size 4½ W: d Set at Perfs: From 2602 To 2806 — Sec Twp-Blk Rge

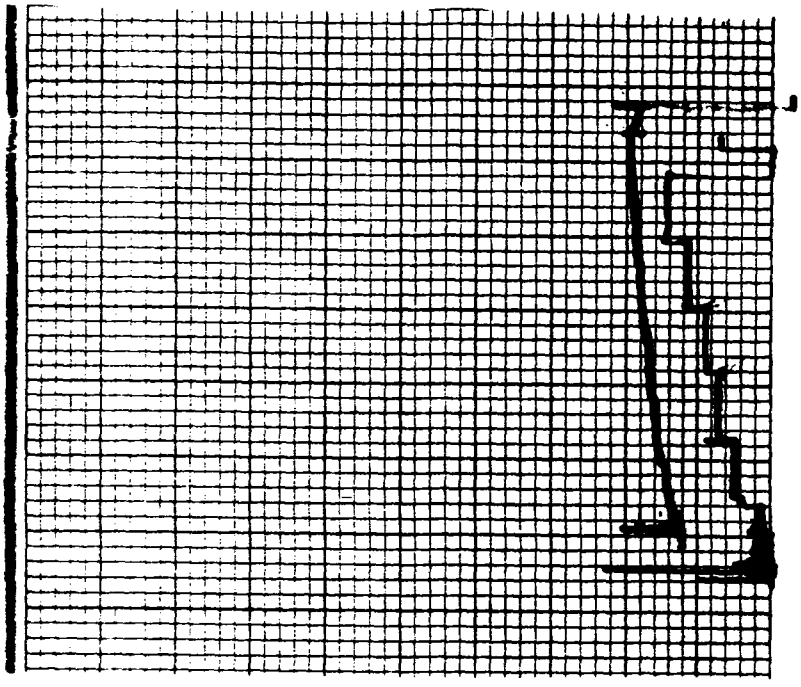
Tbg size 2 3/8 W: d Set at Perfs: From To — County State

Producing thru Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
12:20				475			
12:25		50		515			
12:30		50		555			
12:35	:15	50		560			
12:40		100		604			
12:45		100		615			
12:50	:30	100		625			
12:55		150		650			
1:00		150		658			
1:05	:45	150		665			
1:10		200		685			
1:15		200		695			
1:20	1:00	200		705			
1:25		250		715			
1:30		250		725			
1:35	1:15	250		735			
1:40		300		745			
1:45		300		755			
1:50	1:30	300		764			11. BBLS Total
5 minute fall-off							
1:51				735			
1:52				725			
1:53				722			
1:54				719			
1:55				715			


Anadarko
Ballard Grayburg San Andres #10-9
1-14-86
Surface PSI
BWPD
50
100
150
200
250
300
350
400
450

Anadarko
Ballard Grayburg San Andres #10-9
1-14-86



B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 5-14-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 9-9

Csg size 5½ Wt d Set at — Perfs: From 2490 To 2708 — Sec Twp-Blk Rge

Tbg size Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
10:45	Start			490			
10:50		75		520			
10:55		75		550			
11:00	:15	75		580			
11:05		100		585			
11:10		100		590			
11:15	:30	100		600			
11:20		150		605			
11:25		150		615			
11:30	:45	150		620			
11:35		200		625			
11:40		200		630			
11:45	1:00	200		635			
11:50		300		650			
11:55		300		660			
12:00	1:15	300		670			
12:05		400		685			
12:10		400		695			
12:15	1:30	400		705			
12:20		500		720			
12:25		500		730			
12:30	1:45	500		743			
12:35		600		765			
12:40		600		775			
12:45	2:00	600		785			
12:50		700		805			
12:55		700		815			
1:00	2:15	700		825			
1:05		800		845			
1:10		800		855			
1:15	2:30	800		870			

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 Hobbs, New Mexico 88240

Company Anadarko Test Date 5-14-86 Unit

Lease Ballard Grayburg San Andres

Total Depth Plug Back TD Elevation Well # 5-9

Csg size Wt d Set at Perfs: From 2490 To 2708 Sec Twp-Blk Rge

Tbg size Wt d Set at Perfs: From To County Eddy State New Mexico

Producing thru Packer set at Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
1:20		900		890			
1:25		900		900			
1:30	2:45	900		910			
1:35		1000		930			
1:40		1000		935			
1:45	3:00	1000		945			
1:50		1100		960			
1:55		1100		970			
2:00	3:15	1100		980			
2:05		1200		995			
2:10		1200		1005			
2:15	3:30	1200		1010			
2:20		1300		1025			
2:25		1300		1035			
2:30	3:45	1300		1050			
2:35		1400		1065			
2:40		1400		1070			
2:45	4:00	1400		1085			
2:50		1600		1100			
2:55		1600		1110			
3:00	4:15	1600		1120			
3:05		1800		1140			
3:10		1800		1150			
3:15	4:30	1800		1160			
3:20		2000		1170			
3:25		2000		1178			
3:30	4:45	2000		1185			
3:35		2100		1195			
3:40		2100		1200			
3:45	5:00	2100		1210			Total BBLS. 188.9

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 Hobbs, New Mexico 88240

Company Anadarko Test Date 5-14-86 Unit

Lease Ballard Grayburg San Andres

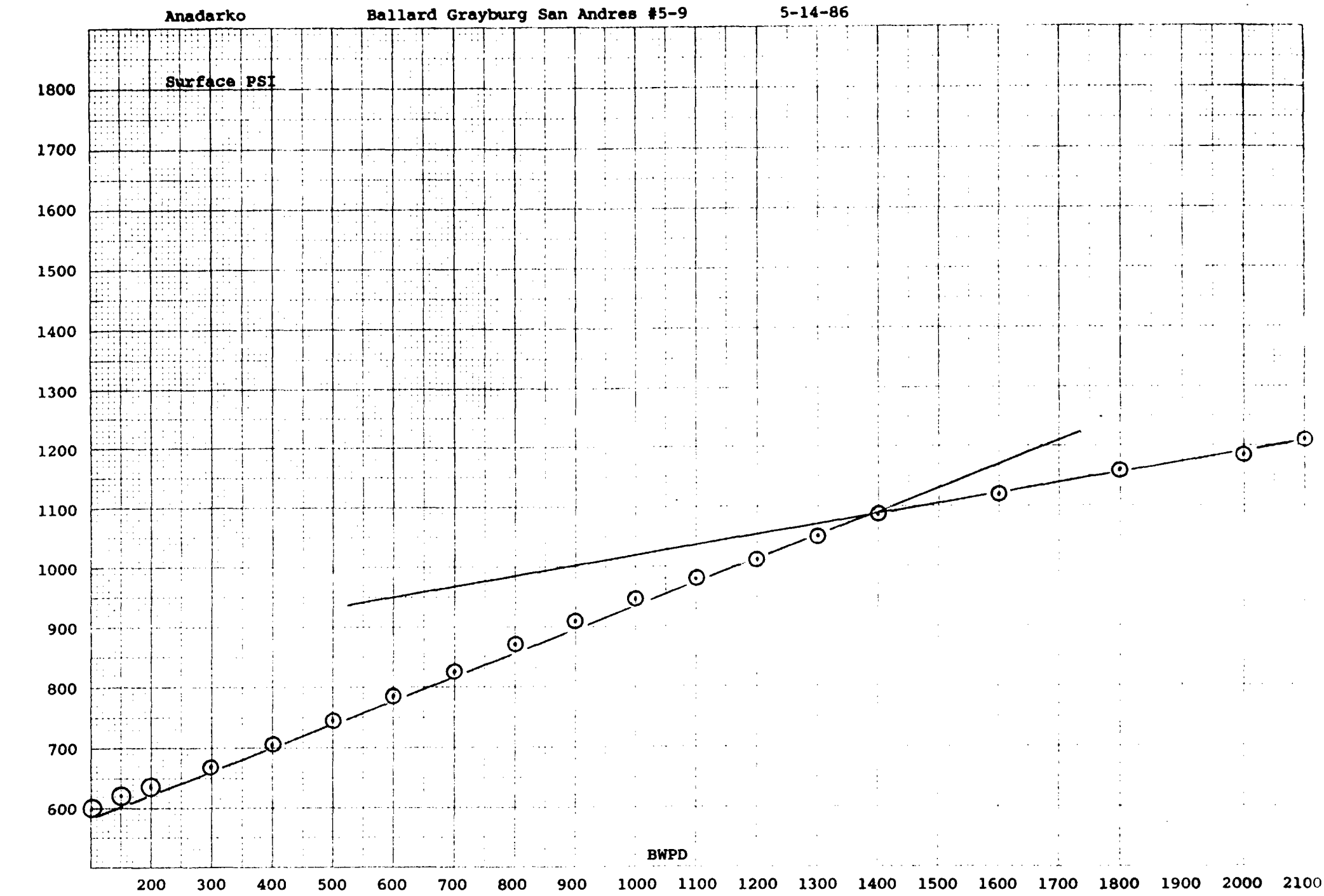
Total Depth Plug Back TD Elevation Well # 5-9

Csg size Wt d Set at Perfs: From 2490 To 2708 Sec Twp-Blk Rge

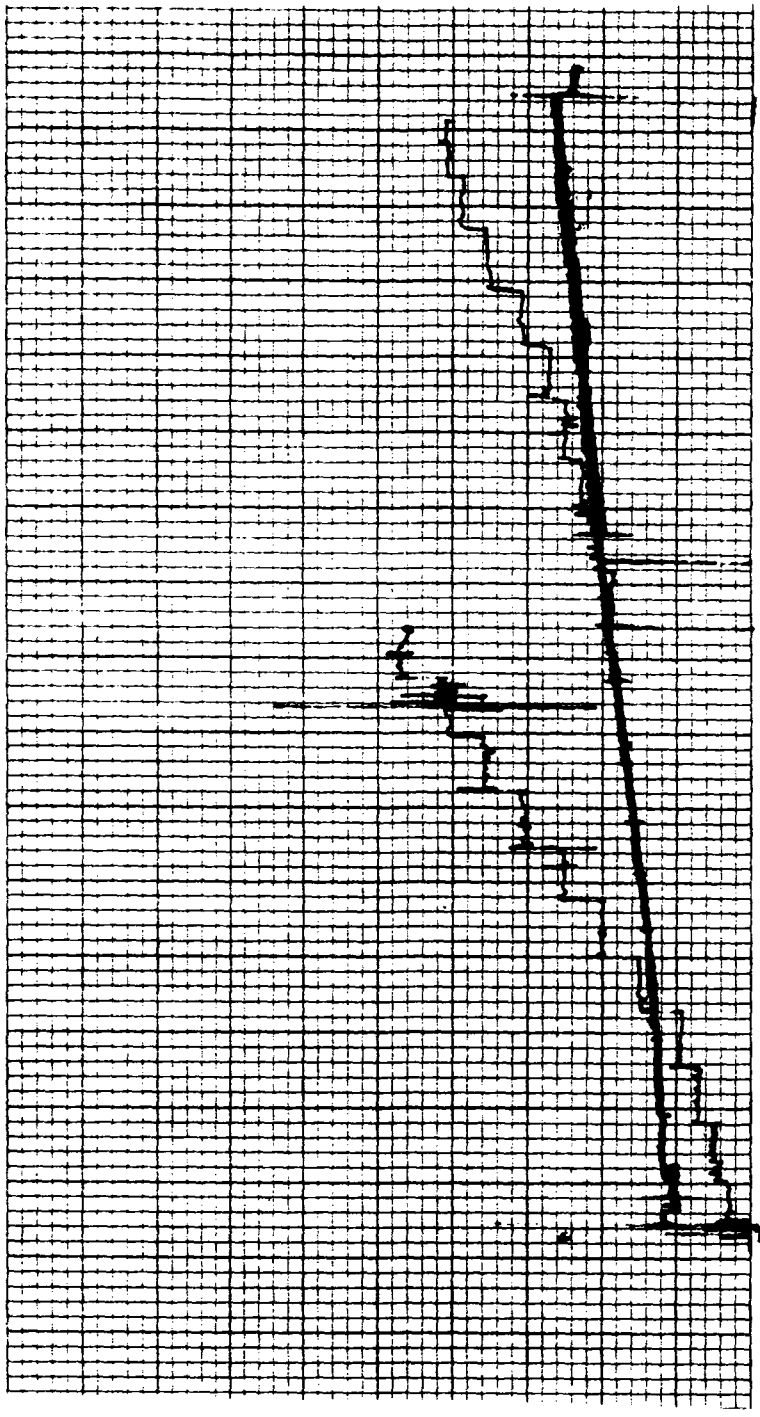
Tbg size Wt d Set at Perfs: From To County State

Producing thru Packer set at Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
5 minute	fall	off	ISIP	1120			
3:46				1120			
3:47				1110			
3:48				1110			
3:49				1100			
3:50				1100			


Anadarko
Ballard Grayburg San Andres #5-9
5-14-86
Surface PSI
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
BWPD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100

Anadarko
Ballard Grayburg San Andres #5-9
5-14-86



O. 5908

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-16-86 — Unit

Lease Ballard Grayburg San Andres — Well # 5-9

Total Depth — Plug Back TD — Elevation — Sec — Twp-Blk — Rge

Csg size 5½ Wt — d — Set at — Perfs: From 2490 To 2708 — County Eddy — State New Mexico

Tbg size 2 3/8" Wt — d — Set at — Perfs: From — To — Co. Rep Jimmy Fletcher

Producing thru — Packer set at

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
9:00				314			
9:05		50		300			
9:10		50		320			
9:15	:15	50		325			
9:20		100		330			
9:25		100		338			
9:30	:30	100		345			
9:35		150		355			
9:40		150		362			
9:45	:45	150		370			
9:50		200		385			
9:55		200		390			
10:00	1:00	200		398			
10:05		300		415			
10:10		300		427			
10:15	1:15	300		440			
10:20		400		460			
10:25		400		475			
10:30	1:30	400		485			
10:35		600		520			
10:40		600		540			
10:45	1:45	600		559			
10:50		700		575			
10:55		700		590			
11:00	2:00	700		585			
11:05		800		610			
11:10		800		630			
11:15	2:15	800		650			

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 Hobbs, New Mexico 88240

Company Anadarko Test Date 1-16-86

Total Depth Plug Back TD Elevation

Csg size 5½ Wt d Set at Perfs: From 2490 To 2708

Tbg size 2 3/8 Wt d Set at Perfs: From To

Producing thru Packer set at

Unit

Lease Ballard Grayburg San Andres

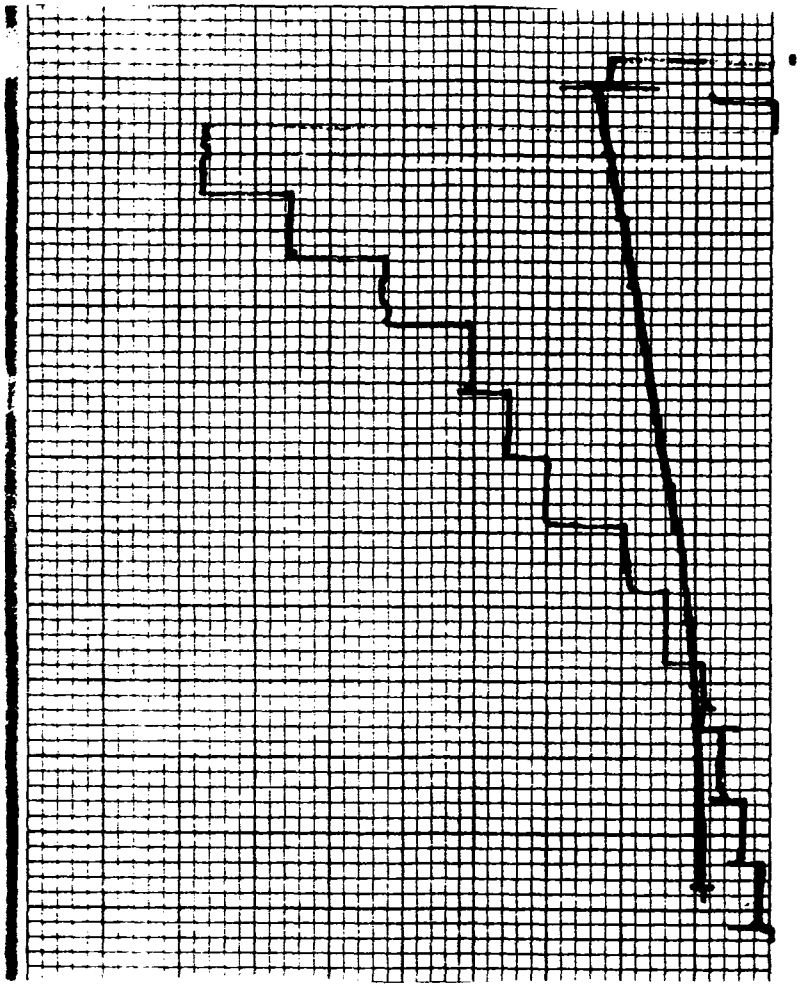
Well # 5-9 Sec Twp-Blk Rge

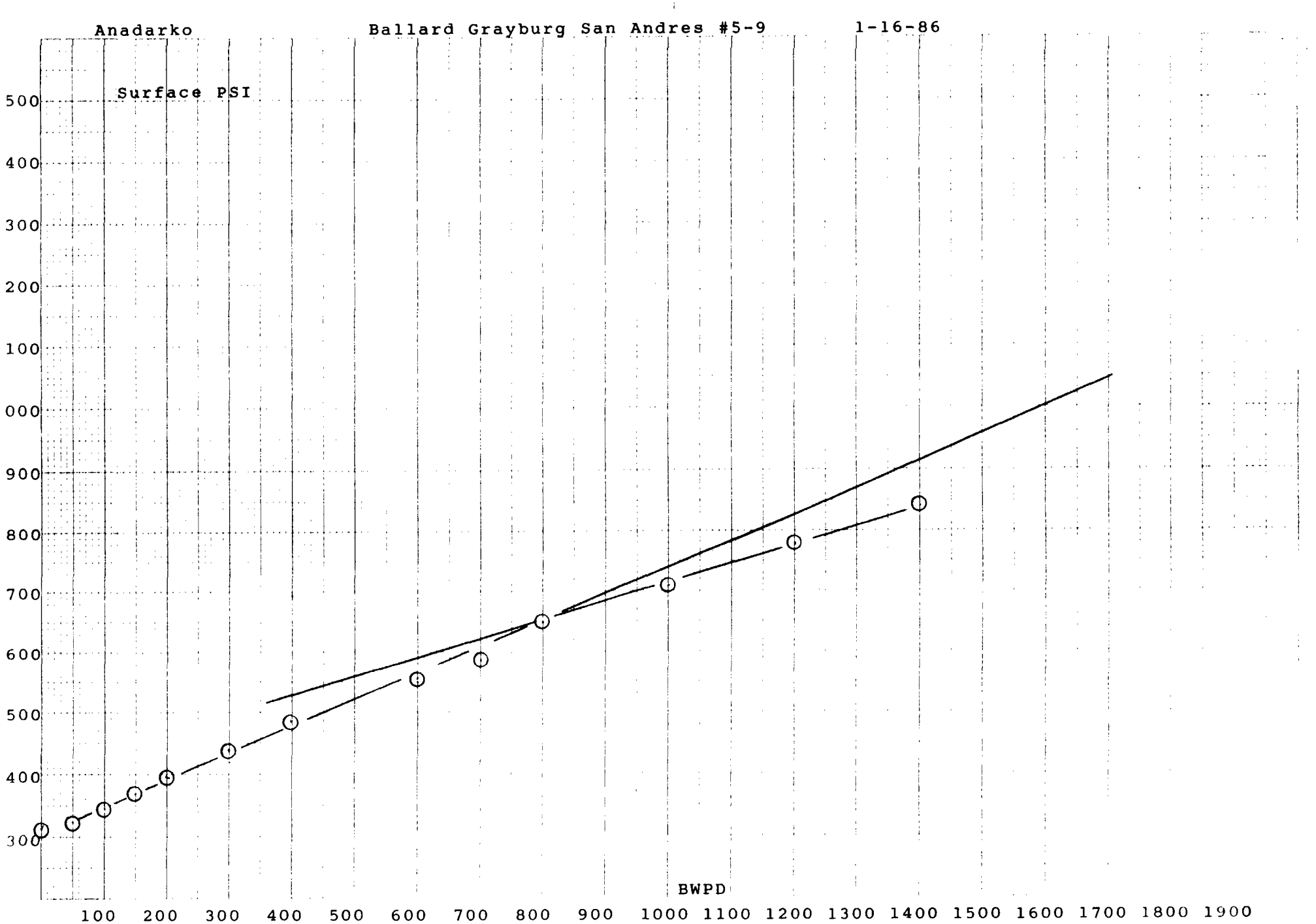
County Eddy State New Mexico

Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
11:20		1000		673			
11:25		1000		692			
11:30	2:30	1000		710			
11:35		1200		742			
11:40		1200		768			
11:45	2:45	1200		780			
11:50		1400		812			
11:55		1400		830			
12:00	3:00	1400		840			71.7 Total BBLS
5 minute fall-off							
12:01		-		790			
12:02				788			
12:03				785			
12:04				782			
12:05				778			

Anadarko
Ballard Grayburg San Andres #5-9
1-16-86




Anadarko
Ballard Grayburg San Andres #5-9
1-16-86
Surface PSI
500
400
300
200
100
000
900
800
700
600
500
400
300
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-15-86 — Unit

Lease Ballard Grayburg San Andres

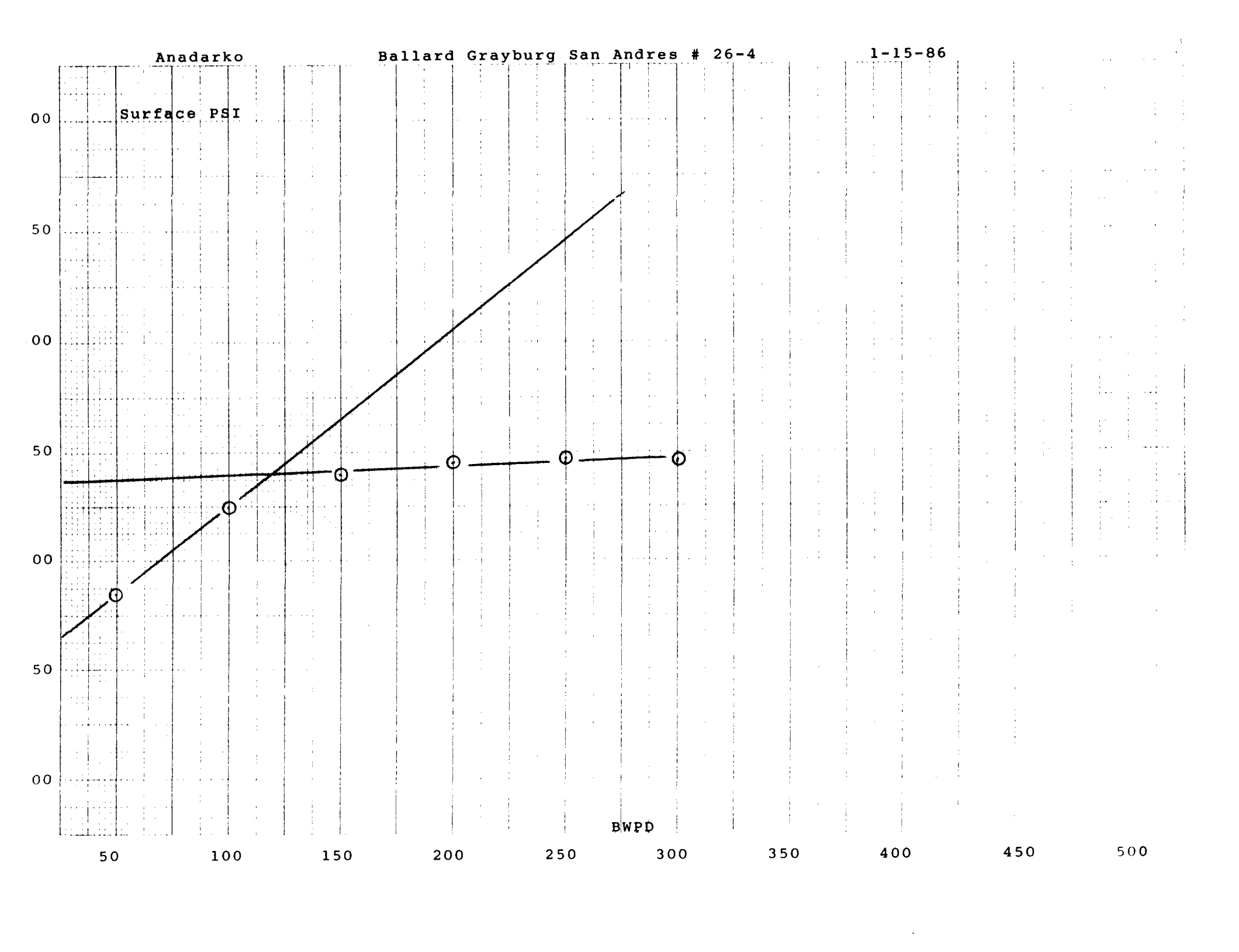
Total Depth — Plug Back TD — Elevation — Well # 26-4

Csg size 4½ Wt d Set at — Perfs: From 2586 To 2777 — Sec Twp-Blk Rge

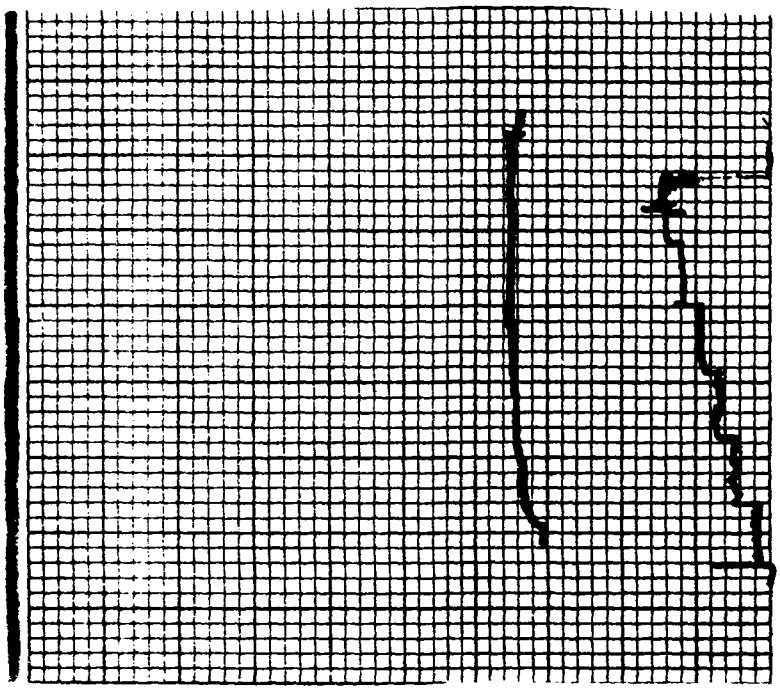
Tbg size 2 3/8 Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
2:25				1175			
2:30		50		1265			
2:35		50		1275			
2:40	:15	50		1285			
2:45		100		1315			
2:50		100		1323			
2:55	:30	100		1325			
3:00		150		1335			
3:05		150		1340			
3:10	:45	150		1340			
3:15		200		1345			
3:20		200		1345			
3:25	1:00	200		1345			
3:30		250		1345			
3:35		250		1345			
3:40	1:15	250		1345			
3:45		300		1345			
3:50		300		1345			
3:55		300		1345			
5 minute fall-off							Total BBLS 11.4
3:56				1305			
3:57				1300			
3:58				1295			
3:59				1290			
4:00				1285			


Anadarko
Ballard Grayburg San Andres # 26-4
1-15-86
Surface PSI
00
50
00
50
00
50
00
BWPD
50
100
150
200
250
300
350
400
450
500

Anadarko
Ballard Grayburg San Andres #26-4
1-15-86



B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 5-15-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 5-14

Csg size 4½ Wt d Set at Perfs: From 2447 To 2728 — Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at Perfs: From To — County Eddy State New Mexico

Producing thru Packer set at — Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
8:15	Start			345			
8:20		100		380			
8:25		100		410			
8:30	:15	100		435			
8:35		200		460			
8:40		200		490			
8:45	:30	200		510			
8:50		300		540			
8:55		300		560			
9:00	:45	300		575			
9:05		400		600			
9:10		400		620			
9:15	1:00	400		640			
9:20		500		665			
9:25		500		680			
9:30	1:15	500		695			
9:35		600		725			
9:40		600		740			
9:45	1:30	600		755			
9:50		700		780			
9:55		700		800			
10:00	1:45	700		825			
10:05		800		840			
10:10		800		860			
10:15	2:00	800		880			
10:20		900		900			
10:25		900		920			
10:30	2:15	900		930			
10:35		1000		960			
10:40		1000		980			
10:45	2:30	1000		990			

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 Hobbs, New Mexico 88240

Company Anadarko Test Date 5-15-86 Unit

Lease Ballard Grayburg San Andres

Total Depth Plug Back TD Elevation Well # 5-14

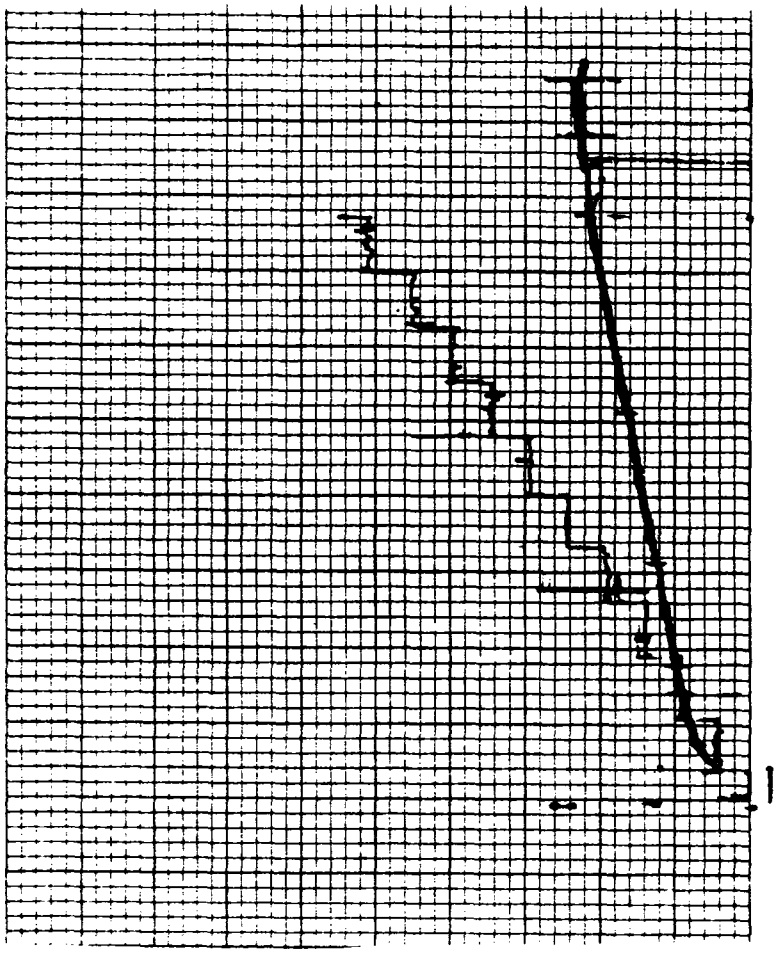
Csg size 4½ Wt d Set at Perfs: From 2447 To 2728 Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at Perfs: From To County Eddy State New Mexico

Producing thru Packer set at Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
10:50		1100		1000			
10:55		1100		1010			
11:00	2:45	1100		1020			
11:05		1200		1040			
11:10		1200		1050			
11:15		1200		1065			Total BBLS 80.2
5 minute fall off			ISIP	1030			
11:16				1025			
11:17				1020			
11:18				1015			
11:19				1010			
11:20				1010			

Anadarko
Ballard Grayburg San Andres #5-14
5-15-86



GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-16-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 5-14

Csg size 4½ Wt d Set at Perfs: From 2447 To 2728 — Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at Perfs: From To — County Eddy State New Mexico

Producing thru Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
12:35				365			
12:40		50		378			
12:45		50		385			
12:50	:15	50		390			
12:55		100		400			
1:00		100		409			
1:05	:30	100		415			
1:10		150		425			
1:15		150		435			
1:20	:45	150		440			
1:25		200		451			
1:30		200		470			
1:35	1:00	200		480			
1:40		300		502			
1:45		300		518			
1:50	1:15	300		525			
1:55		400		545			
2:00		400		560			
2:05	1:30	400		570			
2:10		600		610			
2:15		600		625			
2:20	1:45	600		640			
2:25		800		675			
2:30		800		700			
2:35	2:00	800		710			
2:40		1000		755			
2:45		1000		775			
2:50	2:15	1000		780			Total BBLS 37.4

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-39[illegible]4 Hobbs, New Mexico 88240

Company Anadarko Test Date 1-16-86 Unit

Lease Ballard Grayburg San Andres

Total Depth Plug Back TD Elevation Well # 5-14

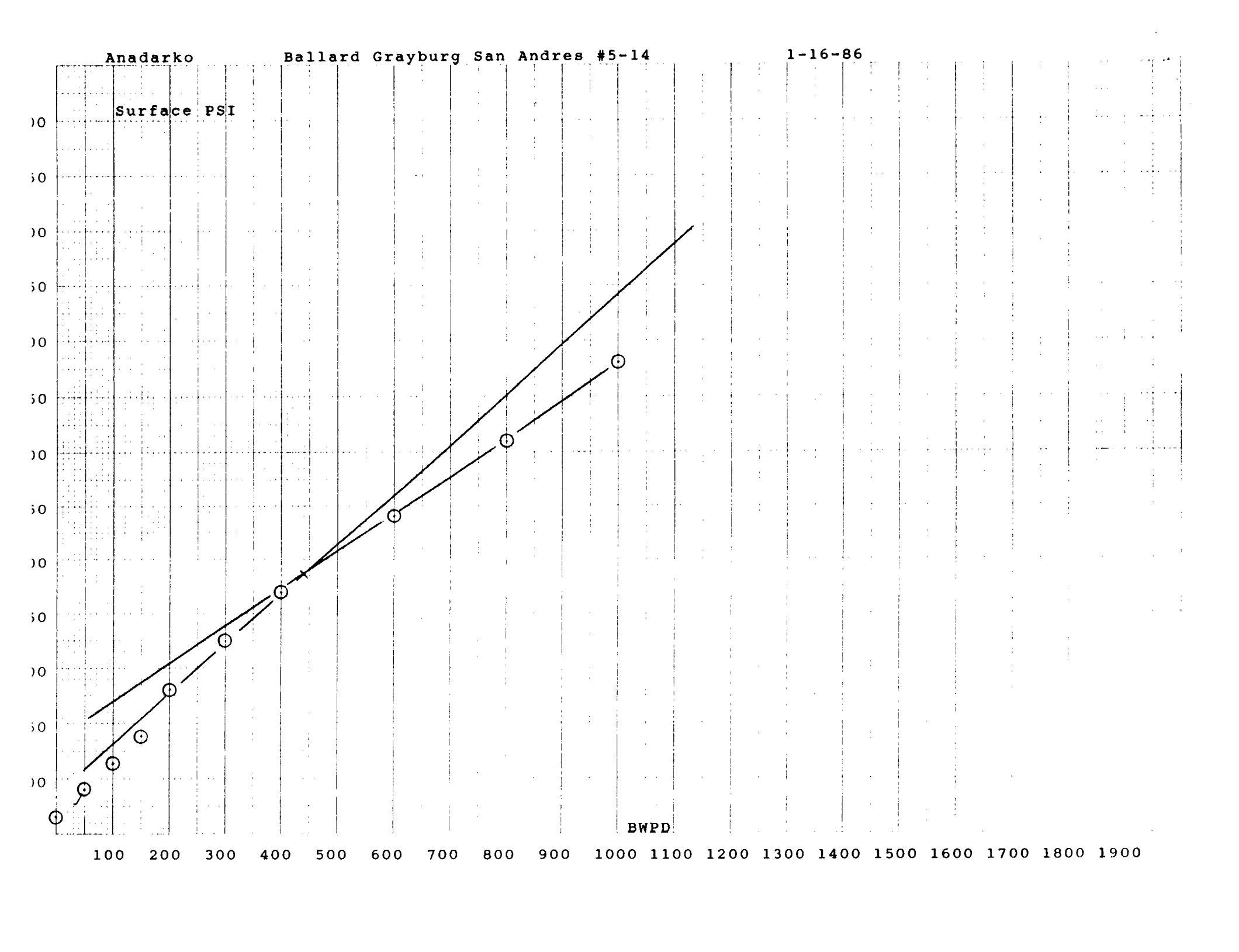
Csg size 4½ Wt d Set at Perfs: From 2447 To 2728 Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at Perfs: From To County Eddy State New Mexico

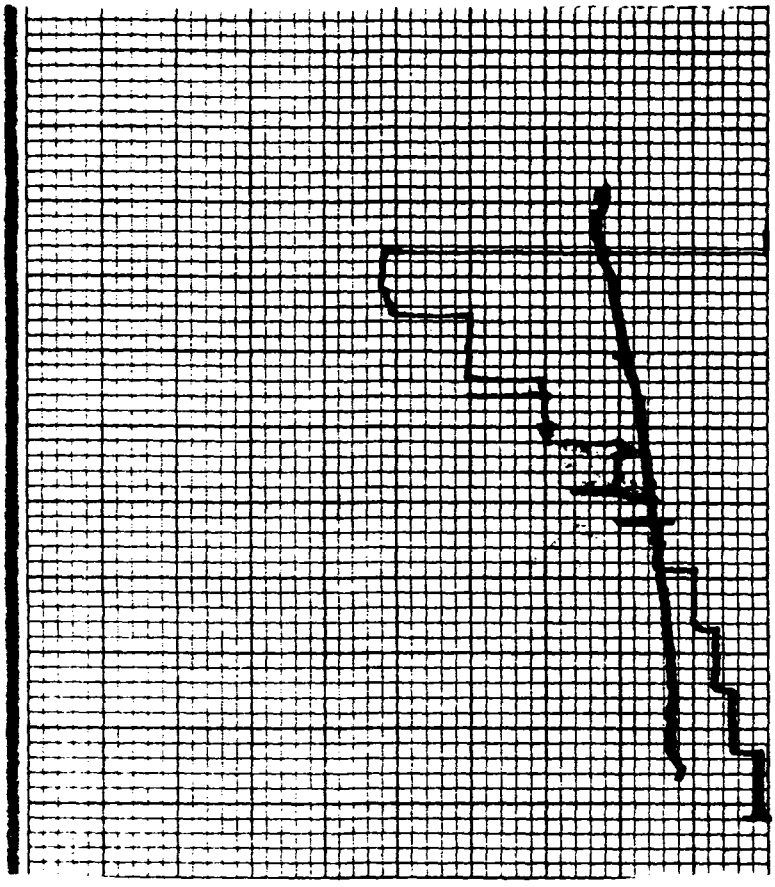
Producing thru Packer set at Co. Rep Jimmy Fletcher

Well Information

Time of Reading	Elap Time Hrs.	Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
5 minute fall-off							
2:51				758			
2:52				755			
2:53				748			
2:54				745			
2:55				741			


Anadarko
Ballard Grayburg San Andres #5-14
1-16-86
Surface PSI
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

Anadarko
Ballard Grayburg San Andres #5-14
1-16-86



GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-14-86 — Unit

Lease Ballard Grayburg San Andre

Total Depth — Plug Back TD — Elevation — Well # 8-4

Csg size — Wt — d — Set at — Perfs: From 2572 To 2752 — Sec — Twp-Blk — Rge

Tbg size 2 3/8 — Wt — d — Set at — Perfs: From — To — County Eddy — State New Mexico

Producing thru — Packer set at — Co. Rep Tommy Thompson

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
2:25	Start			443			
2:30		100		450			
2:35		100		452			
2:40	:15	100		455			
2:45		200		463			
2:50		200		469			
2:55	:30	200		474			
3:00		400		502			Having trouble with tras
3:05		400		518			in inj. system
3:10	:45	400		532			
3:15		600		569			
3:20		600		595			Having trouble with tras
3:25	1:00	600		609			in system
3:30		800		648			
3:35		800		673			
3:40	1:15	800		694			
3:45		1000		736			
3:50		1000		759			
3:55	1:30	1000		777			
	Ran	out of	data tape	Having	to use	strip chart	
4:20		1200		800			
4:25		1200		815			
4:30	1:45	1200		830			
4:35		1400		860			
4:40		1400		870			
4:45	2:00	1400		880			
4:50		1600		910			
4:55		1600		929			
5:00		1600		939			115 BBLS total

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-39[illegible]4 Hobbs, New Mexico 88240

Company Anadarko Test Date 1-14-86 Unit

Lease Ballard Grayburg San Andre

Total Depth Plug Back TD Elevation Well # 8-4

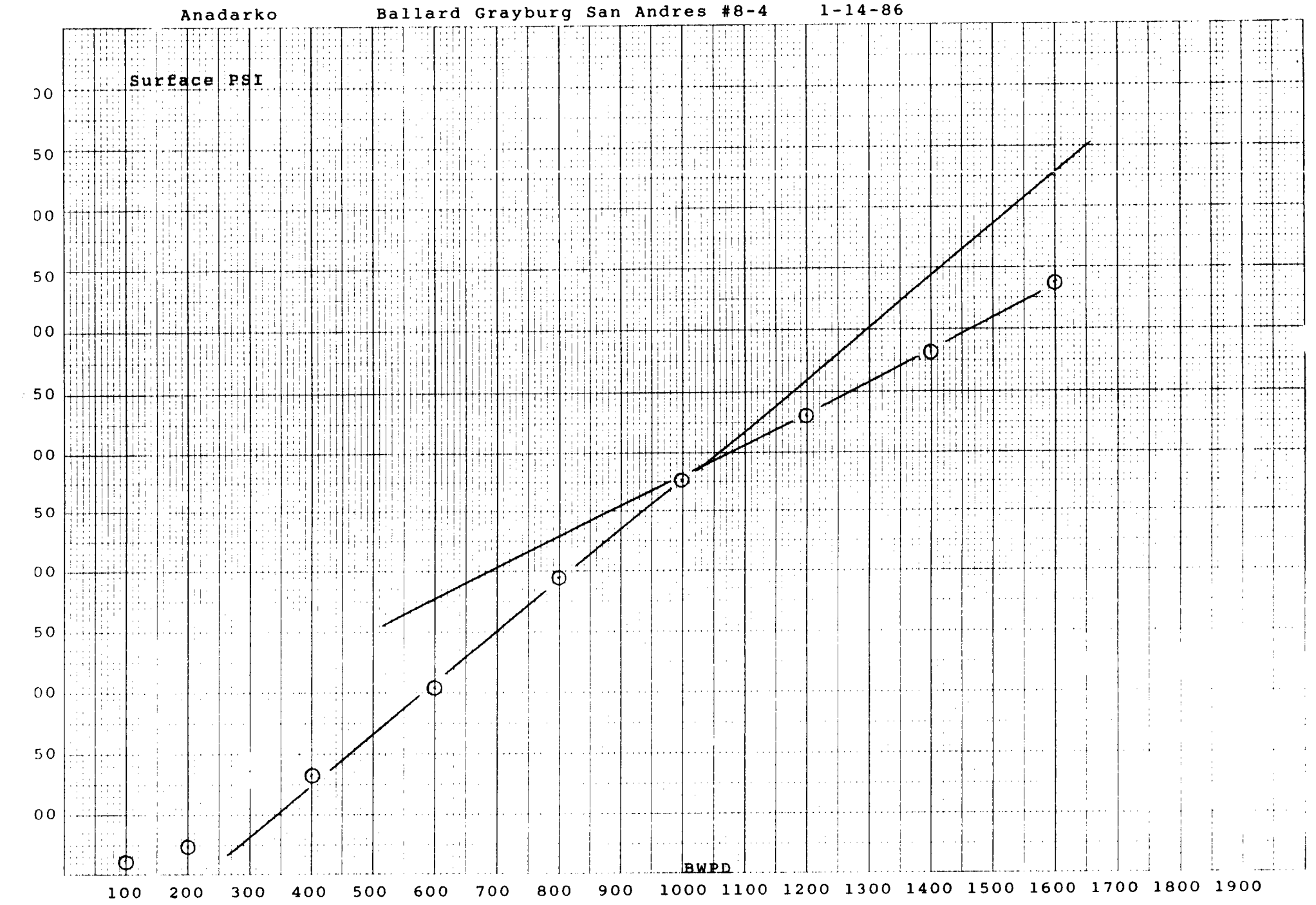
Csg size Wt d Set at Perfs: From 2572 To 2752 Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at Perfs: From To County Eddy State New Mexico

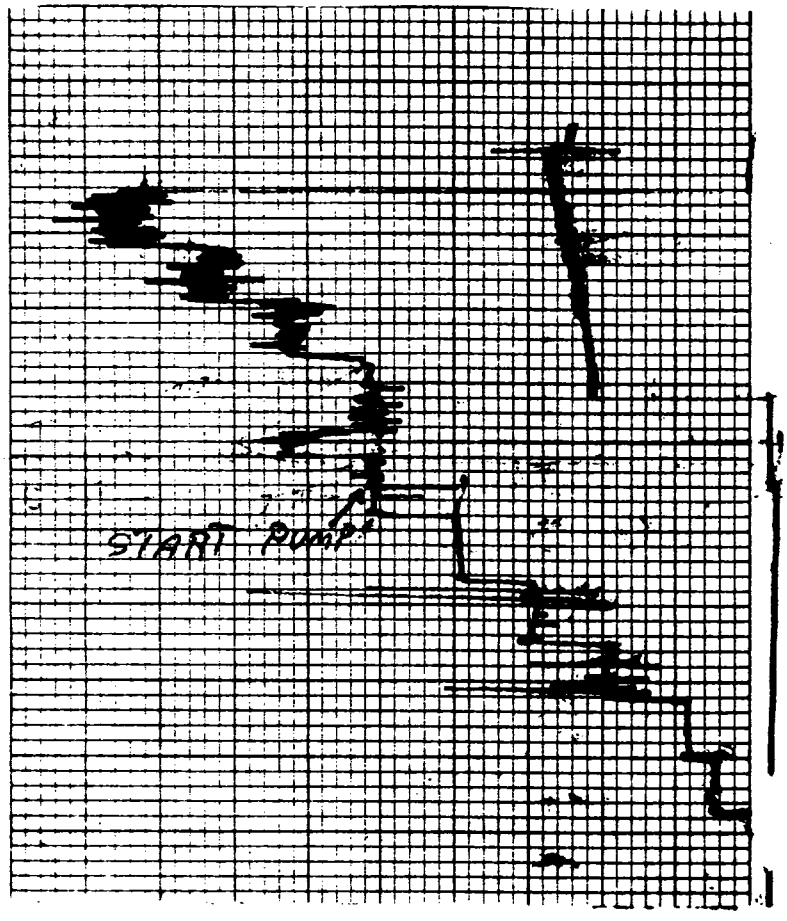
Producing thru Packer set at Co. Rep Tommy Thompson

Well Information

Time of Reading	Elap Time Hrs.	Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
5 minute fall-off							
5:01				900			
5:02				910			
5:03				880			
5:04				850			
5:05				830			


Anadarko
Ballard Grayburg San Andres #8-4
1-14-86
Surface PSI
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

Anadarko
Ballard Grayburg San Andres #8-4
1-14-86



B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-13-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 9-2

Csg size 4½ Wt d Set at Perfs: From 2532 To 2718 — Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at Perfs: From To — County Eddy State New Mexico

Producing thru Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
8:40	Shut in			295			
8:45	Start			295			
8:50		50		335			
8:55		50		285			
9:00	:15	50		285			
9:05		100		305			
9:10		100		305			
9:15	:30	100		305			
9:20		300		365			
9:25		300		390			
9:30	:45	300		420			
9:35		500		490			
9:40		500		530			
9:45	1:00	500		555			
9:50		700		625			
9:55		700		645			
10:00	1:15	700		675			
10:05		900		730			
10:10		900		755			
10:15	1:30	900		780			
10:20		1100		830			
10:25		1100		855			
10:30	1:45	1100		870			
10:35		1300		915			
10:40		1300		930			
10:45	2:00	1300		945			
10:50		1500		980			
10:55		1500		995			
11:00	2:15	1500		1005			
See Page #2							

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 Hobbs, New Mexico 88240

Company Anadarko Test Date 1-13-86 Unit

Lease Ballard Grayburg San Andres

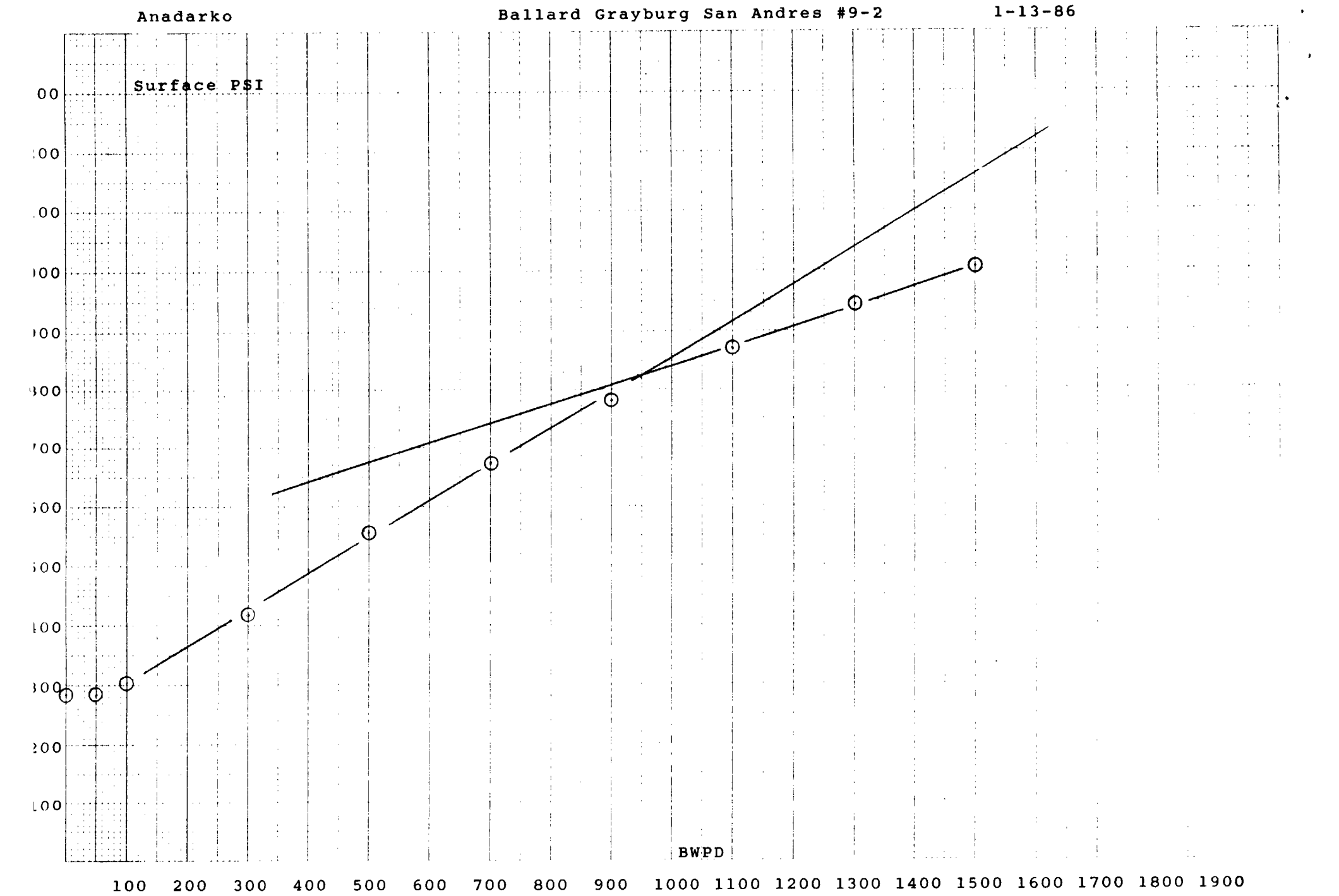
Total Depth Plug Back TD Elevation Well # 9-2

Csg size 4½ Wt d Set at Perfs: From 2532 To 2718 Sec Twp-Blk Rge

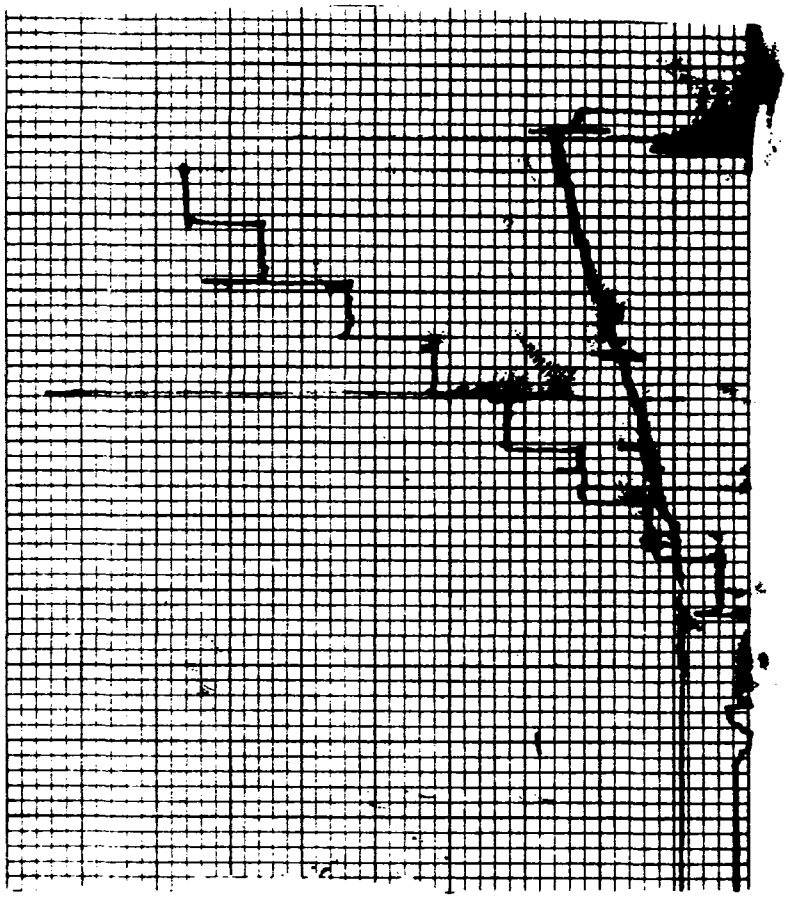
Tbg size 2 3/8 Wt d Set at Perfs: From To County Eddy State New Mexico

Producing thru Packer set at Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
ISIP				985			
11:01				915			
11:02				905			
11:03				895			
11:04				885			
11:05				875			


Anadarko
Ballard Grayburg San Andres #9-2
1-13-86
Surface PSI
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

Anadarko
Ballard Grayburg San Andres #9-2
1-13-86



B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-15-86 — Unit

Lease Ballard Grayburg San Andre

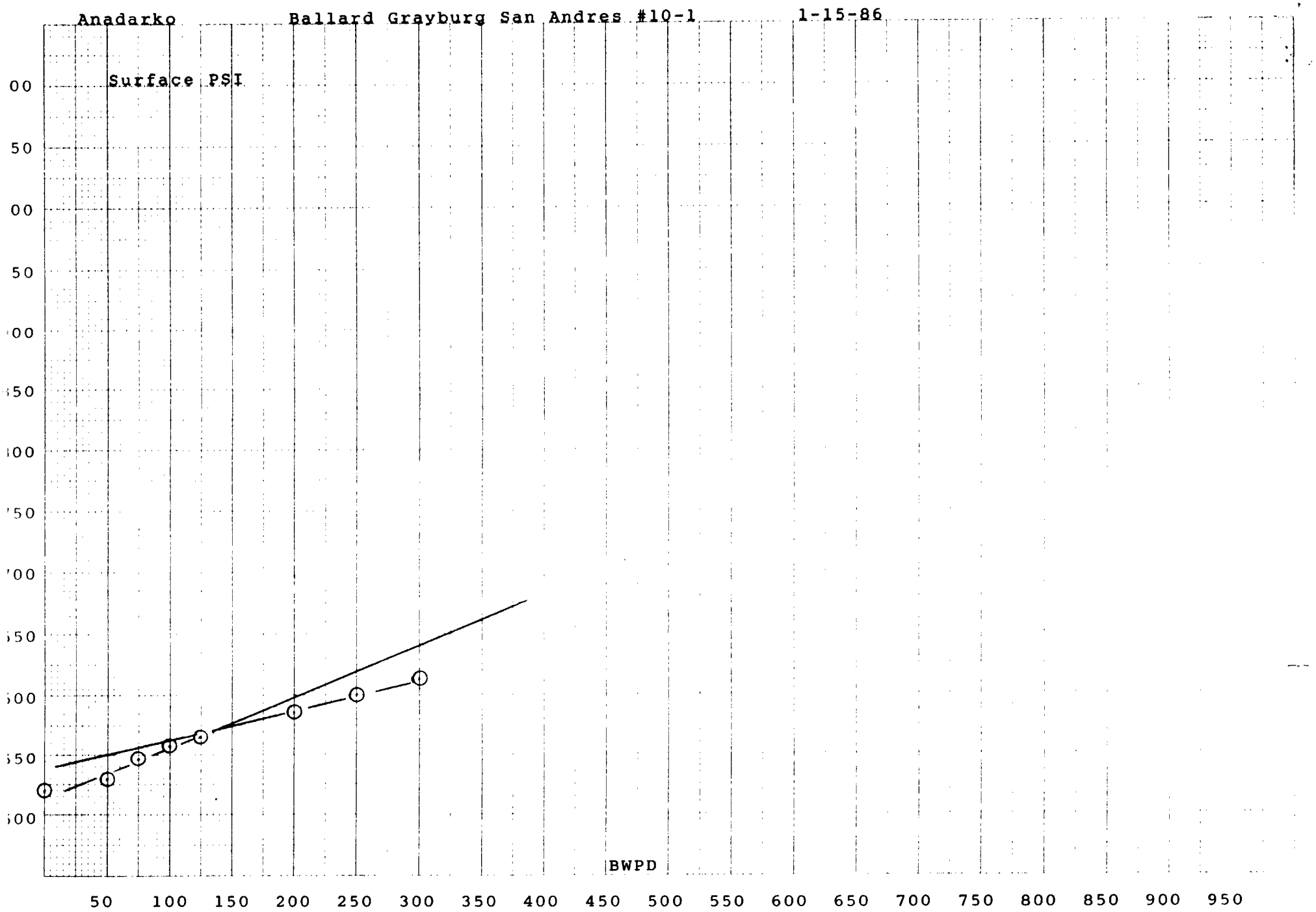
Total Depth — Plug Back TD — Elevation — Well # 10-1

Csg size — Wt — d — Set at — Perfs: From 2580 To 2788 — Sec — Twp-Blk — Rge

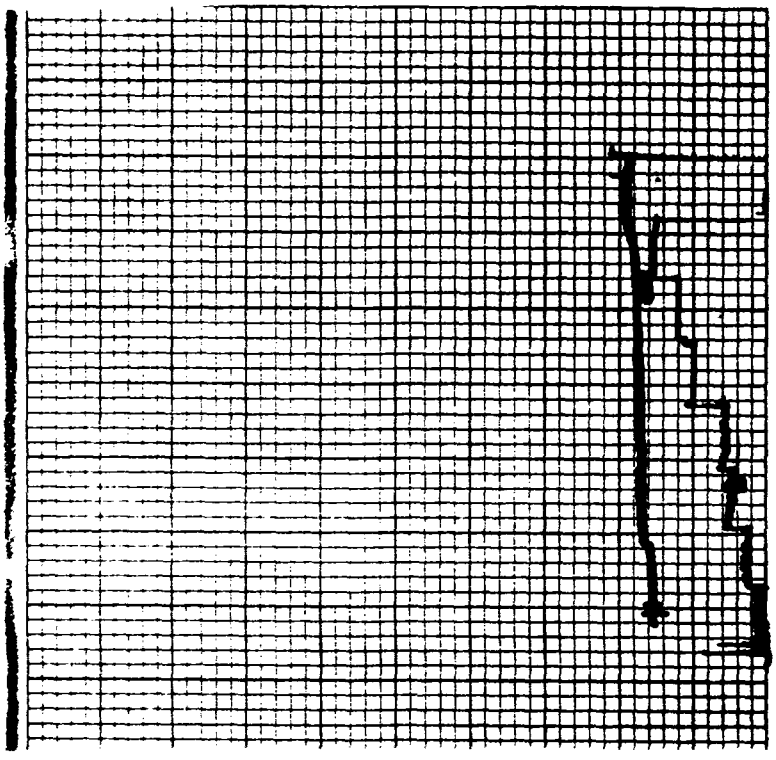
Tbg size 2 3/8 Wt — d — Set at — Perfs: From — To — County Eddy — State New Mexico

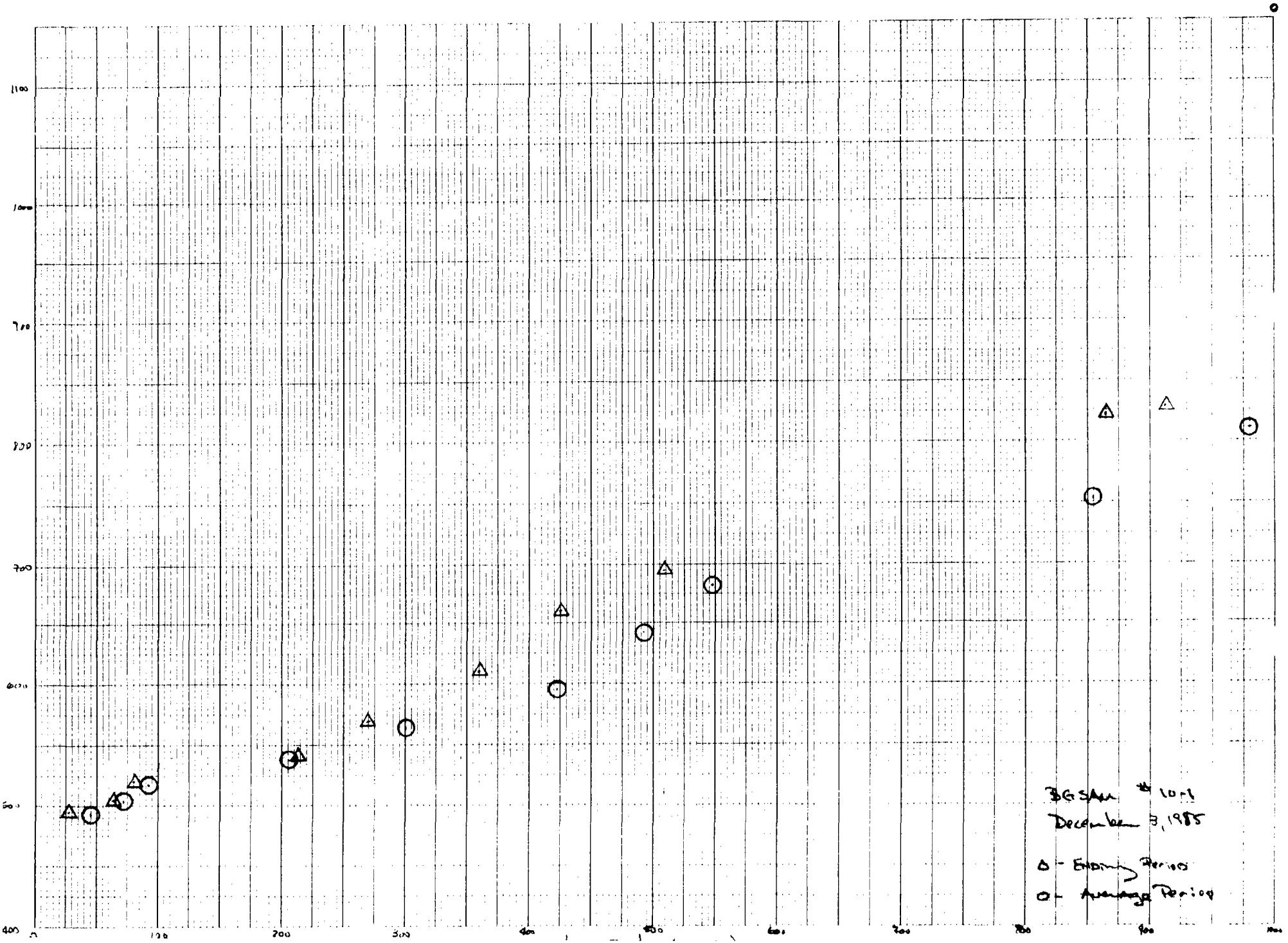
Producing thru — Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
3:25				520			
3:30		50		530			
3:35		50		530			
3:40	:15	50		530			
3:45		75		538			
3:50		75		542			
3:55	:30	75		545			
4:00		100		548			
4:05		100		550			
4:10	:45	100		557			
4:15		125		559			
4:20		125		561			
4:25	1:00	125		565			
4:30		200		573			
4:35		200		578			
4:40	1:15	200		585			
4:45		250		589			
4:50		250		595			
4:55	1:30	250		600			
5:00		300		610			
5:05		300		615			
5:10	1:45	300		613			
5 minute fall-off							
5:11				610			
5:12				598			
5:13				598			
5:14				597			
5:15				597			


Anadarko
Ballard Grayburg San Andres #10-1
1-15-86
Surface PSI
BWPD
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950

Anadarko
Ballard Grayburg San Andres #10-1
1-15-86




BG SAM
December 8, 1985
Δ - Ending Period
○ - Average Period

STEP RATE TEST
BALLARD 10-1
DECEMBER 3, 1985

TIME	PSIG (SURFACE)		BWPD INJECTION
8:15	487		77
8:20	490		62
8:25	490		42
8:30	492		30
8:35	495		30
8:40	495		27
1st Setting Average Pressure = 492		Rate = 45	
8:40	500		102
8:45	500		62
8:50	500		62
8:55	505		69
9:00	505		64
9:05	505		65
2nd Setting Average Pressure = 503		Rate = 71	
9:05	515		142
9:10	510		72
9:15	517		91
9:20	519		84
9:25	519		84
9:30	520		80
3rd Setting Average Pressure = 517		Rate = 92	

STEP RATE TEST
BALLARD 10-1
(CONT'D)

TIME	PSIG (SURFACE)	BWPD INJECTION
9:30	535	212
9:35	537	187
9:40	538	205
9:45	540	211
9:50	540	211
9:55	540	211
4th Setting Average Pressure = 538		Rate = 206
9:55	565	333
10:00	565	358
10:05	563	289
10:10	560	270
10:15	565	278
10:20	568	270
5th Setting Average Pressure = 564		Rate = 300
10:20	580	474
10:25	587	442
10:30	592	453
10:35	600	420
10:40	603	387
10:45	610	361
6th Setting Average Pressure = 595		Rate = 423

STEP RATE TEST
BALLARD 10-1
(CONT'D)

TIME	PSIG (SURFACE)		BWPD INJECTION
10:45	605		630
10:50	635		558
10:55	645		476
11:00	645		435
11:05	659		428
11:10	660		425
7th Setting Average Pressure = 642		Rate = 492	
11:10	675		599
11:15	678		586
11:20	680		555
11:25	683		526
11:30	690		514
11:35	695		508
8th Setting Average Pressure = 684		Rate = 548	
11:35	720		890
11:40	726		846
11:45	740		823
11:50	747		863
11:55	760		866
12:00	822		865
9th Setting Average Pressure = 753		Rate = 859	

STEP RATE TEST
BALLARD 10-1
(CONT'D)

TIME	PSIG (SURFACE)		BWPD INJECTION
12:00	790		1124
12:05	800		1031
12:10	805		943
12:15	815		939
12:20	820		927
12:25	827		912
10th Setting Average Pressure =	810	Rate =	979
12:25	840		1075
12:30	840		1031
12:35	845		1024
12:40	860		1028
12:45	865		1024
12:50	872		1033
11th Setting Average Pressure =	854	Rate =	1036
12:50	900		1553
12:55	916		1424
1:00	920		1348
1:05	938		1338
1:10	940		1290
1:15	955		1276
12th Setting Average Pressure =	928	Rate =	1372

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 5-13-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 13-2

Csg size Wt d Set at — Perfs: From 2526 To 2707 — Sec Twp-Blk Rge

Tbg size Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
8:45	Start.			720			
8:50		100		735			
8:55		100		742			
9:00	:15	100		750			
9:05		300		770			
9:10		300		785			
9:15	:30	300		795			
9:20		500		812			
9:25		500		825			
9:30	:45	500		835			
9:35		700		855			
9:40		700		875			
9:45	1:00	700		885			
9:50		900		915			
9:55		900		925			
10:00	1:15	900		935			
10:05		1100		960			
10:10		1100		975			
10:15	1:30	1100		985			
10:20		1300		1015			
10:25		1300		1030			
10:30	1:45	1300		1045			
10:35		1500		1090			
10:40		1500		1110			
10:45	2:00	1500		1130			
10:50		1700		1170			
10:55		1700		1060			
11:00	2:15	1700		1170			
11:05		1900		1200			
11:10		1900		1400			
11:15	2:30	1900		1340			

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 Hobbs, New Mexico 88240

Company Anadarko Test Date 5-13-86 Unit

Lease Ballard Grayburg San Andres

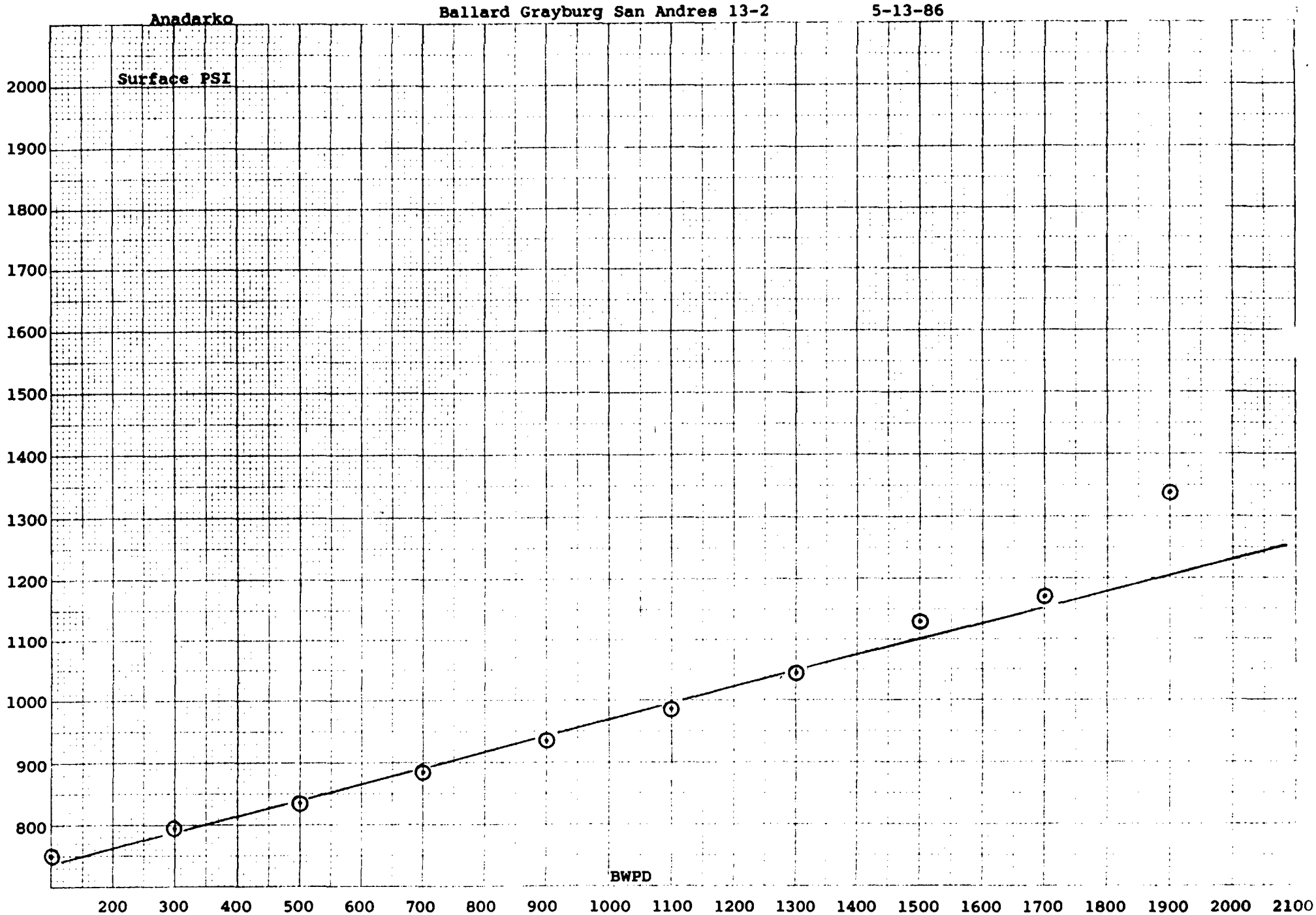
Total Depth Plug Back TD Elevation Well # 13-2

Csg size Wt d Set at Perfs: From 2526 To 2707 Sec Twp-Blk Rge

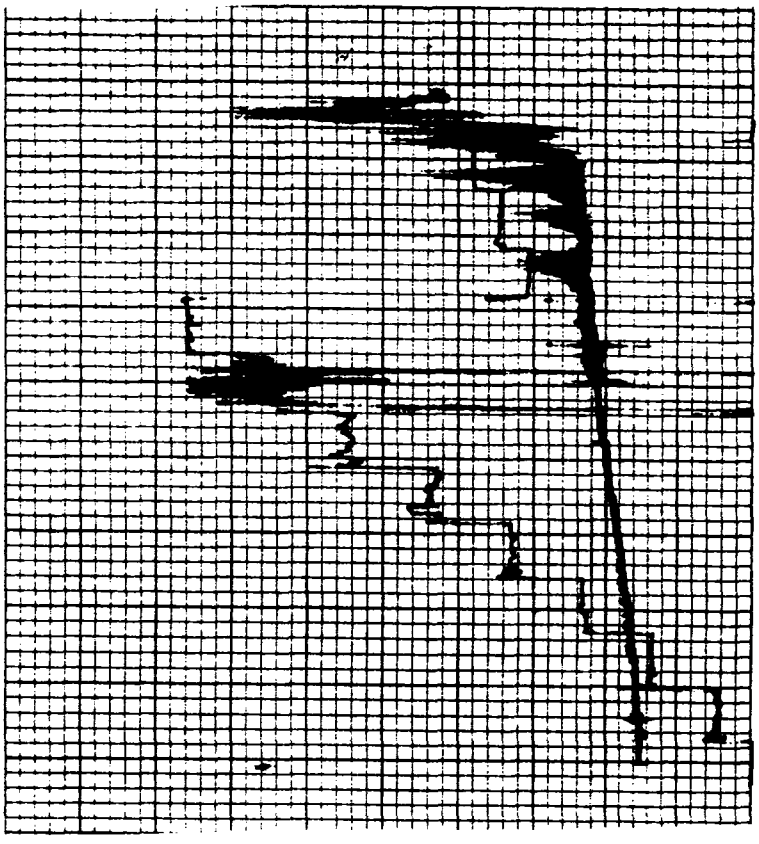
Tbg size Wt d Set at Perfs: From To County Eddy State New Mexico

Producing thru Packer set at Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
11:20		2100		1900			Suspect blockage in pipe
11:25		2100		2000			above packer
11:30	2:45	2100		3000			
5 minute fall		off	ISIP	2450			Total BBLS 122.6
11:31				2270			
11:32				2220			
11:33				1950			
11:34				1900			
11:35				1890			
End of test							


Anadarko
Ballard Grayburg San Andres 13-2
5-13-86
Surface PSI
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
BWPD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100

Anadarko
Ballard Grayburg San Andres #13-2
5-13-86



B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-14-86 — Unit

Lease Ballard Grayburg San Andre

Total Depth — Plug Back TD — Elevation — Well # 13-2

Csg size Wt d Set at — Perfs: From 2526 To 2707 — Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
8:30	Start			567			
8:35		50		573			
8:40		50		578			
8:45	:15	50		583			
8:50		100		591			
8:55		100		595			
9:00	:30	100		604			
9:05		200		621			
9:10		200		632			
9:15	:45	200		641			
9:20		300		657			
9:25		300		668			
9:30	1:00	300		677			
9:35		400		693			
9:40		400		697			
9:45	1:15	400		702			
9:50		500		715			
9:55		500		726			
10:00	1:30	500		737			
10:05		600		755			
10:10		600		769			
10:15	1:45	600		780			
10:20		800		805			
10:25		800		820			
10:30	2:00	800		831			
10:35		1000		857			
10:40		1000		870			
10:45	2:15	1000		881			
10:50		1200		906			
10:55		1200		916			
11:00	2:30	1200		926			

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-39[illegible]4
Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-14-86 — Unit

Lease Ballard Grayburg San Andres

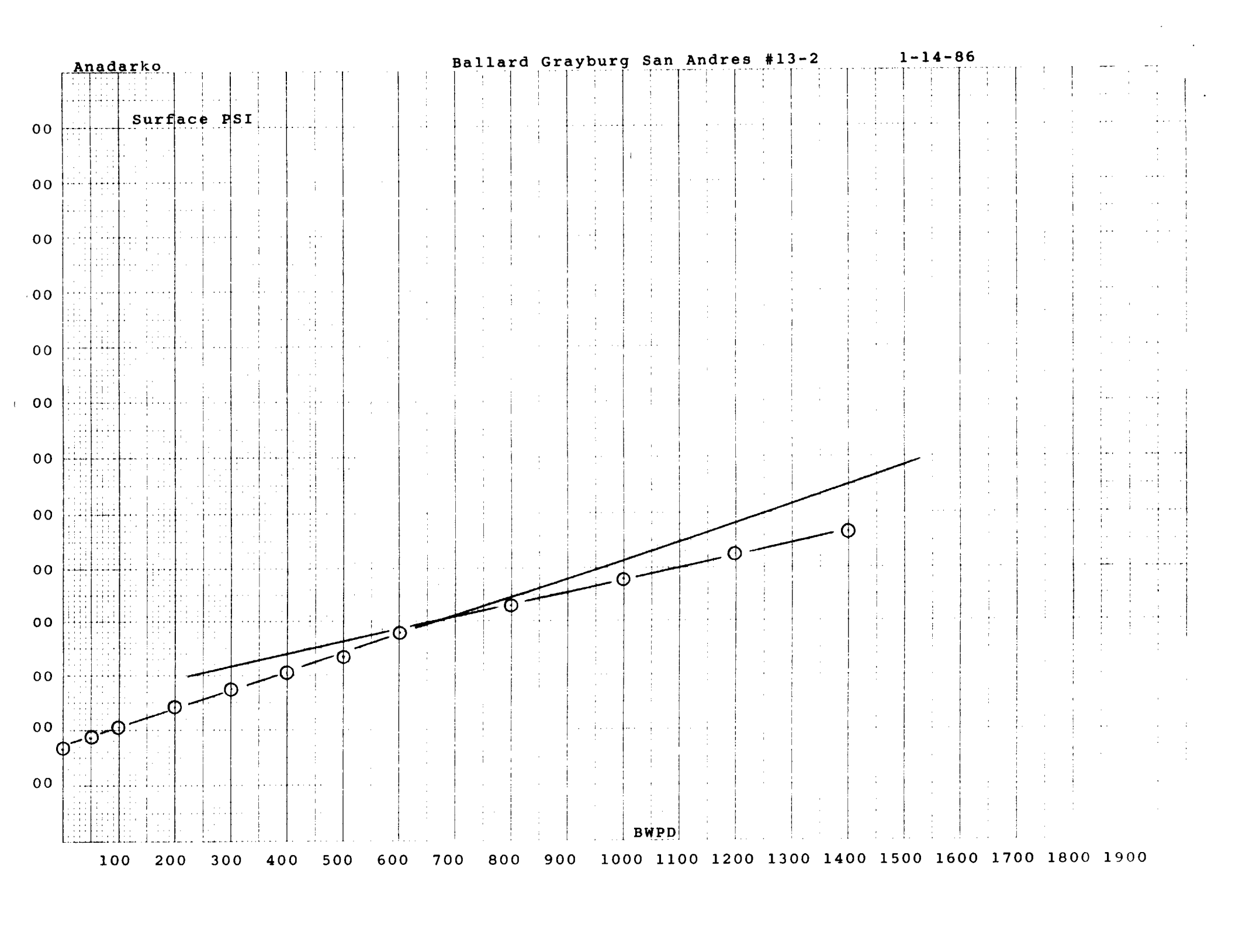
Total Depth — Plug Back TD — Elevation — Well # 13-2

Csg size — Wt — d — Set at — Perfs: From 2526 To 2707 — Sec — Twp-Blk — Rge

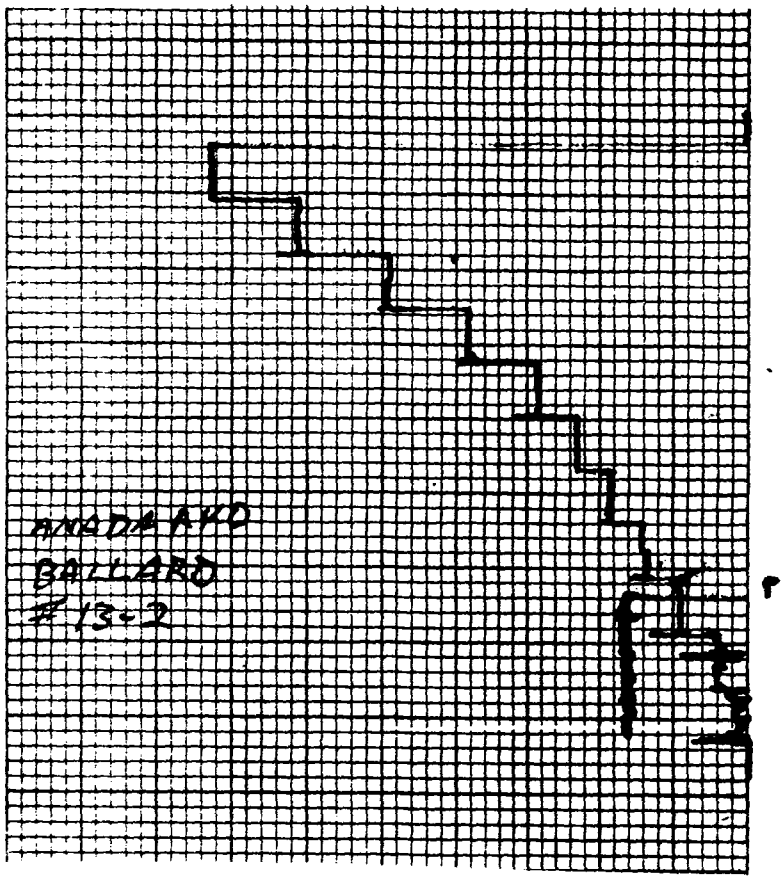
Tbg size 2 3/8 Wt — d — Set at — Perfs: From — To — County — State

Producing thru — Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
11:05		1400		948			
11:10		1400		957			
11:15	2:45	1400		965			
5 minute fall-off							
11:16				911			
11:17				910			
11:18				905			
11:19				903			
11:20				901			


Anadarko
Ballard Grayburg San Andres #13-2
1-14-86
Surface PSI
00
00
00
00
00
00
00
00
00
00
00
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

Anadarko
Ballard Grayburg San Andres #13-2
1-14-86



B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-13-86 — Unit

Lease Ballard Grayburg San Andres

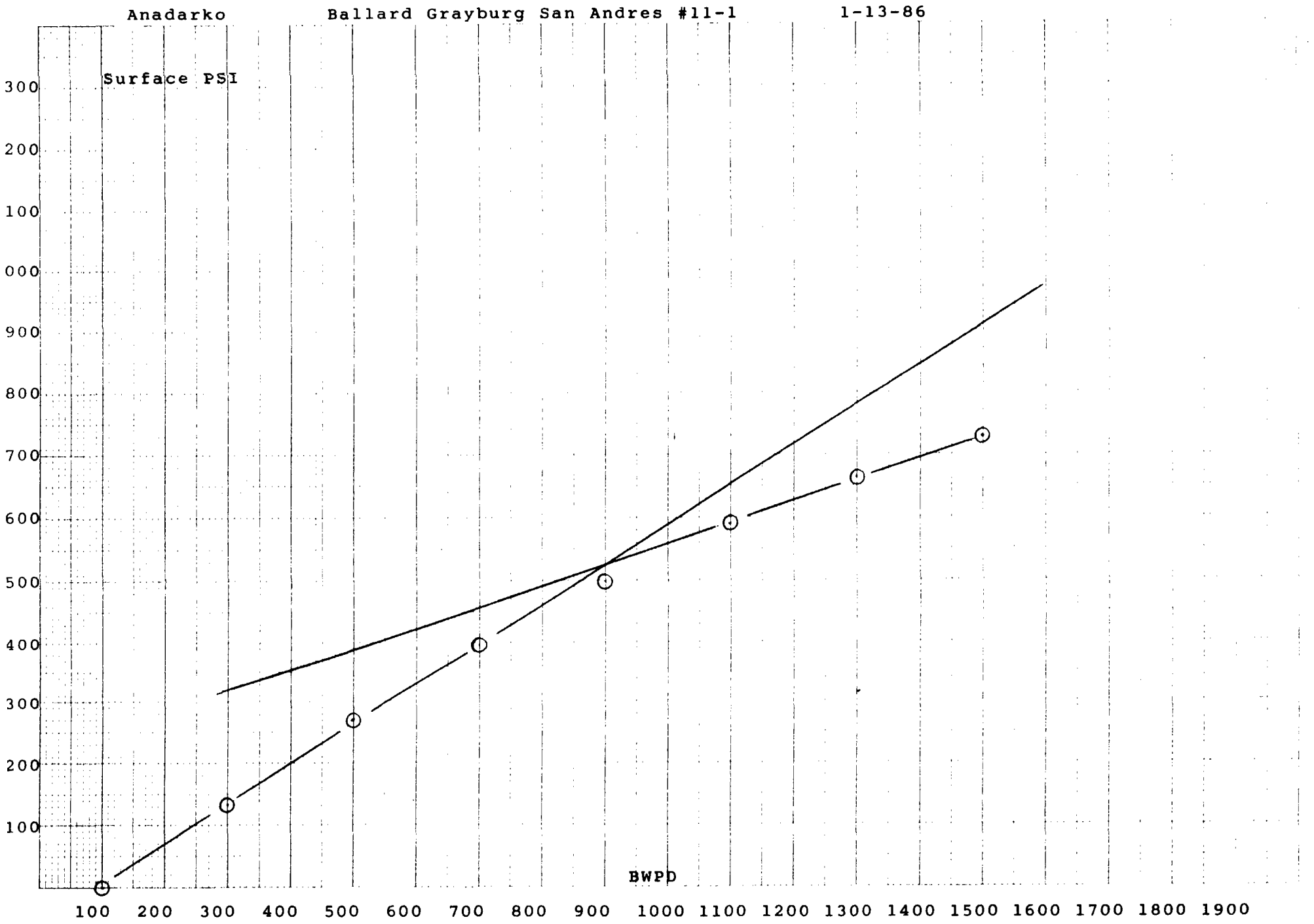
Total Depth — Plug Back TD — Elevation — Well # 11-1

Csg size 4½ Wt d Set at Perfs: From 2508 To 2680 — Sec Twp-Blk Rge

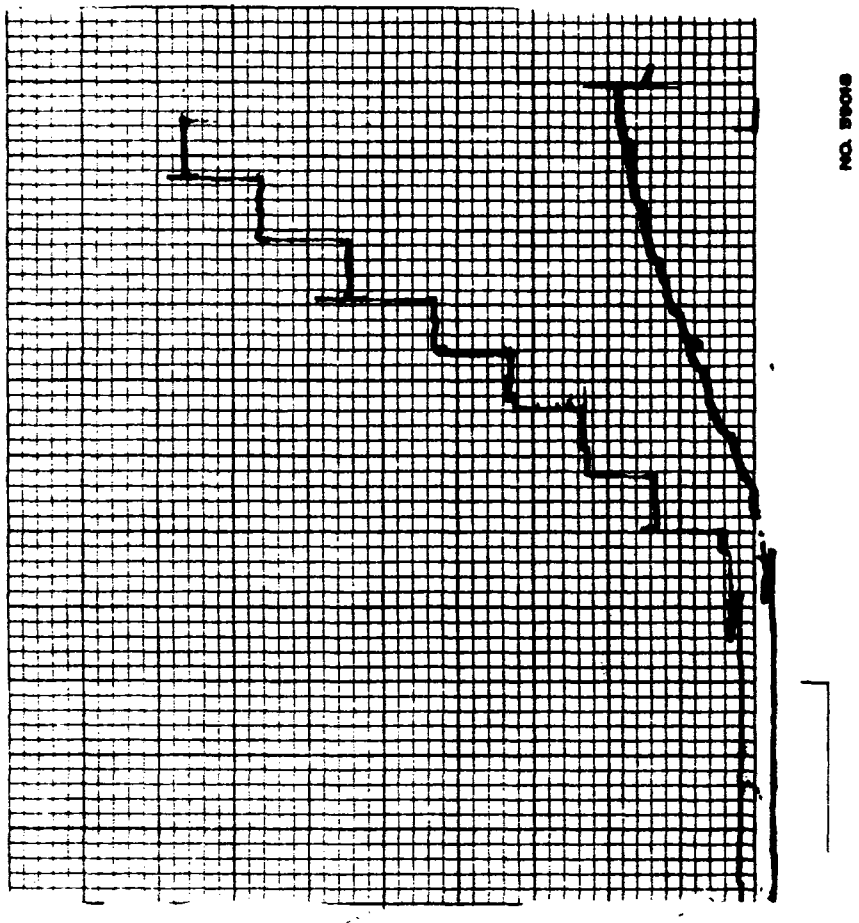
Tbg size 2 3/8 Wt d Set at Perfs: From To — County Eddy State New Mexico

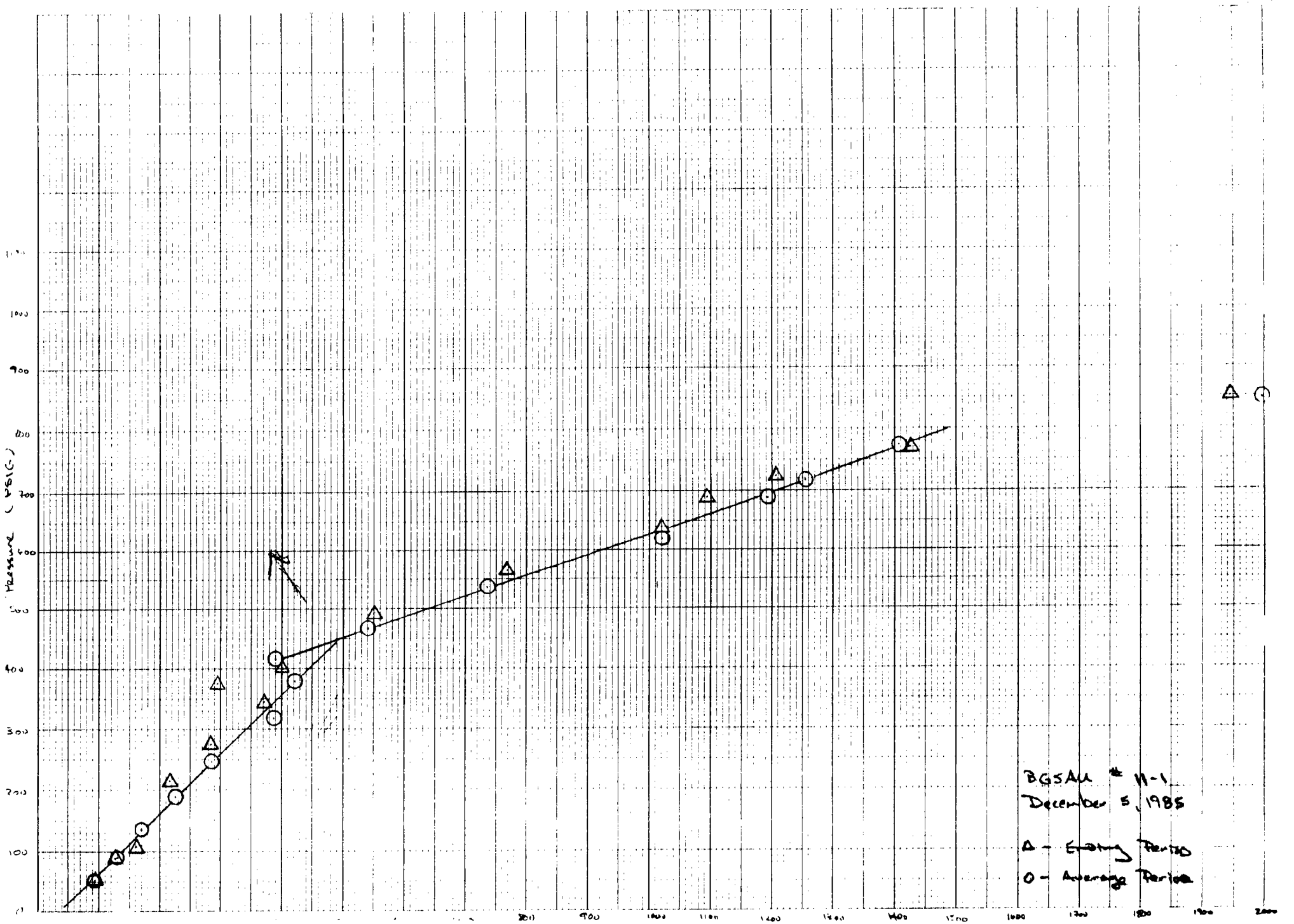
Producing thru Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
11:30				Vac			
11:35	Start.			Vac			
11:40		100		Vac			
11:45		100		Vac			
11:50	:15	100		Vac			
11:55		300		0			
12:00		300		85			
12:05	:30	300		135			
12:10		500		205			
12:15		500		235			
12:20	:45	500		270			
12:25		700		335			
12:30		700		365			
12:35	1:00	700		395			
12:40		900		460			
12:45		900		480			
12:50	1;15	900		500			
12:55		1100		555			
1:00		1100		575			
1:05	1:30	1100		590			
1:10		1300		640			
1:15		1300		654			
1:20	1:45	1300		665			
1:25		1500		705			
1:30		1500		720			
1:35	2:00	1500		730			
5 minute fall-off							
1:36				585			
1:37				575			
1:38				565			
1:39				555			
1:40				560			


Anadarko
Ballard Grayburg San Andres #11-1
1-13-86
Surface PSI
300
200
100
000
900
800
700
600
500
400
300
200
100
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

Anadarko
Ballard Grayburg San Andres #11-1
1-13-86





STEP RATE TEST
BALLRD 11-1
DECEMBER 5, 1985

TIME	PSIG (SURFACE)	BWPD INJECTION
8:20	50	92
8:25	50	91
8:30	50	91
8:35	50	91
8:40	50	92
8:45	50	93
1st Setting Average Pressure = 50		Rate = 92
8:45	90	130
8:50	90	131
8:55	90	133
9:00	90	132
9:05	90	133
9:10	90	127
2nd Setting Average Pressure = 90		Rate = 131
9:10	113	189
9:15	110	179
9:20	136	166
9:25	140	163
9:30	145	162
9:35	159	161
3rd Setting Average Pressure = 134		Rate = 170

STEP RATE TEST
BALLARD 11-1
(CONT'D)

TIME	PSIG (SURFACE)		BWPD INJECTION
9:35	165		241
9:40	180		236
9:45	185		225
9:50	190		221
9:55	200		215
10:00	214		216
4th Setting Average Pressure =	189	Rate = 226	
10:00	224		336
10:05	236		292
10:10	245		289
10:15	245		232
10:20	260		281
10:25	273		283
5th Setting Average Pressure =	247	Rate = 286	
10:25	295		419
10:30	300		395
10:35	305		382
10:40	322		378
10:45	339		390
10:50	346		371
6th Setting Average Pressure =	318	Rate = 389	

STEP RATE TEST
BALLARD 11-1
(CONT'D)

TIME	PSIG (SURFACE)		BWPD INJECTION
10:50	360		469
10:55	365		412
11:00	377		396
11:05	380		433
11:10	390		417
11:15	400		401
7th Setting Average Pressure =	379	Rate = 421	
11:15	440		572
11:20	420		370
11:25	425		464
11:30	420		313
11:35	419		330
11:40	374		294
8th Setting Average Pressure =	416	Rate = 390	
11:40	447		550
11:45	446		540
11:50	460		539
11:55	469		510
12:00	480		544
12:05	492		551
9th Setting Average Pressure =	466	Rate = 539	

STEP RATE TEST
BALLARD 11-1
(CONT'D)

TIME	PSIG (SURFACE)		BWPD INJECTION
12:05	520		737
12:10	520		748
12:15	533		741
12:20	540		701
12:25	545		717
12:30	564		769
10th Setting Average Pressure = 537		Rate = 736	
12:30	600		1039
12:35	600		1016
12:40	620		1038
12:45	625		964
12:50	638		1036
12:55	640		1020
11th Setting Average Pressure = 621		Rate = 1019	
12:55	650		1146
1:00	678		1198
1:05	680		1242
1:10	693		1246
1:15	700		1228
1:20	690		1092
12th Setting Average Pressure = 688		Rate = 1192	

STEP RATE TEST
BALLARD 11-1
(CONT'D)

TIME	PSIG (SURFACE)		BWPD INJECTION
1:20	717		1367
1:25	720		1317
1:30	710		1194
1:35	718		1208
1:40	720		1229
1:45	725		1205
13th Setting Average Pressure = 718		Rate = 1253	
1:45	780		1676
1:50	760		1472
1:55	768		1496
2:00	780		1500
2:05	776		1490
2:10	770		1422
14th Setting Average Pressure = 772		Rate = 1509	
2:10	840		2105
2:15	843		2041
2:20	847		1962
2:25	856		1977
2:30	850		1959
2:35	850		1944
15th Setting Average Pressure = 848		Rate = 1998	

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 5-14-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 24-2

Csg size 5½ Wt — d — Set at — Perfs: From 2511 To 2756 — Sec — Twp-Blk — Rge

Tbg size 2 3/8 Wt — d — Set at — Perfs: From — To — County Eddy — State New Mexico

Producing thru — Packer set at — Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
7:15	Start			680			
7:20		100		700			
7:25		100		708			
7:30	:15	100		715			
7;35		200		725			
7:40		200		730			
7:45	:30	200		735			
7:50		300		750			
7:55		300		765			
8:00	:45	300		770			
8:05		500		800			
8:10		500		805			
8:15	1:00	500		820			
8:20		700		850			
8:25		700		860			
8:30	1:15	700		870			
8:35		900		875			
8:40		900		885			
8:45	1:30	900		915			
8:50		1100		945			
8:55		1100		955			
9:00	1:45	1100		975			
9:05		1300		990			
9:10		1300		1015			
9:15	2:00	1300		1030			
9:20		1500		1045			
9:25		1500		1060			
9:30	2:15	1500		1045			

B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 5-14-86 — Unit

Lease Ballard Grayburg San Andres

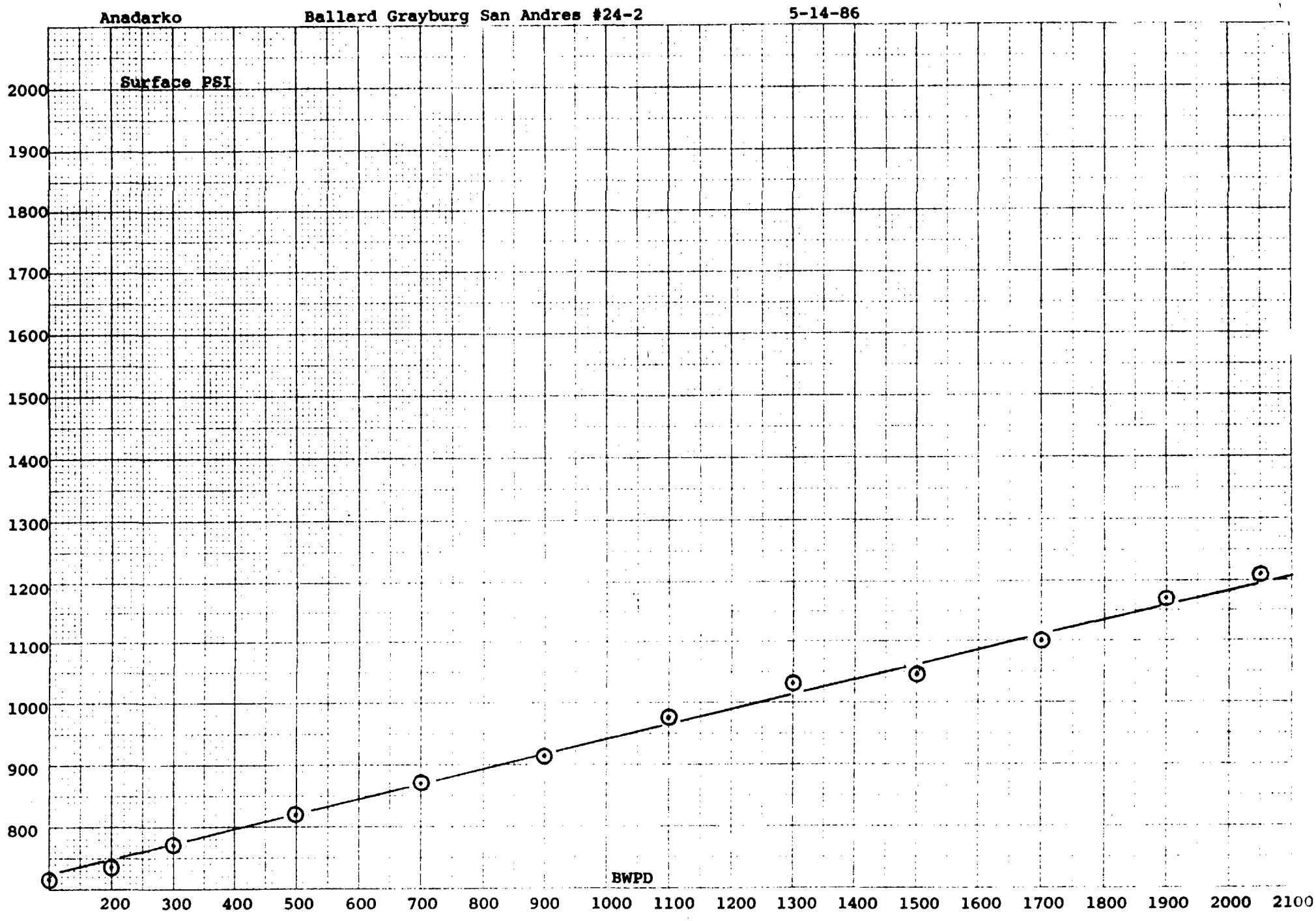
Total Depth — Plug Back TD — Elevation — Well # 24-2

Csg size 5½ Wt d Set at — Perfs: From 2511 To 2756 — Sec Twp-Blk Rge

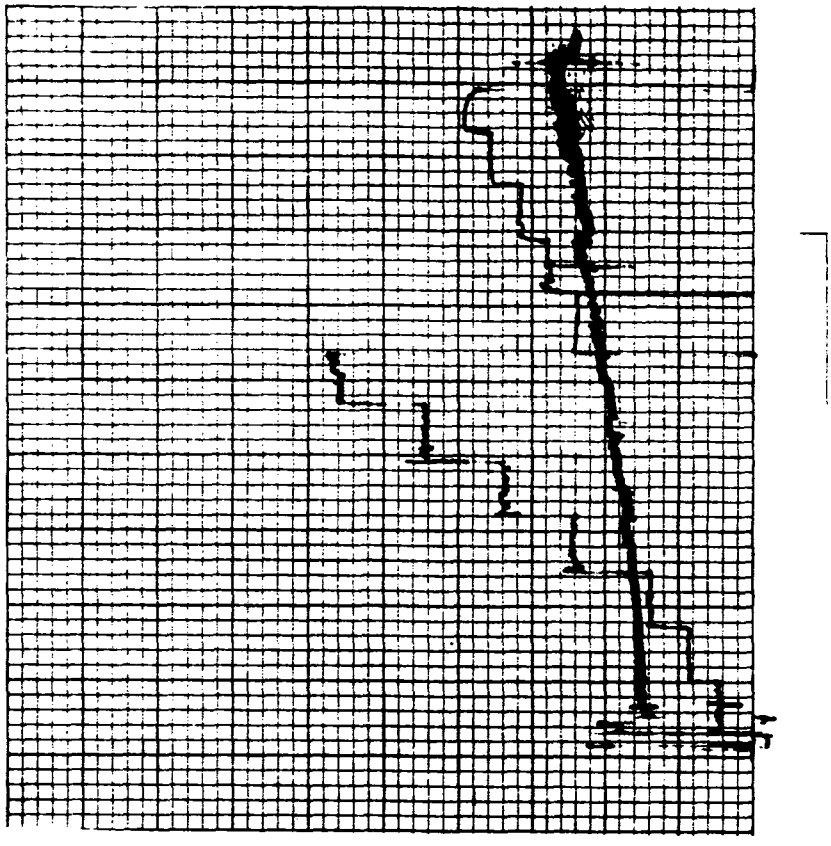
Tbg size 2 3/8 Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jerry Buckles

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
9:35		1700		1050			
9:40		1700		1070			
9:45	2:30	1700		1100			
9:50		1900		1120			
9:55		1900		1150			
10:00	2:45	1900		1170			
10:05		2050		1190			
10:10		2050		1200			
10:15	3:00	2050		1210			
5 minute fall-off			ISIP	1115			Total BBLS. 122.5
10:16				1110			
10:17				1105			
10:18				1100			
10:19				1095			
10:20				1090			


Anadarko
Ballard Grayburg San Andres #24-2
5-14-86
Surface PSI
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
BWPD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100

Anadarko
Ballard Grayburg San Andres #24-2
5-14-86



B & D WELL TESTERS
Step Rate Test

Phone (505) 397-3914 — Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-14-86 — Unit

Lease Ballard Grayburg San Andres

Total Depth — Plug Back TD — Elevation — Well # 24-2

Csg size 5½ Wt d Set at — Perfs: From 2511 To 2756 — Sec Twp-Blk Rge

Tbg size 2 3/8 Wt d Set at — Perfs: From To — County Eddy State New Mexico

Producing thru — Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
6:15	Shut in			205			
6:20		100		234			
6:25		100		245			
6:30	:15	100		254			
6:35		200		275			
6:40		200		293			
6:45	:30	200		300			
6:50		300		328			
6:55		300		350			
7:00	:45	300		365			
7:05		400		395			
7:10		400		414			
7:15	1:00	400		425			
7:20		600		455			Trash in injection syste
7:25		600		485			
7:30	1:15	600		510			
7:35		800		555			
7:40		800		575			
7:45	1:30	800		605			
7:50		900		625			
7:55		900		655			
8:00	1:45	900		675			
8:05		1100		715			
8:10		1100		735			
8:15	2:00	1100		755			
8:20		1300		795			
8:25		1300		815			
8:30	2:15	1300		835			

B & D WELL TESTERS

Step Rate Test

Phone (505) 397-3914

Hobbs, New Mexico 88240

Company Anadarko — Test Date 1-14-86 — Unit

Lease Ballard Grayburg San Andres

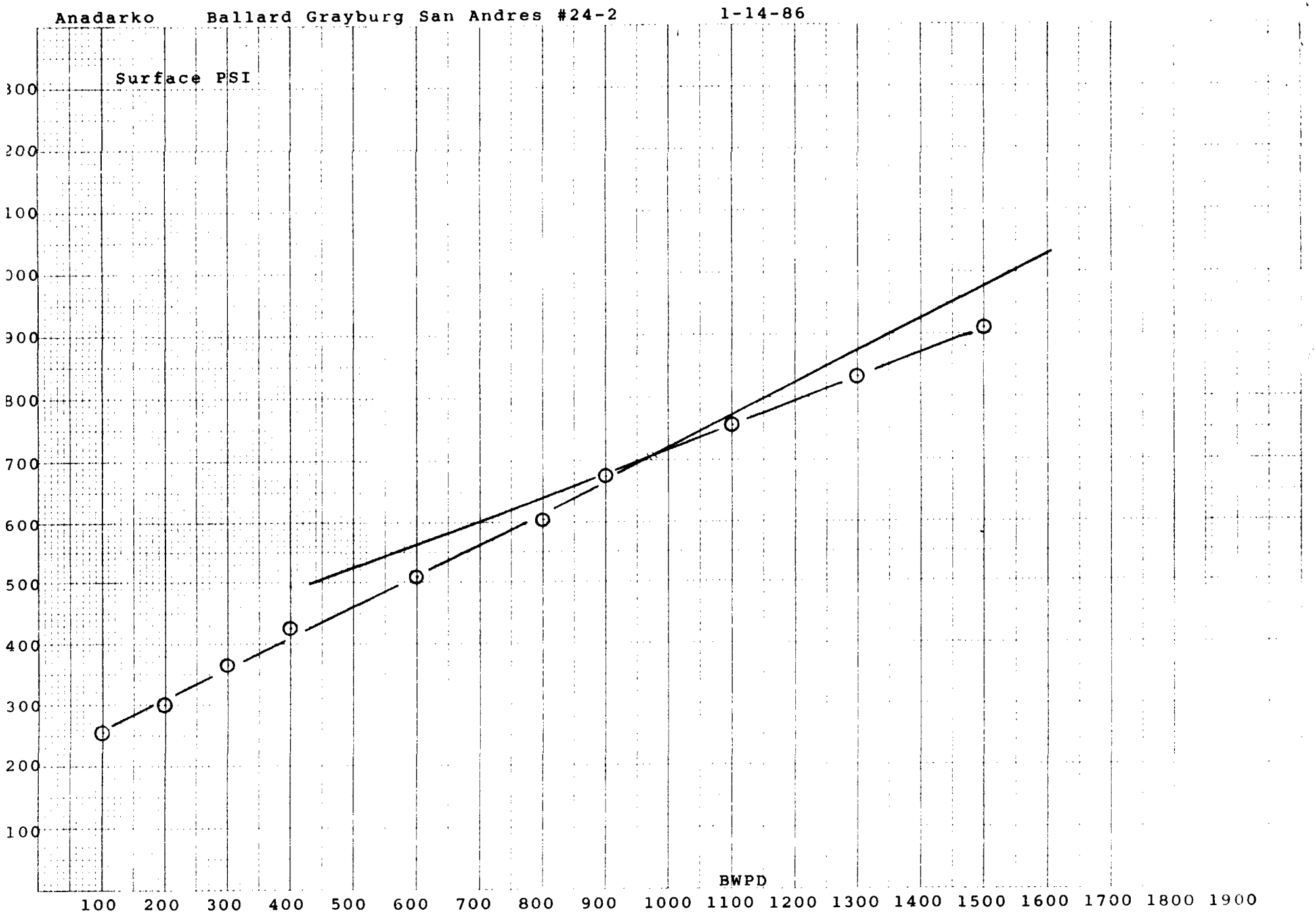
Total Depth — Plug Back TD — Elevation — Well # 24-2

Csg size 5½ Wt d Set at Perfs: From 2511 To 2756 — Sec Twp-Blk Rge

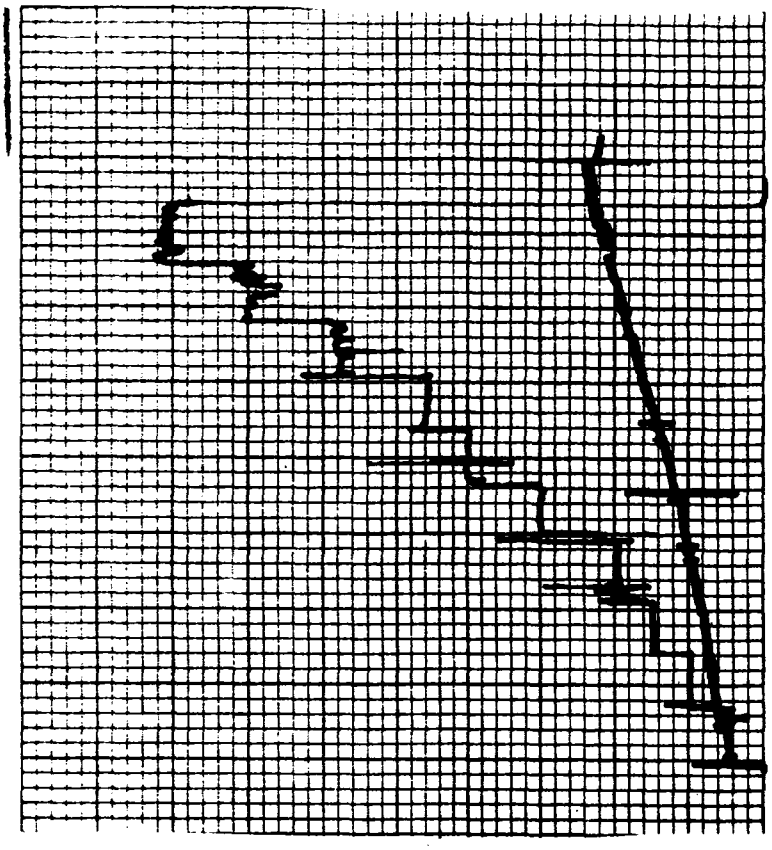
Tbg size 2 3/8 Wt d Set at Perfs: From To — County Eddy State New Mexico

Producing thru Packer set at — Co. Rep Jimmy Fletcher

Time of Reading	Elap Time Hrs.	Well Information: Rate BBLS Per Day	Total BBLS Per Rate	Surface PSIG	Surface PSI Cor for Friction	BHP	Remarks
8:35		1500		865			
8:40		1500		885			
8:45	2:30	1500		910			Total BBLS 76.1
5 minute fall-off							
8:46				855			
8:47				852			
8:48				850			
8:49				847			
8:50				835			


Anadarko Ballard Grayburg San Andres #24-2 1-14-86
Surface PSI
300
200
100
900
800
700
600
500
400
300
200
100
BWPD
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

Anadarko
Ballard Grayburg San Andres #24-2
1-14-86



NO. 5908

#9364

BALLARD GRAYBURG-SAN ANDRES UNIT

INJECTION PRESSURE LIMITATION STUDY

January, 1988

John H. Beaird III
Sr. Reservoir Engineer

CONTENTS

BALLARD GB-SA UNIT

INJECTION PRESSURE LIMITATION STUDY

TABLE OF CONTENTS

LIST OF EXIBITS

BALLARD GB-SA UNIT

INJECTION PRESSURE LIMITATION STUDY

LIST OF EXHIBITS

EXHIBIT #	DESCRIPTION
1	Unit Map
2	Type Log
3	Unit Performance Curve
4	1982 Expansion Unit Performance Curve
5	1985 Expansion Unit Performance Curve
6	Full Wave Sonic Log BGBSAU #23-4
7	Frac Pressure - Rock Properties Log
8	Frac Pressure - Bore Hole Stress Log
9	Frac Pressure - Fracture Height Log
10	Equilibrium Analysis - 100' Height
11	Equilibrium Analysis - 150' Height
12	Equilibrium Analysis - 200' Height
13	Equilibrium Analysis - 250' Height
14	Delta Pressure vs Height Plot
15	Injectivity Profile Cross-Section
16	Delta Pressure w/Height from Temperature Logs

DISCUSSION

FRACTURE HEIGHT - STRESS VARIATIONS

If the fracture is assumed to be more or less in the vertical plane, the magnitude of the least principal stress can be calculated from Hooke-Biot's Law of Poro-Elastic Deformation:

$$= P\ (\ \ ) + \frac{V}{1-V}\ (Po - P\ \ ) \qquad (1)$$

Where: P = Pore Pressure

Po = Overburden Pressure

V = Poisson's Ratio

= Biot's Constant

And:

$$= (\ 1 - Cr/Cb) \qquad (2)$$

Where: Cb = Bulk Compressibility

Cr = Framework Compressibility

Studies of waterfloods of low-permeability by Martin Felsenthal and Howard H. Ferrel indicate the least principal stress can be calculated from:

$$= P + \frac{V}{1-V}\ (Po - P) \qquad (3)$$

Where: P = Pore Pressure

Po = Overburden Pressure

V = Poisson's Ratio

The only difference between equations (1) and (3) being the adjustment of pore pressure effects in equation (1) with the addition of Biot's constant.

Rock properties necessary to calculate least principal stresses from equations (1) or (3) can be obtained from laboratory analysis of core samples or from compressional and shear wave arrival times (Full Wave Sonic Logs) and Density Logs. The latter of the two was chosen for the Ballard GB-SA Pressure Limitation Study.

Full Wave Sonic logs can be run in either open or cased holes. Density logs however, can be run only in open holes, which would require Anadarko to either drill a new well or choose an existing well which had a density log. Using logs from an existing well was chosen as the most economical alternative of the two. The Ballard GB-SA unit contains a total of 92 wells. Of these, 13 have open hole density logs. The Ballard GB-SA Unit #23-4 (WIW) was selected for fracture height modeling due to its central location within the unit (See Exhibit #1, Unit Map) and because it is an active injection well.

The logging suite of the Ballard GB-SA Unit #23-4 is given as Exhibits #2, #6, #7, #8, and #9 as follows:

1. Exhibit #2

   Compensated Densilog - Compensated Neutron/Gamma Ray

   A. Formation Tops

      1. Grayburg

         a. Loco Hills

         b. Metex

         c. Premier

B. Unitized Interval

1. Top - 20' below base of Loco Hills
2. Bottom - 450' below the top of the San Andres (not shown)

2. Exhibit #6

Full Wave Sonic Log

3. Exhibit #7

Frac Pressure - Rock Properties

A. Track 1

1. Gamma Ray
2. Caliper

B. Track 2

1. DTS (msec/ft) Delta Time Shear Wave
2. DTC (msec/ft) Delta Time Compressional Wave
3. RHOB (gm/cc) Bulk Density

C. Track 3

1. ESP Estimated Static Poisson's Ratio
2. POIS Dynamic Poisson's Ratio

D. Track 4

1. CD (1/10 psi) Bulk Compressibility
2. GD (10 psi) Shear Modulus
3. YD (10 psi) Young's Modulus

4. Exhibit #8

Frac Pressure - Borehole Stress

A. Track 1

1. Gamma Ray

2. Caliper

B. Track 2

1. PPG (psi/ft) Pore Pressure Gradient

2. POG (psi/ft) Overburden Stress Gradient

3. A*PPG (psi/ft) Alpha x PPG

C. Track 3

1. TSTR (psi) Effective Tangential Stress

2. SSTR (psi) Effective Shear Stress

3. RSTR (psi) Effective Radial Stress

D. Track 4

1. Mp (psi) Mud Pressure

2. FIPS (psi) Fracture Initiation Pressure

5. Exhibit #9

Frac Pressure - Fracture Height

A. Track 1

1. Gamma Ray

2. Caliper

B. Track 2

1. FEI (psi) Fracture Energy Index

2. FCPS (psi) Static Fracture Closure Pressure

C. Track 3

1. DPU (psi) Pressure Increment to extend fracture upward
2. DPU (psi) Pressure Increment to extend fracture downward

Exhibits #7 and #8 contain rock property and borehole stress information which is calculated from the data supplied by the Full Wave Sonic Log (Exhibit #6) and Density Log (Exhibit #2). This study will center on the results shown on Exhibit #9 (Frac Pressure - Fracture Height) and neither Exhibit #7 nor Exhibit #8 will be discussed in detail. Equations for each calculated quantity are given below the log heading. Conversion constants necessary to do any of the calculations by hand are given in the Appendix, A-1. See Appendix, A-2, for theory and equation derivation.

The calculated fracture closure pressure [from equation (1)] is shown on Exhibit #9: Frac pressure - Fracture Height; Track 2 as a solid blue line. The pressure scale is from 0 to 5000 psi in 500 psi increments. Closure pressures were also calculated by hand from equation (3) and are shown by the solid red line. Differences in closure pressures between the two calculations are highlighted in yellow.

Closure pressures calculated from equation (1) for the Upper Grayburg (2300' to 2480') range from 1150 psi to 1500 psi with the interval average being 1250 psi. Pressures calculated from equation (3) are 300 psi to 400 psi higher than those calculated by equation (1). The closure pressure curve in general

is smooth with few stress variations through the section. Closure pressures calculated from equation (1) for the Lower Grayburg (2480' to 2710') range from 1000 psi to 2000 psi with the average for the perforated zones being 1500 psi. Pressures calculated from equation (3) are very close to the values calculated from equation (1) (indicating that Biot's constant is = 1.0). The closure pressure curve in general is rather erratic. Stress variations of up to 1000 psi are calculated within the section which do not correlate to the complete lithology interval in which they occur and do not correlate consistently with similar lithologies vertically through the section.

The differences in the measured closure stresses of the Upper and Lower Grayburg sections appear to indicate an error in the values measured for the lower section. Apparently the history of the lower section (perforation, acid breakdown, acidizing, injection) has caused near-wellbore changes which distort the Compressive and Shear Wave arrival times. This conclusion is supported by a Full Wave Sonic Log obtained in open hole from the Taylor #4, Square Lake GB-SA Field, Lea County, New Mexico. The log response through the entire Grayburg section of the Taylor #4 is similar to the response in the Upper Grayburg section of the Ballard GB-SA Unit #23-4. A detailed analysis of the Delta-Pressure plot will not be presented because of the erroneous data. However, a brief description will be presented for completeness.

The Delta Pressure plot is shown on the Frac Pressure - Frac Height Log in Track 3. The plot depicts heights above and below each set of perforations bounded by 100 psi increments up to 1000

psi. Two important points should be brought out about this presentation: 1) Each set of perforations is evaluated independently. An average closure stress is taken through each set of perforations (shown by the * on the closure pressure plot). The average stress is then compared to the stresses encountered above and below for an estimation of height. A discontinuity results when two set of calculations cross (at 2505, 2520, 2551, 2578, etc. in this example). 2) The delta-pressure increments in this analysis represent the increases in pressure above the propagation pressure of the perforated interval and not just pressure increments above the closure pressure (A more detailed discussion is presented in the Appendix, A-2, Section IV, Fracture Extension.). The results of this type of analysis can be seen on the Delta Pressure curve above 2478'. Since no stress barriers are encountered which are greater than those at 2478', the program calculates the fracture to grow upward from that point without limit. The program is essentially assuming unlimited lateral growth and is calculating height from a statics evaluation of stresses without regard to either a limited injection volume (in the case of a frac job) or an injection/leakoff equilibrium (in the case of an injection well).

FRACTURE HEIGHT - PSUEDO 3-D - FRACURE DESIGN MODEL

Since no significant stress barriers exist within the Grayburg formation to retard vertical fracture growth, equilibrium fracture height was calculated using Pseudo 3-D Fracture Design Models. The various methods of designing hydraulic fractures can be divided into two main groups according to the particular form

of the width equation used in arriving at the solutions. Group I, consisting of methods derived by Perkins & Kern and Nordgren, assumes that the fracture width is proportional to its height. The Group II methods, consisting of the works of Christianovich & Zheltov, LeTirant and Dupuy, Geertsma, and Daneshy, use a fracture width equation where width is proportional to length. All design methods assume fracture height to be constant and equal to an estimated number. The computed geometry of hydraulic fractures then is essentially an approximation. All the various methods do however yield reasonable results, with no method having an unquestionably proven advantage over the others. A discussion on the mechanics of hydraulic fracturing and on the mathematics behind fracture geometry computations is given in the Appendix, A-3.

In this analysis, a constant injection rate of 250 B/D was assumed. Injection pressure above closure pressure (Delta Pressure, psi) and fluid velocities at the fracture tip (V, ft/m) were then measured for fractures having constant assumed heights of 100', 150', 200', and 250'. Exhibits #10, #11, #12, and #13 are graphical presentations of the calculated data. Exhibit #10 shows the equilibrium analysis for a 100' vertical fracture. On this graph the fracture height is shown by a green diamond; velocity is shown by a red triangle; and delta pressure is shown by an orange square. All three quantities are plotted versus the fracture volume. At equilibrium the fluid velocity at the fracture tip is zero. This point is estimated by a linear extrapolation of the velocity data, shown by the red highlighted

line A. A vertical line is then drawn from the fracture volume at zero velocity, shown by the yellow highlighted line B. The intersection of a linear extrapolation of delta pressure curve (orange highlighted Line C) and line B yields the delta pressure at equilibrium. In this example, the equilibrium delta pressure is 347 psi or 3.47 psi/ft over the assumed height of 100 feet. The same procedure is repeated for assumed heights of 150', 200', and 250' (Exhibits #11, #12, and #13) and yields delta pressures of 2.63 psi/ft, 2.13 psi/ft, and 1.80 psi/ft respectively. Exhibit #14 is a graphical presentation of the delta pressures (psi/ft) that result at equilibrium and their corresponding assumed heights. The calculated data from 100' to 250' of vertical height plots as a smooth curve and has been extrapolated to include data for vertical heights up to 550'. By combining Exhibit #14 with fracture heights estimated from temperature logs, a safe injection pressure can be obtained.

Exhibit #15 is a North-South Cross-Section through the center of the Ballard GB-SA Unit (See Exhibit #1, Unit Map). The cross-section is hung stratigraphically on the top of the Grayburg formation. All of the logs shown are Injectivity Profiles obtained between March, 1981 and February, 1983. Each log contains three indicators of fluid flow. A velocity profile, shown by the red shaded areas in the left portion of Track 1, indicates the percentage of total injection into each set of perforations. A tracer profile, shown by the yellow shaded areas in the right portion of Track 1, measures the movement of injection fluid outside of the perforations but within the

immediate vicinity of the wellbore. A temperature gradient and decay profiles, shown in Track 2, indicate fluid flow by temperature anomalies between the initial temperature gradient and the temperature recovery of the decay profiles.

Several papers have been published which discuss the use of temperature logs in determining post-fracture height Estimated fracture heights are shown on Exhibit #15 by the dashed lines labeled "Top Fluid Migration" and "Bottom Fluid Migration". Measured heights range from 260' to 375', with 330' being the average. None of the logs indicate fracturing outside of the confining strata (Grayburg formation). Injection rates and pressures range from 540 BPD at 600 psi to 270 BPD at 1250 psi. The following table contains injection data from the wells shown on Exhibit #15 that have injection rates similar to the 250 B/D used in the fracture height equilibrium analysis.

WELL#	#LOG (Lft to Rt)	INJECTION (BPD)	PRESSURE (PSI)	HEIGHT (FT)
13-3	1	270	1250	354
23-3	2	266	1200	346
5-4	5	308	1310	375
16-1	7	188	1175	295

By combining the above height range with Exhibit #14 a delta pressure of 1.55 psi/ft (457 psi @ 295') and 1.275 psi/ft (478 psi @ 375') is obtained (See Exhibit #16, delta pressure w/height from temperature logs.). An evaluation of the average injection

pressure (1230 psi) and the average closure pressure obtained from the 1985 expansion area step-rate tests (630 psi) indicates that the 457 psi to 478 psi delta pressure estimate is reasonable.

Based on this evaluation, a new pressure limit of 450 psi above the formation parting pressure as determined by step-rate tests is requested for Ballard GB-SA Unit wells operated under Order No. R-7773. Below is a table containing the injection wells operated under the subject order, current pressure limits, and requested pressure limits.

WELL	PRESSURE LIMIT (CURRENT) PSIG	PRESSURE LIMIT (REQUESTED) PSIG
1. 10-9	895	1345
2. 26-4	1290	1550
3. 5-9	1032	1482
4. 5-14	925	1375
5. 8-4	737	1187
6. 9-2	770	1220
7. 10-1	520	970
8. 11-1	475	925
9. 13-2	750	1200
10. 24-2	655	1105

In summary, operating under the requested pressure limits listed above will improve injectivity into the 1985 expansion area resulting in the recovery of an additional 250 MBO while at the same time confining the resulting fracture to the Grayburg formation.

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2. Hagoot, J., Weatherill, B. and Settari, A.: "Modeling The Propagation Of Waterflood-Induced Hydraulic Fractures," SPEJ (August, 1980) 293-303.

3. Kuo, M.C.T. and DesBrisay, C.L.: "Prediction Of Fracture Extension During Waterflood Operations," Paper SPE 12769 Presented At The 1984 California Regional Meeting, Long Beach, April 11-12.

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EXHIBIT #1 & #2

DresserAtlas

DRESSER

Compensated Densilog®
Compensated Neutron
Gamma Ray

FILE NO

API NO

COMPANY ANADARKO PRODUCTION CO.

WELL BALLARD GBSA TRACT 22 NO. 4

FIELD LOCO HILLS

COUNTY EDDY STATE NEW MEXICO

EXHIBIT #2
BGBSAU PRESSURE LIMITATION STUDY
TYPE LOG

...FWL

...S RGE. 29 E

Other Services

DIL/SFL
PROLOG

Permanent Datum GROUND LEVEL Elev. 3501

Log Measured from K.B. 12.2 Ft. Above Permanent Datum KB 3513.2

Drilling Measured from K.B. DF

GL 3501

Date	10 7 82			
Run No.	ONE			
Service Order	54531			
Depth—Driller	2765			
Depth—Logger	2765			
Bottom Logged Interval	2763			
Top Logged Interval	SURFACE			
Casing—Driller	8 5/8 @ 380	@		
Casing—Logger	377			
Bit Size	7 7/8			
Type Fluid in Hole	Salt Gel Starch			
Density and Viscosity	10.2 32			
pH and Fluid Loss	8.5 NA cc	cc	cc	
Source of Sample	PIT			
Rm @ Meas. Temp	.052 @ 77 °F	@ °F	@ °F	
Rmf @ Meas. Temp	.046 @ 77 °F	@ °F	@ °F	
Rmc @ Meas. Temp	— @ — °F	@ °F	@ °F	
Source of Rmf and Rmc	M —			
Rm @ BHT	.045 @ 98°F	@ °F	@ °F	
Time Since Circ.	1			
Max. Rec. Temp. Deg. F	98 °F	°F	°F	
Equip. No. and Location	6... [illegible]			
Recorded By	[illegible]			
Witnessed By	[illegible]			

BEFORE EXAMINER STOGNER
Oil Conservation Division
Exhibit No. 2
Case No. 9364

EXHIBIT #3 & #4